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Impact of teacher quality on perceived mathematics performance: Mediating roles of technology, motivation, and student interest

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Abstract

This study aims to examine the impact of teacher quality on perceived mathematics performance, with a focus on the mediating roles of technology, motivation, and student interest. A descriptive survey was conducted at the Akenten Appiah-Menka University of Skills Training and Entrepreneurial Development in Kumasi, Ghana, involving a sample size of 370 students. Structured questionnaires were used to collect data from the students, employing both simple random sampling and stratified random sampling techniques. The questionnaire was designed to assess students' perceptions of technology, teacher quality, motivation, student interest, and perceived mathematics performance. To test the hypotheses, Structural Equation Modeling (SEM) was conducted using Amos software (version 23). The results of the structural equation modeling (SEM) analysis revealed that there was no significant effect between teacher quality and perceived mathematics performance. However, the mediating variables of technology, motivation, and interest were found to exhibit full mediation in the relationship between teacher quality and perceived mathematics performance. These findings imply that improving students' perceived mathematics performance depends not only on teacher quality but also on enhancing technological integration, fostering student motivation, and cultivating interest in mathematics, highlighting the importance of holistic instructional strategies.

Keywords: Motivation; Perceived mathematics performance; Structural equation model; Student interest; Teacher quality; Technology

1. Introduction

Mathematics education is critical for providing students with the skills and knowledge they need to succeed in a variety of academic and professional fields. The quality of teaching in mathematics has been recognized as a key factor influencing students' performance and achievement outcomes. Numerous studies have highlighted the significant effect of teacher quality and student achievement (Darling-Hammond, 2000). However, the precise mechanisms through which teacher quality influences mathematics achievement are still not fully understood. In tertiary institutions, student achievement is a critical aspect of educational outcomes. Previous studies have consistently shown that teachers with solid content knowledge and pedagogical skills are more likely to foster positive learning experiences and facilitate students' mathematics performance (Darling-Hammond, 2000). However, the ways in which teacher quality translates into improved mathematics performance are multifaceted and context-dependent. Effective teaching practices, including instructional methods, pedagogical approaches, and teacher-student interactions, are crucial in fostering student learning and engagement. Additional measures such as exams for licensure and promotion were implemented to improve teacher quality (Mensah et al., 2017). These policies aim to improve the emotional, psychological, and professional practices of educators, including mathematics teachers (Abudu & Donkor, 2014; Darling-Hammond, 2000).

This study contributes to the literature in two main ways. First, it reveals that teacher quality has no significant direct effect on perceived mathematics performance. Second, it demonstrates that technology, motivation, and student interest fully mediate the relationship between teacher quality and perceived mathematics performance.

The integration of technology in teaching practices has the potential to improve students' academic performance by providing access to information, facilitating interactive learning experiences, and promoting independent study. Digital tools, interactive software, and online resources allow students to explore mathematical concepts, solve problems, and visualize abstract ideas. Fonseca et al. (2014) found evidence supporting the beneficial effects of technology on students' achievement and motivation. Cheng et al. (2015) demonstrated that technology use in the classroom influences learning outcomes, long-term knowledge retention, and student engagement. Student motivation and interest have been identified as critical factors influencing student engagement and achievement in mathematics (Hidi & Renninger, 2006).

Motivated students are more likely to persist in challenging mathematical tasks, exhibit positive attitudes towards the subject, and achieve higher levels of performance. Student interest, characterized by genuine curiosity and enthusiasm for the subject matter, can similarly impact their level of engagement and performance in tertiary education (Boadu & Boateng, 2024). To improve teaching and learning methods in mathematics classrooms, students should be exposed to a variety of problem-solving techniques that reinforce their understanding of the subject. However, it is imperative to advance a comprehensive understanding of the elements that impact students' academic outcomes to enhance their overall performance. Numerous studies have delved into the factors that influence students' mathematics performance and have specifically examined their interrelationships. Moreover, previous research has discussed the direct effects of specific factors on students' mathematics achievement. For example, a recent study by Boadu et al. (2023) concluded that peer tutoring partially mediates mathematics achievement through motivation. While the influence of teacher quality on mathematics performance has been widely acknowledged, the specific mechanisms through which teacher quality impacts student outcomes remain complex and multifaceted.

Additionally, the role of mediating factors, such as technology use, motivation, and student interest, in this relationship requires further examination. Although previous research has explored the influence of teacher quality on mathematics achievement (Darling-Hammond, 2000), there is still a need to comprehend the specific mechanisms through which teacher quality influences student outcomes. Furthermore, while the integration of technology in mathematics instruction has become increasingly prevalent, its mediation effect in the relationship between teacher quality and students' mathematics performance necessitates further investigation. Similarly, although motivation and student interest have been recognized as significant factors in academic performance, their mediating effects in the context of teacher quality and mathematics performance require deeper exploration. Hence, there exists a gap in the existing literature that calls for attention. Specifically, there is a need to comprehensively analyze the mediating effects of technology, motivation, and student interest in the relationship between teacher quality and perceived mathematics performance.

The current study aims to contribute to the existing literature by investigating the effect of teacher quality on perceived mathematics performance, with a specific focus on the mediating roles of technology, motivation, and student interest. This approach extends previous research by considering the interplay of these factors and providing a more comprehensive understanding of the pathways through which teacher quality can influence mathematics performance in tertiary education. While previous studies have acknowledged the importance of teacher quality and effective teaching practices in mathematics, this study aims to delve deeper into the specific mechanisms through which these factors influence students' mathematics performance. This study recognizes the emerging role of technology in the classroom and its potential to enhance student learning experiences in mathematics. By considering these less researched elements, such as the integration of technology and motivation, this study offers a comprehensive and multifaceted analysis of the factors that contribute to improved mathematics performance. Through this unique perspective, the study aims to provide valuable insights and practical recommendations for enhancing mathematics education and promoting student success in academic and professional endeavors. The significance of this study lies in its ability to provide a more comprehensive understanding of the mechanisms through which teacher quality influences students' mathematics performance in tertiary education.

By exploring the mediating roles of technology, motivation, and student interest, the study offers valuable insights that can inform the development of targeted interventions and policies to enhance mathematics education and promote student success. The findings of this research can contribute to the broader understanding of the multifaceted factors that influence students' mathematics performance, enabling educational institutions and policymakers to implement more effective teaching and learning strategies. The study can elucidate the interplay between teacher quality, technology, motivation, and student interest shedding light on the complex pathways that ultimately lead to improved mathematics performance among tertiary-level students. Hence the study aims to address the following research questions:

H1: Teacher quality (TQ) has a direct effect on perceived mathematics performance (PMP).

$$PMP = \alpha_0 + \alpha_1 TQ + \varepsilon^1 \quad (1)$$

H2: Technology (TC) mediates the relationship between teacher quality (TQ) and perceived mathematics performance (PMP).

$$PMP = \beta_0 + \beta_1 TC + \beta_2 TQ + \varepsilon^2 \quad (2)$$

H3: Motivation (MO) mediates the relationship between teacher quality (TQ) perceived mathematics performance (PMP).

$$PMP = \lambda_0 + \lambda_1 MO + \lambda_2 TQ + \varepsilon^3 \quad (3)$$

H4: Student interest (SI) mediates the relationship between teacher quality (TQ) and perceived mathematics performance (PMP).

$$PMP = \gamma_0 + \gamma_1 SI + \gamma_2 TQ + \varepsilon^4 \quad (4)$$

2. Literature Review

2.1. Conceptual Review and Framework

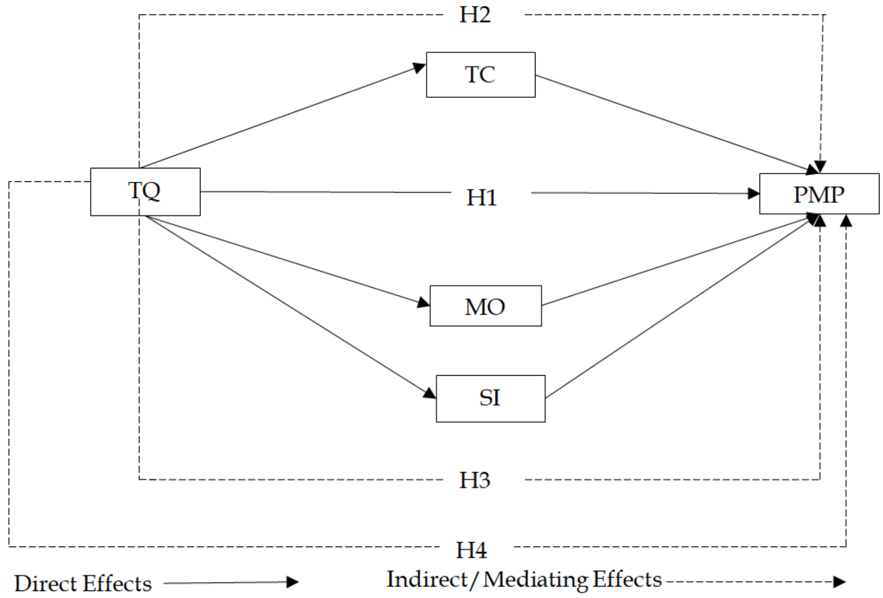
The conceptual framework visually represents the connections between the factors and their combined influence on perceived mathematics performance. The arrows within the framework illustrate the hypothesized relationships among the different components. The framework comprises one independent variable (teacher quality), three mediating variables (technology, motivation, and student interest), and one dependent variable (perceived mathematics performance). Teacher quality encompasses the combination of content pedagogical knowledge, classroom skills, and instructional practices possessed by teachers (Boadu et al., 2023).

The integration of technology in mathematics instruction has the potential to enhance learning experiences and progress students' understanding of mathematical concepts (Boadu & Boateng, 2024). Academic success and learning are greatly influenced by motivation, which includes intrinsic motivation, self-control, and engagement as vital elements in the learning environment (Deci & Ryan, 2013). Student interest refers to individuals' curiosity, personal connection, and enjoyment of mathematics (Boadu & Boateng, 2024). Perceived mathematics performance is the dependent variable in this study, representing students' perceptions of mathematics performance. While previous studies have examined the individual relationships between teacher quality, technology, motivation, and student interest with mathematics performance, few have examined the complex, mediating pathways between these factors in an integrated framework. This study enhances the methodology by incorporating more objective assessments, addressing a limitation of previous research. Figure 1 illustrates the proposed conceptual model and the hypotheses tested in this study.

2.2. Theoretical Framework

This section critically evaluates key theories and concepts related to teacher quality, technology, motivation, interest, and mathematics achievement. It draws upon previous research to establish a foundation for understanding the relationships among these factors. However, the literature review identifies a gap in understanding the specific mechanisms through which teacher quality influences mathematics achievement.

Figure 1
Conceptual Framework (Source: Field Survey 2025)



Note. PMP: Perceived Mathematics Performance; MO: Motivation; SI= Student Interest; TQ: Teacher Quality; TC: Technology.

2.2.1. Self-Determination Theory

The study incorporates Self-Determination Theory [SDT] as a theoretical lens to understand the mediating role of student motivation. SDT proposes that individuals have inherent psychological needs for independence, skill, and affiliation. When these needs are fulfilled, intrinsic motivation and engagement are fostered (Deci & Ryan, 2013). The literature review highlights the importance of teacher practices on students' motivation and engagement in mathematics, using Self-Determination Theory. However, it identifies a need for further research to explore how teacher practices impact students' motivation and engagement, particularly in the context of mathematics education. This theory is relevant to Hypothesis 3, which proposes that motivation mediates the relationship between teacher quality and students' perceived mathematics performance. The literature review highlights the importance of teacher practices in influencing students' motivation and interest in mathematics.

2.2.2. Bandura's Social Cognitive Theory

The framework acknowledges the impact of instructor practices on students' motivation and engagement in mathematics. Bandura social cognitive theory is also employed in this study, positing that learning is influenced by personal, environmental, and behavioral factors (Bandura, 1986). The literature review recognizes the role of observational learning and motivation in students' mathematics performance but identifies a gap in understanding how environmental factors, such as technology, teaching quality, and student interest, interact to shape students' beliefs, motivation, and learning experiences. In the context of this research, perceived students' mathematics performance is influenced by motivation and observational learning. Environmental factors, such as technology, teaching quality, and student interest, play an important role in determining students' beliefs, motivation, and learning experiences.

This theory is relevant to Hypothesis 2 and Hypothesis 4, which explore the mediating roles of technology and student interest, respectively, in the relationship between teacher quality and students' perceived mathematics performance. The literature review recognizes the importance of environmental factors, such as technology and student interest, in influencing students' beliefs, motivation, and learning experiences.

2.2.3. Interest Development and Interest-Driven Learning Theory

The study acknowledges the significance of interest development and interest-driven learning. Theories of interest development propose that individuals' interest in a subject can significantly predict their engagement and achievement (Hidi & Renninger, 2006). In the mathematics education context, nurturing students' interest in the subject matter is seen as a means to enhance their motivation, effort, and performance. However, it identifies a gap in understanding how teachers can effectively promote student curiosity, connect mathematics to real-world contexts, and provide opportunities for exploration and discovery to enhance students' interest in mathematics. By critically evaluating previous studies, the theoretical review section identifies gaps in the existing literature, highlighting the need for further research to investigate the specific mechanisms through which teacher quality, technology integration, motivation, and interest influence perceived mathematics performance. This is relevant to Hypothesis 4, which explores the mediating role of student interest in the relationship between teacher quality and students' perceived mathematics performance. The literature review highlights the importance of nurturing students' interest in mathematics to enhance their motivation, effort, and performance.

3. Method

3.1. Research Design

The research paradigm refers to the conceptual framework that researchers employ to guide the methodology and data analysis in their work (Nguyen, 2019). In this particular study, the researcher adopted a positivist research paradigm. Positivism involves the establishment of scientific laws and the empirical testing of theories. Positivist researchers typically employ quantitative methods such as surveys and empirical hypothesis testing. The research design, on the other hand, offers a framework for conducting the study and outlines the steps and measures for data collection and analysis (McMillan et al., 2010).

Descriptive survey design was used in this study, which involves administering a questionnaire to a sample of participants at a particular moment to capture their ideas, attitudes, actions, and traits (Creswell, 2015).

3.2. Participants

A sample is a portion of the population specifically selected for research purposes. When the sample accurately represents the population, the researcher can confidently generalize the findings. According to Haviz et al. (2020), sampling techniques refer to the procedures, methods, or strategies employed to gather evidence or data for analysis, with the aim of uncovering new information or enhancing subject-matter expertise. The study used a combination of stratified sampling and simple random sampling to select the study participants. Stratified sampling was used to ensure the sample was representative of the different academic levels (100, 200, and 300 levels). The population was first divided into these homogeneous subgroups based on academic level, ensuring adequate representation from each level in the final sample. Simple random sampling was then used to select individuals from each academic level, giving every student an equal chance of being included in the study (Boadu & Boateng, 2024).

Students present in their classes at the time of data collection were selected using a simple random procedure to minimize bias. By combining stratified and simple random sampling techniques, the study aimed to reduce potential sampling bias and obtain a representative sample that reflects the characteristics of the overall population. In total, 370 students were selected from an estimated population of 5,000 students at AAMUSTED University in Kumasi. The selected participants were drawn from departments such as Mathematics, Information and Communication Technology, Applied Electricity, Building Construction, and Home Economics, where mathematics is a required core subject. The sample consisted of 200 male students and 170 female students. Data were collected over a one-week period using a structured questionnaire administered during scheduled class times, which supported a high response rate and ensured standardized data collection across participants. Table 1 shows the characteristics of the students participated in the study.

Table 1
Demographics of Students

Demographics	*Frequency (N)*	*Percentages (%)*
Gender		
Male	200	54.1
Female	170	45.9
Age		
15 – 18 years	32	8.6
19 – 22 years	320	86.5
23 – 26 years	13	3.5
Above 27 years	5	1.4
Level of study		
L 100	30	8.1
L 200	300	81.1
L 300	40	10.8
Program of Study		
Mathematics	105	28.4
ICT	60	16.2
Applied Electricity	88	23.8
Building Construction	36	9.7
Home Economics	81	21.9

3.3. Questionnaire and Measures

The study aimed to examine the impact of teacher quality on students' perceived mathematics performance, as well as the mediating roles of technology, motivation, and interest. The research questions were divided into two parts. Part A focused on collecting socio-demographic data, while Part B addressed the five variables under investigation. In Part B, the variables were measured using a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree).

The study included one independent variable (Teacher Quality-TQ), three mediators (Technology-TC, Motivation-MO, and Student Interest-SI), and Perceived Mathematics Performance-PMP) as the dependent variable. In total, there were 50 measurement items corresponding to the five constructs. The study also accounted for students' gender, age, level, and program of study as additional factors.

3.4. Validity and Reliability

In quantitative research, the validity and reliability of instruments are assessed using exacting statistical analysis. The degree to which a measure faithfully represents the notion or idea under investigation is referred to as validity. Conversely, reliability concerns the constancy of a measurement's results throughout time or when employed by several researchers (Boadu & Boateng, 2024).

The measurement items were drawn from previous research, indicating the constructs being measured were grounded in existing literature. However, the items were modified to suit the specific context of the current study. This is an important step to ensure the measures accurately represent the intended constructs within the study setting. To further validate the measures, a pilot test was conducted. This allowed the researchers to identify and eliminate any ambiguous or poorly performing items. By refining the measurement items based on the pilot testing, the researchers helped ensure the final instruments had strong content validity-meaning they effectively captured the intended constructs.

The internal consistency reliability of the key study variables was assessed using Cronbach's alpha (α) coefficient. The alpha values reported for the technology (α = .716), motivation (α = .779), teacher quality (α = .821), student interest (α = .712), and perceived mathematics performance (α =

.828) constructs all exceeded the commonly accepted threshold of .7. This indicates the measurement items within each scale demonstrated strong inter-item reliability, meaning they were consistently measuring the same underlying construct as recommended by Boadu et al. (2023) indicating the instrument's appropriateness for use in the study. The high alpha values provide confidence that the instruments produced stable and consistent results, which is crucial for the trustworthiness of the study findings.

3.5. Ethical Consideration

The researchers formally requested permission from the university to conduct the study in an official request. We would like to clarify that written informed consent was obtained from all participants prior to their involvement in the study. For participants under the age of 16, we confirmed that parental/guardian consent was obtained prior to participation. The authors stated that the study was approved by the Akenten Appiah-Menka University of Skills Training and Entrepreneurial Development Institutional Ethics and Research Committee with reference AAMUSTED/IERC/2025/023. Written informed consent was obtained from heads of the departments and lecturers, as well as from students. The privacy and anonymity of the participants were respected.

3.6. Data Analysis

In this study, SPSS with AMOS (version 23) was used to code, enter, and analyze the quantitative data. SPSS was used for data management, coding, and initial statistical analyses, while AMOS was specifically employed for conducting the structural equation modeling (SEM) analysis. Structural equation modeling (SEM) is a statistical technique used to analyze complex relationships among variables and test theoretical models. SEM is based on several assumptions, and it is important to assess whether these assumptions hold in order to ensure the validity and reliability of the analysis. The SEM analysis allowed for the examination of the relationships among the variables in the study, including the identification of direct and indirect effects.

To ensure the assumptions underlying SEM are met, researchers typically conduct preliminary analyses and diagnostic checks before performing the SEM analysis. If the assumptions are violated, appropriate data transformations, such as log transformations or nonlinear transformations, can be applied to address the violations. In some cases, alternative statistical approaches may be considered if the assumptions cannot be adequately met. By assessing and addressing these assumptions, researchers can enhance the validity and reliability of the SEM analysis and draw meaningful conclusions from the results. Here is a discussion of the assumptions underlying SEM and how they can be tested:

Linearity. SEM assumes that the relationships between variables are linear. This means that the effects of one variable on another are constant across different levels of the variables involved. Linearity can be tested by examining scatterplots and assessing whether the relationships appear to be linear or by conducting preliminary analyses such as correlation analysis.

Normally distributed variables. SEM assumes that the variables involved in the analysis are normally distributed. This assumption is important for accurate parameter estimation and hypothesis testing. Normality can be tested by examining the distribution of the variables using descriptive statistics, histograms, and normality tests such as the Shapiro-Wilk test or the Kolmogorov-Smirnov test.

Multivariate normality. In addition to individual variable normality, SEM assumes that the joint distribution of all variables in the model is multivariate normal. This assumption can be assessed using multivariate normality tests such as Mardia's coefficient of multivariate kurtosis or the Henze-Zirkler's test.

Homoscedasticity. SEM assumes that the variances of the observed variables are equal across different levels of the variables involved. Homoscedasticity can be evaluated by examining scatterplots and assessing whether the spread of data points is consistent across the range of values.

Absence of multicollinearity. SEM assumes that the observed variables are not highly correlated with each other, indicating the absence of multicollinearity. Multicollinearity can be assessed by examining the correlations between variables and checking for high correlation coefficients (e.g., above 0.8 or 0.9).

Absence of outliers. SEM assumes that there are no extreme outliers that excessively influence the parameter estimates and statistical results. Outliers can be identified using graphical methods, such as boxplots or scatterplots, and statistical techniques like the Mahalanobis distance or the Cook's distance.

3.7. Descriptive Analysis

Descriptive analysis was performed in the study to assess the normality of the questionnaire responses, using mean and standard deviation values. Testing for normality helps determine if the data can be reasonably assumed to be sampled from a population that follows a normal distribution. Assumption of normality is important for many statistical methods and techniques that rely on the normality assumption, such as parametric hypothesis testing, confidence intervals, and regression analysis. In Table 2, the results for each item related to the constructs were presented. Among the constructs, teaching quality had the greatest mean score of 4.045 and a standard deviation of 0.083. On the other hand, perceived students' mathematics performance had the lowest mean score of 3.515 and a standard deviation of 0.142. The mean and standard deviation values for each construct indicated that the data passed the normality test.

Table 2
Descriptive Analysis

SN	*Variables*	*Mean*	*SD*
TQ	Teaching Quality	4.045	0.083
TQ1	The teachers at my school have excellent subject knowledge	4.08	0.998
TQ3	The teachers create a positive and inclusive classroom environment	3.94	1.018
TQ4	The teachers provide timely and constructive feedback on my work	4.00	1.025
TQ7	The teachers have good classroom management skills	4.16	0.992
PMP	Perceived Mathematics Performance	3.515	0.142
PMP1	I have faith in my abilities to handle mathematical challenges.	3.29	1.401
PMP2	I enjoy learning and studying mathematics	3.61	1.102
PMP3	I believe that I can improve my mathematics skills with practice	3.66	1.058
PMP6	I actively participate and engage in mathematics class discussions	3.50	1.190
TC	Technology	3.853	0.038
TC4	I feel comfortable using technology for educational purposes	3.86	0.985
TC 6	I believe that technology should be integrated into all aspects of education	3.85	1.058
TC 7	Using technology helps me develop important digital skills for the future	3.85	1.091
MO	Motivation	3.723	0.101
MO7	I believe that education is essential for my personal and professional growth	3.86	1.158
MO8	I actively seek out opportunities to expand my learning beyond the classroom	3.60	1.063
MO9	I am enthusiastic about exploring new topics and subjects	3.71	1.162
SI	Student Interest	3.897	0.074
SI2	The teaching methods used in my classes capture my attention	4.00	1.042
SI3	I enjoy participating in class discussions and activities related to the subjects	3.89	1.012
SI4	I feel motivated to learn more when I can relate the topics to real-life situations	3.80	1.078

3.8. Exploratory Factor Analysis

Exploratory factor analysis [EFA] is used to identify the latent components within a collection of observable data (Boadu & Boateng, 2024). EFA reduces the dimensionality of the data and offers information on the underlying structures of the variables that are being observed (Hair et al., 2011). In EFA, the researcher begins with a set of observed variables and employs statistical methods to extract and interpret factors. Additionally, EFA provides information about the uniqueness of each observed variable, representing the variance that is specific to that variable and not shared with other factors (Kline, 2023).

In this study, EFA was used to find the factors associated with the observed variables. The factor extraction methods employed were principal component analysis PCA] or maximum likelihood estimation, which estimated the factor loadings matrix [L] and the factor scores matrix (F). Principal component analysis is a commonly used method in EFA that aims to identify linear combinations of observed variables (components) that explain the maximum amount of variance in the data. PCA extracts factors based on the eigenvalues of the correlation or covariance matrix, where factors with eigenvalues greater than 1 are retained. PCA is useful in reducing the dimensionality of the data and identifying the most important factors that underlie the observed variables. By using PCA, the study can identify the basic factors associated with the observed variables and determine their respective loadings.

Although PCA is primarily a data reduction technique rather than a latent factor analysis method, it was selected for this study to efficiently identify the main components underlying the observed variables. The goal of the EFA was to explore the structure of the data, reduce dimensionality, and identify preliminary factor loadings that could inform the subsequent Confirmatory Factor Analysis [CFA] and Structural Equation Modeling [SEM]. This approach allows for a clear and interpretable factor structure while providing initial evidence for construct validity, ensuring that the extracted components align with the theoretical constructs of technology, motivation, interest, teacher quality, and perceived mathematics performance.

Maximum likelihood estimation is another widely used method in EFA that estimates the factor loadings by maximizing the likelihood of the observed data under a specified factor model.

This method assumes that the observed variables are normally distributed and that the relationships between the variables and factors are linear. Maximum likelihood estimation is particularly useful when the data meet the assumptions of multivariate normality and linearity. By utilizing maximum likelihood estimation, the study can estimate the factor loadings matrix and the factor scores matrix [F], which are essential for understanding the relationships between the observed variables and latent factors. The main objective of the EFA was to ascertain the loadings of each observed variable on its respective latent variable. The suitability of the sample for factor analysis was calculated using the Kaiser-Meyer-Olkin [KMO] measure of sampling adequacy, which yielded a value of 0.796.

This value exceeded the recommended threshold of 0.5, indicating a strong relationship between the components and the adequacy of the sample. Additionally, Bartlett's sphericity test ($p < .001$) indicated sufficient correlation among the variables to proceed with factor analysis. The chi-square value was 2098.466 with 136 degrees of freedom. In this study, five factors were extracted and subsequently rotated. The total variance explained was 65.701%, which exceeded the minimum threshold of 50%. The determinant value of 0.003 suggested that the matrix was positively defined (refer to Table 3). Iteratively eliminating items with low factor loadings allowed for the analysis of the fit indices for each eliminated item (Hair et al., 2011). The EFA values are depicted in Table 3. These specific methods contribute to validating the research model in the following ways:

Dimensionality Reduction. EFA, using methods like PCA, reduces the dimensionality of the data by identifying the underlying factors that explain the shared variance among the observed variables. This helps in simplifying the analysis and providing a more parsimonious representation of the data.

Construct Validity. By extracting factors and estimating factor loadings, EFA provides evidence for the construct validity of the research model. It helps to confirm that the observed variables are indeed related to the latent constructs or factors in the expected manner.

Model Fit and Interpretability. The fit indices, such as the total variance explained and determinant value, provide information about how well the identified factors account for the observed data and whether the factor model is a good fit. These indices contribute to the validation of the research model by indicating the adequacy of the factor structure and the interpretability of the extracted factors. By employing these specific methods in the EFA, the study can identify the underlying factors, validate the research model, and obtain valuable insights into the relationships among the observed variables and latent constructs.

Table 3
Exploratory Factor Analysis

Rotated Component Matrix[a]					
Measurement items	*Component* 1	2	3	4	5
TQ1					.728
TQ3					.819
TQ4					.801
TQ7					.789
TC4	.823				
TC6	.801				
TC7	.774				
SI1			.751		
SI2			.775		
SI3			.782		
PMP1				.778	
PMP2				.802	
PMP3				.804	
PMP6				.798	
MO7		.797			
MO8		.818			
MO9		.805			

Total Variance Explained		65.701%
Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.796
Bartlett's Test of Sphericity	Approx. Chi-Square	2098.466
	Df	136
	Sig.	< 0.001
Determinant		.003

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization. Rotation converged in 5 iterations

3.9. Confirmatory Factor Analysis

Researchers build a theoretical model in CFA that explains the connections between latent components and observable data. A collection of structural equations that specify how the latent components affect the observed variables often serves as the model's representation. Using CFA, researchers can evaluate the model's goodness-of-fit by comparing the covariance matrix predicted by the model with the observed covariance matrix. The observed variables are compatible with the proposed factor structure if the model fit is adequate. CFA is commonly used in fields such as psychology, education, and social sciences to validate or refine theoretical models, assess construct validity, and examine the underlying structure of multi-item scales or questionnaires. The factor loadings, which show the direction and intensity of the association between each latent component and its corresponding observable variable, can be interpreted by researchers (Marsh et al., 2004).

To perform CFA, researchers often use software such as Amos (v.23) to estimate the model and assess its fit (Dogbe et al., 2020; Lahey et al., 2012). When evaluating the fitness of a CFA model, several criteria are considered. According to Hair et al. (2011), recommended criteria include a CMIN/DF value of less than 3, Tucker-Lewis Index [TLI], Comparative Fit Index [CFI] values of at least 0.9, Root Mean Square Error of Approximation [RMSEA], and Standardized Root Mean

Square Residual [SRMR] values less than 0.08, and a *P*-close value greater than .05. These criteria assess various aspects of model fit, such as inconsistency, deviation from the ideal model, and agreement with the baseline model (Xia & Yang, 2019).

The CFA findings are typically presented in Table 4, showing the factor loadings and fit indices. The confirmatory factor analysis approach is frequently used to remove variables with low factor loadings (less than 0.5) from additional investigation. The model's validity and good correlation between the data and the model were indicated by the CFI value of 0.948, which was higher than 0.90. The GFI final result gave a value of 0.9358. This suggests that the final model was well-made. Additionally, RMSEA produced a value of 0.052, which was deemed acceptable because it was less than 0.08, and the RMR resulted in a value of 0. 057. These show that the core elements of the five constructs were legitimate and appropriate. The standard factor loadings results are depicted in Figure 2. The CMIN/DF value for the fitness assessments was 1.987 (< 3). *P*-Close produced a value of .377 which specified statistical insignificance at 5% (Hair et al., 2011).

Table 4

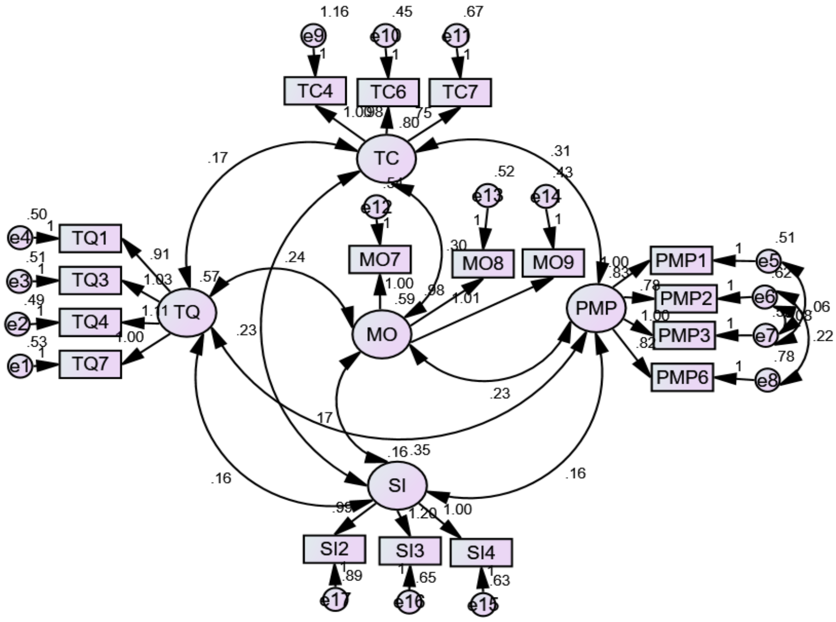
Confirmatory Factor Analysis (CFA)

Model Fit Indices: CMIN = 210.644; DF = 106; CMIN/DF = 1.987; CFI =0 .948; TLI =0.933; RMR =0 .057; RMSEA = 0.052; GFI=0.938; AGFI=0.910; P Close = .377	*SFL*
Teacher Quality(TQ)	
The teachers at my school have excellent subject knowledge (TQ1)	0.91
The teachers create a positive and inclusive classroom environment (TQ3)	1.03
The teachers provide timely and constructive feedback on my work (TQ4)	1.11
The teachers have good classroom management skills (TQ7)	1.00
Technology(TC)	
I feel comfortable using technology for educational purposes (TC4)	1.00
I believe that technology should be integrated into all aspects of education (TC6)	0.98
Using technology helps me develop important digital skills for the future (TC7)	0.75
Motivation(MO)	
I believe that education is essential for my personal and professional growth (MO7)	1.00
I actively seek out opportunities to expand my learning beyond the classroom (MO8)	0.98
I am enthusiastic about exploring new topics and subjects (MO9)	1.01
Student Interest(SI)	
The teaching methods used in my classes capture my attention (SI2)	0.95
I enjoy participating in class discussions and activities related to the subjects (SI3)	1.20
I feel motivated to learn more when I can relate the topics to real-life situations (SI4)	1.00
Perceived Mathematics Performance (PMP)	
I have faith in my abilities to handle mathematical challenges (PMP1)	1.00
I enjoy learning and studying mathematics (PMP2)	0.78
I believe that I can improve my mathematics skills with practice (PMP3)	1.00
I actively participate and engage in mathematics class discussions (PMP6)	0.82

Note. SFL: Standard factor loading.

The CFA and the preceding EFA were conducted on the same dataset, which may potentially inflate model fit and affect the robustness of the measurement model. However, several steps were taken to ensure the reliability and validity of the measurement model, including careful elimination of items with low factor loadings, examination of multiple fit indices (CMIN/DF, CFI, TLI, RMSEA, SRMR), and assessment of composite reliability [CR] and average variance extracted [AVE] for all constructs. Additionally, the factor structure identified in EFA was grounded in theoretical constructs, which further supports the validity of the measurement model despite using the same dataset. The explanation of why CFA was chosen and how it contributes to validating the research model:

Figure 2
Confirmatory Factor Analysis Diagram



3.9.1. Theoretical model testing

CFA is employed when researchers have a pre-established theoretical model that specifies the relationships between latent components (factors) and observed variables. By using CFA, researchers can evaluate whether the observed data align with the proposed factor structure and assess the goodness of fit of the model. This allows for the validation or refinement of the theoretical model under investigation.

3.9.2. Construct validity assessment

CFA is widely used in various fields, including psychology, education, and social sciences, to assess construct validity. Construct validity refers to the extent to which the observed variables accurately measure the underlying constructs or factors they are intended to represent. By examining the factor loadings in CFA, which indicate the direction and strength of the associations between latent factors and observed variables, researchers can evaluate how well the observed variables reflect the underlying constructs.

3.9.3. Fit indices evaluation

In CFA, fit indices are used to assess the goodness of fit between the proposed model and the observed data. Fit indices, such as the Comparative Fit Index, Tucker-Lewis Index, Root Mean Square Error of Approximation, and Standardized Root Mean Square Residual, provide information about different aspects of model fit, including overall fit, discrepancy between observed and predicted covariance matrices, and model parsimony. By evaluating these fit indices against recommended thresholds, researchers were able to determine the adequacy of the model fit. By using CFA, the researchers in this study were able to validate the research model by assessing the fit between the observed data and the hypothesized factor structure.

The factor loadings provided insights into the relationship between latent factors and observed variables, contributing to the evaluation of construct validity. The fit indices allowed for an evaluation of the overall goodness of fit, providing evidence for the model's validity and adequacy.

3.9.4. Limitations and methodological considerations

We acknowledge that PCA was used in EFA as a data reduction technique rather than a true latent factor method; it was chosen to efficiently explore the underlying structure of the observed variables and inform CFA and SEM. Both EFA and CFA were conducted on the same dataset, which may inflate model fit. To mitigate this, items with low loadings were removed, multiple fit indices were evaluated, and the factor structure was theoretically grounded. Slightly elevated factor loadings above 1.0 in CFA were examined and found to be due to estimation procedures in AMOS; no coding errors or model misfit were detected, and the overall measurement model remains valid and reliable. Cross-validation with a separate dataset is recommended for future studies to further strengthen robustness.

3.10. Composite Reliability, Average Variance Explained and Cronbach Alpha

After conducting the analysis using SPSS (v.23), the CA values were computed for the retained items. The calculated CA values for the variables of teacher quality [TQ], technology [TC], motivation [MO], student interest [SI], and perceived mathematics performance [PMP] were .821, .716, .779, .712, and .828, respectively. These values depicted in Table 5 show that the CA for each construct met the recommended threshold of .70, as suggested by Taber (2018) and Bannor et al. (2023) to ensure reliability. To assess convergent validity, two criteria were considered. First, the observed variables' average variance extracted must be larger than or equal to 0.5. Also, the composite reliability should be at least .7. Based on the findings, it was determined that all constructs met these criteria.

Table 5
Composite Reliability, Average Variance Explained, and Cronbach Alpha

Constructs	*Composite Reliability (CR)*	*Average Variance Explained (AVE)*	*Cronbach Alpha (CA)*
Teacher Quality	0.89474	0.61412	0.821
Technology	0.84164	0.63934	0.716
Motivation	0.84826	0.65079	0.779
Student Interest	0.81317	0.59205	0.712
Perceived Mathematics Performance	0.90160	0.63163	0.828

Specifically, the variable of student interest [SI] had the lowest AVE of 0.59205 and the lowest CR of 0.81317. These results indicate that the study achieved convergent validity, as outlined by Boadu and Boateng (2024). Finally, the average extracted variance was higher than the minimum requirement of .50 that Bannor et al. (2023) and Dos Santos and Cirillo (2023) specified. As a result, Table 5 shows that the study's instrument met the necessary convergent validity requirements.

3.11. Discriminant Validity

This study compared the square root of average extracted variance with correlation coefficients in order to investigate discriminant validity, much like the research done by Bamfo et al. (2018). The degree to which measurement items in one concept are unrelated to measurement items in another is assessed by discriminant validity (Trochim & Donnelly, 2001). It is advised that the smallest √AVE be larger than the maximum correlation coefficient in order to demonstrate discriminant validity (Arthur et al., 2022; Boadu & Boateng, 2024). Table 6 shows that the highest correlation coefficient was 0.445 and the smallest √AVE value was 0.7694.

Table 6
Discriminant Validity

VARAIBLES	*TQ*	*TC*	*MO*	*SI*	*PMP*
TQ	**0.7836**				
TC	0.258***	**0.7996**			
MO	0.412***	0.445***	**0.8067**		
SI	0.362***	0.434***	0.376***	**0.7694**	
PMP	0.236***	0.381***	0.335***	0.302***	**0.7948**

Note. *** Values represent correlations between variables; √AVE are bold.

Consequently, the dataset exhibited discriminant validity, meeting the appropriate thresholds as recommended by Boadu et al. (2023). Specifically, the results revealed that the variable of student interest had the lowest Average Variance Extracted of 0.7694.

5. Results

5.1. Path Analysis

Researchers employ path analysis as a statistical technique to construct the structural model and investigate causal relationships between variables (Afthanorhan & Ahmad, 2014). Path analysis is a type of multiple regression analysis that examines how dependent variables are associated with two or more independent variables. The arrows in the diagram indicate the direction of effects, helping to illustrate the hypothesized causal pathways and facilitating the interpretation of the analysis results. Path analysis enables researchers to explore cause-effect relationships between dependent and independent variables (Nayebi, 2020).

The structural model demonstrated an acceptable fit to the data. The CMIN/DF value of 2.097 was below the recommended threshold of 3, indicating good model parsimony. The CFI (0.941) and TLI (0.925) exceeded the minimum criterion of 0.90, confirming a good incremental fit. The GFI (0.935) and AGFI (0.907) also supported adequate model fit. Additionally, the RMSEA value of 0.055 and RMR value of 0.063 were below 0.08, indicating acceptable residuals, while the PClose value of 0.219 further confirmed a close-fitting model. Overall, these indices indicate that the proposed structural model fits the data well and is suitable for hypothesis testing.

5.2. Direct effect

The findings regarding the direct effects of the independent variable (teacher quality), along with the mediators (technology, motivation, and student interest), on the dependent variable (perceived mathematics performance) are presented in Table 7. Figure 3 presents the mediation structural paths tested in the study.

Table 7
Path Estimates

Direct Path	*Unstd. Estimate*	*Standardized Path Coefficients (β)*	*Critical Ratio (C.R.)*	*Standard Error (S.E.)*	*P-value*
TQ→PMP	0.076	0.064	0.887	0.086	.375
TQ→TC	0.238	0.196	3.545	0.067	***
TQ→MO	0.418	0.412	5.988	0.070	***
TQ→SI	0.194	0.243	2.975	0.065	.003
TC→PMP	0.254	0.253	3.249	0.078	.001
MO→PMP	0.492	0.214	5.099	0.096	***
SI→PMP	0.262	0.128	2.258	0.116	.024

Model Fit Indices: *CMIN = 224.419; DF = 107; CMIN/DF = 2.097; CFI = 0.941; TLI= 0.925; RMR = 0.063; RMSEA = 0.055; GFI = 0.935; AGFI = 0.907; PClose = 0.219*

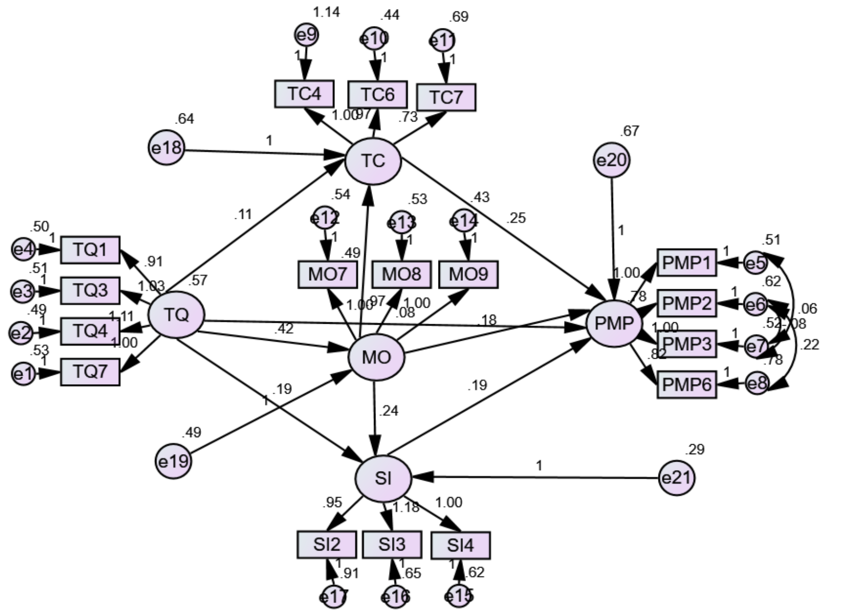
Note. *** ~ *P*-value significant at 1% (.01) ~ *P*-value significant at 5% (.05)

5.2.1. Direct effect of teacher quality on perceived mathematics performance

The unstandardized estimate for the path from teacher quality to perceived mathematics performance (TQ → PMP) is 0.076, indicating that a one-unit increase in teacher quality leads to a 0.076-unit increase in perceived mathematics performance on the original measurement scale. However, the standard error of 0.086 and a critical ratio of 0.887 indicate that this estimate is not statistically reliable. The relationship is not statistically significant (p = .375). The standardized path coefficient (β = 0.064) suggests a weak positive effect, implying that teacher quality does not have a significant direct effect on perceived mathematics performance. This finding contradicts previous research, which demonstrated a direct positive relationship between teacher quality and mathematics performance. Darling-Hammond (2000) meta-analysis discovered a significant correlation between teacher quality and student outcomes, including mathematics achievement.

These studies have shown that highly qualified and effective teachers, who exhibit expertise in instructional strategies, possess substantial content knowledge, and can deliver clear explanations and support to students, directly enhance students' mathematics performance.

Figure 3
Mediation Structural Paths



Extensive empirical research consistently supports a positive relationship between teacher quality and students' performance in mathematics. These findings provide empirical evidence supporting the direct effect of teacher quality on students' performance in mathematics. Recent research by Arthur et al. (2022) further indicated a significant positive effect of teacher quality on mathematics achievement. Additionally, teachers who cultivate positive teacher-student relationships and establish supportive learning environments have been found to have a significant positive influence on student mathematics accomplishment. The current study's finding of no direct positive effect of teacher quality on student mathematics achievement is notable and warrants further investigation to understand the potential reasons for this divergent result. While research findings may vary to some extent, the majority of studies have examined the relationship between teacher quality and student outcomes, particularly in the context of mathematics education.

However, high-quality teachers who possess strong content knowledge, pedagogical expertise, and effective instructional strategies are more likely to foster student learning and improve mathematics outcomes.

H1: Teacher quality has a direct effect on perceived mathematics performance was not confirmed.

5.2.2. Direct effect of teacher quality on technology

The unstandardized estimate for the path from teacher quality to technology (TQ → TC) is 0.238, indicating that a one-unit increase in teacher quality results in a 0.238-unit increase in technology use. The standard error of 0.067 and a critical ratio of 3.545 show that the estimate is statistically reliable. The relationship is statistically significant at the 1% level ($p < .01$). The standardized path coefficient ($\beta = 0.196$) indicates a moderate positive effect, suggesting that higher teacher quality is associated with increased integration of technology in learning. The finding is consistent with previous studies, which have consistently supported the notion that teacher quality affects student achievement in technology education (Johnson, 2019). Effective teachers with strong technological expertise, pedagogical skills, and the ability to create supportive learning environments can enhance students' abilities to use and understand technology, develop problem-solving skills, and foster creativity and innovation.

5.2.3. Direct effect of teacher quality on motivation

The unstandardized estimate for the path from teacher quality to motivation (TQ → MO) is 0.418, meaning that a one-unit increase in teacher quality leads to a 0.418-unit increase in students' motivation. The standard error of 0.070 and a critical ratio of 5.988 indicate strong statistical reliability. This relationship is statistically significant at the 1% level ($p < 0.01$). The standardized coefficient ($\beta = 0.412$) reflects a strong positive effect, demonstrating that teacher quality is a powerful predictor of students' motivation. Previous studies, including Ekmekci and Serrano (2022), have consistently supported the idea that teacher quality affects student motivation. High-quality teachers who possess effective instructional strategies, create supportive learning environments, and demonstrate enthusiasm and passion for teaching were found to significantly enhance student motivation levels. The study underscores the essential role of teacher quality in promoting student motivation. Teachers who possess effective instructional practices, create positive and supportive classroom environments, and establish strong connections with their students.

5.2.4. Direct effect of teacher quality on student interest

The unstandardized estimate for the path from teacher quality to interest (TQ → SI) is 0.194, indicating that improvements in teacher quality led to increased student interest. The standard error of 0.065 and a critical ratio of 2.975 confirm that the estimate is statistically reliable. The relationship is statistically significant at the 5% level ($p = .003$). The standardized coefficient ($\beta = 0.243$) suggests a moderate positive effect, indicating that teacher quality significantly enhances students' interest. The findings are consistent with previous studies, including Fauth et al. (2019), which have demonstrated that teacher quality has a direct positive effect on student outcomes. Highly effective teachers with strong pedagogical skills and subject matter expertise were able to significantly enhance student interest. The results of the current study highlighted a strong relationship between teacher quality and student interest. Teachers who fostered a positive and supportive classroom environment, used innovative instructional methods, and demonstrated enthusiasm for the subject matter were more likely to elicit and sustain student interest. Effective teachers who possess strong pedagogical skills, subject matter expertise, and a passion for teaching can significantly enhance student interest in the subject matter. By creating engaging learning experiences, connecting the subject matter to real-world contexts, and fostering positive relationships with their students, teachers can spark curiosity, motivation, and a desire to learn.

5.2.5. Direct effect of technology on perceived mathematics performance

The unstandardized estimate for the relationship between technology and perceived mathematics performance (TC → PMP) is 0.254, showing that a one-unit increase in technology use leads to a 0.254-unit increase in perceived mathematics performance. The standard error of 0.078 and a critical ratio of 3.249 indicate statistical reliability, and the relationship is significant at the 1% level ($p < .01$). The standardized coefficient ($\beta = 0.253$) reflects a moderate positive effect, highlighting the importance of technology in enhancing perceived mathematics performance. Previous studies, including Higgins et al. (2019) have consistently supported the findings of the current study, demonstrating that technology has a direct positive impact on student mathematics achievement. Technology-enhanced instructional approaches, such as computer-based simulations, interactive software, and online learning platforms, were found to significantly enhance students' knowledge and performance in mathematics (Higgins et al., 2019).

These researchers investigated various aspects of technology use, including digital tools, educational apps, and online resources. The findings highlighted a strong positive relationship between technology and mathematics performance.

5.2.6. Direct effect of motivation on perceived mathematics performance

The unstandardized estimate for the path from motivation to perceived mathematics performance

(MO → PMP) is 0.492, indicating that a one-unit increase in motivation leads to a 0.492-unit increase in perceived mathematics performance. The standard error of 0.096 and a critical ratio of 5.099 demonstrate strong statistical reliability. This relationship is statistically significant at the 1% level ($p < .01$). The standardized coefficient ($\beta = 0.214$) indicates a moderate positive effect, confirming that motivation is a significant predictor of perceived mathematics performance. Extensive research consistently supports the notion that motivation plays a significant role in student mathematics achievement (Arthur et al., 2022). In a meta-analytic review that synthesized findings from multiple studies, researchers found a consistent and direct positive impact of motivation on mathematics achievement. Students who demonstrate a strong desire to learn, set goals, and persist in their mathematical tasks tend to achieve higher levels of success in mathematics. Specifically, intrinsic motivation, which stems from internal factors such as interest and enjoyment, has been associated with positive mathematics performance outcomes. Students with high levels of motivation exhibited greater engagement, effort, and perseverance in their mathematics learning, leading to improved achievement outcomes (Arthur et al., 2022). This study underscores the vital role of motivation in influencing student mathematics performance.

5.2.7. Direct effect of student interest on perceived mathematics performance

The unstandardized estimate for the path from student interest to perceived mathematics performance (SI → PMP) is 0.262, suggesting that a one-unit increase in student interest leads to a 0.262-unit increase in perceived mathematics performance. The standard error of 0.116 and a critical ratio of 2.258 indicate that the estimate is statistically reliable. The relationship is statistically significant at the 5% level ($p = .024$). The standardized coefficient ($\beta = 0.128$) reflects a small but positive effect, indicating that student interest contributes meaningfully to perceived mathematics performance. This is in line with multiple studies (Boadu & Boateng; Koller et al., 2001) that have demonstrated positive influence of student interest on mathematics achievement, as it enhances attention, focus, and the ability to effectively internalize mathematical concepts. When students find mathematics interesting, they tend to pay closer attention to the content being taught, actively participate in class discussions, and demonstrate a higher level of concentration. This increased focus enables students to absorb and internalize mathematical concepts more effectively, resulting in improved achievement outcomes. Teachers can promote interest by incorporating engaging and interactive instructional strategies, providing opportunities for student choice and autonomy, and connecting mathematics to real-world contexts.

5.3. Mediation Analysis Using Bootstrapping

The study conducted a hypothesis path analysis to examine the mediating effects of technology, motivation, and student interest on the relationship between teacher quality and perceived mathematics performance. To rigorously test the indirect effects, the analysis employed bootstrapping, a non-parametric resampling technique recommended for mediation testing because it does not rely on the assumption of normality in the sampling distribution of the indirect effect. Bootstrapping was performed using 5,000 resamples and 95% bias-corrected confidence intervals. In this procedure, the original dataset is repeatedly sampled with replacement to create a large number of bootstrap datasets. For each resample, the mediation paths are estimated, producing a distribution of indirect effect estimates. The lower and upper bounds of the 95% bias-corrected confidence interval are then computed from this distribution. If the confidence interval for an indirect effect does not include zero, the mediation effect is considered statistically significant. Conversely, if zero lies within the interval, the mediation effect is deemed non-significant. This approach allows for a more accurate estimation of indirect effects, particularly when the sample size is moderate and the data may not meet normality assumptions.

H2 states that technology mediates the relationship between teacher quality and perceived mathematics performance. The analysis supported this hypothesis. As shown in Table 8, the bootstrapped standardized indirect effect of teacher quality on perceived mathematics performance through technology (TQ → TC → PMP) was $\beta = 0.095$, with a 95% bias-corrected confidence interval ranging from 0.041 to 0.168. Since zero does not fall within the confidence interval, the indirect effect is statistically significant. Although the direct effect of teacher quality on perceived mathematics performance was not statistically significant (β = 0.064, p = 0.375), teacher quality had a significant effect on technology, and technology had a significant effect on perceived mathematics performance. This pattern indicates that technology fully mediates the relationship between teacher quality and perceived mathematics performance. Therefore:

H2: Technology (TC) mediates the relationship between teacher quality (TQ) and perceived mathematics performance (PMP) was confirmed.

Table 8
Mediating Effect-Bootstrapped Indirect Effects (95% Bias-Corrected CI)

Mediation Path	*SE Effect (β)*	*LBC*	*UBC*	*TE*	*Decision*
TQ → TC → SMA	0.095	0.041	0.168	0.543	Significant
TQ → MO → SMA	0.071	0.036	0.182	0.498	Significant
TQ → SI → SMA	0.066	0.012	0.141	0.367	Significant

Note. SE: Standardized estimates; LBC: Lower bias corrected; UBC: Upper bias-corrected; & TE: Total effect .

H3 proposes that motivation mediates the relationship between teacher quality and perceived mathematics performance. The results from the bootstrapping analysis supported this hypothesis. The standardized indirect effect of teacher quality on perceived mathematics performance via motivation (TQ → MO → PMP) was β = 0.071, with a 95% bias-corrected confidence interval of 0.036 to 0.182. The absence of zero within the confidence interval confirms that the indirect effect is statistically significant. Given that the direct path from teacher quality to perceived mathematics performance was non-significant, while both the paths from teacher quality to motivation and from motivation to perceived mathematics performance were significant, the findings indicate full mediation. Hence:

H3: Motivation (MO) mediates the relationship between teacher quality (TQ) and perceived mathematics performance (PMP) was confirmed.

H4 states that student interest mediates the relationship between teacher quality and perceived mathematics performance. The bootstrapping results confirmed this hypothesis. The standardized indirect effect of teacher quality on perceived mathematics performance through student interest (TQ → SI → PMP) was β = 0.066, with a 95% bias-corrected confidence interval ranging from 0.012 to 0.141. As zero does not lie within the confidence interval, the indirect effect is statistically significant. Although the direct effect of teacher quality on perceived mathematics performance was not significant, teacher quality significantly predicted student interest, and student interest significantly predicted perceived mathematics performance. This indicates that student interest fully mediates the relationship between teacher quality and perceived mathematics performance. Therefore:

H4: Student interest (SI) mediates the relationship between teacher quality (TQ) and perceived mathematics performance (PMP) was confirmed.

6. Discussion

Teacher quality is a crucial factor that significantly influences student performance. Effective teaching can inspire and motivate students and create a supportive learning environment that facilitates academic success. However, the analysis revealed that teacher quality has no significant direct effect on perceived mathematics performance (β = 0.064, S.E. = 0.086, C.R. = 0.887, *p* = .375), indicating that its influence operates primarily through indirect pathways rather than direct impact. The findings of the present study revealed no significant direct influence of teacher quality on perceived mathematics performance, which is contrary to the initial hypothesis. This unexpected finding suggests that teacher quality alone may be insufficient to directly translate into improved mathematics achievement without the presence of enabling psychological and instructional mechanisms. From a theoretical perspective, this outcome aligns with motivation-based and socio-cognitive learning theories, which posit that teaching effectiveness often operates through students' internal processes rather than exerting an immediate direct effect on performance. However, the study finds significant indirect effects, indicating mediation through technology, motivation, and interest. These findings align with the hypothesis of indirect effects of teacher quality on perceived mathematics performance through these mediators.

This implies that the influence of teacher quality operates through how teachers engage students, motivate learning, and integrate instructional resources rather than through direct instructional delivery alone. However, the findings contradict some previous research, such as Arthur et al. (2022) and Sirait (2016), which emphasized the direct influence of teacher quality on students' performance in mathematics. These inconsistencies may be attributed to contextual differences and measurement approaches in educational systems, suggesting that the impact of teacher quality may depend on how teaching practices are enacted within specific learning environments. These conflicting findings highlight the complexity of the relationship between teacher quality and perceived mathematics performance and the importance of considering mediating factors.

The study also examined the mediating role of technology in the relationship between teacher quality and mathematics achievement. The analysis revealed an indirect effect coefficient of 0.095 for teacher quality on mathematics achievement through technology (TQ → TC → SMA). The lower bias-corrected and upper bias-corrected 95% confidence intervals ranged from 0.041 to 0.168, and the total effect was 0.543, indicating a significant mediation effect. Theoretically, this suggests that teacher quality may influence students' performance by shaping how effectively technology is integrated into instruction, even though the statistical evidence for the direct path was not significant. This finding underscores the importance of instructional technology as a mechanism through which teacher competencies may indirectly support learning outcomes. This suggests that teacher quality indirectly influences mathematics achievement through its effect on technology, which directly and positively impacts student performance.

Furthermore, the study estimated the mediating effect of motivation on the relationship between teacher quality and mathematics achievement. The analysis showed an indirect effect coefficient of 0.071 for teacher quality on student mathematics achievement through motivation (TQ → MO → SMA). The 95% bias-corrected confidence interval ranged from 0.036 to 0.182, and the total effect was 0.498, confirming a significant mediation effect. From a motivational theory standpoint, this pattern suggests that teacher quality may influence students' perceptions and learning climate, which in turn influence motivation, rather than directly affecting performance. The absence of a significant direct path may reflect contextual constraints rather than the absence of a meaningful theoretical relationship. This indicates that perceived teacher quality indirectly influences perceived mathematics performance through its impact on motivation (Froiland & Davison, 2016).

Finally, this study examined the mediating role of student interest on the relationship between teacher quality and perceived mathematics performance. The analysis revealed an indirect effect coefficient of 0.066 for teacher quality on student mathematics achievement through interest (TQ → SI → SMA). The lower and upper bias-corrected confidence intervals ranged from 0.012 to 0.141, and the total effect was 0.367, indicating significant mediation. This finding highlight student interest as a potential psychological pathway through which teacher quality may influence learning, suggesting that instructional practices that enhance relevance and engagement are critical for translating teaching quality into academic outcomes. Consistent with research reporting that student interest significantly predicts mathematics outcomes, positive perceptions and interest were found to play a meaningful role in the link between perceptual variables and achievement (Kaku & Arthur, 2025). This suggests that teacher quality indirectly influences perceived mathematics performance through its effect on student interest, which directly and positively impacts student performance (Asare et al., 2024). The significant indirect effects indicate that technology, motivation, and interest play crucial roles in mediating the relationship between teacher quality and mathematics achievement. These findings suggest that student interest functions as a psychological pathway through which aspects of teacher quality influence mathematics performance, highlighting the importance of learner engagement-related processes in instructional effectiveness. More specifically, enhanced student interest may facilitate the translation of instruction quality into improved academic outcomes, rather than a strictly direct effect from teacher quality alone, aligning with didactic perspectives that position engagement and motivational factors as central to learning (Oppong-Gyebi, 2023). Therefore, interventions that enhance the integration of technology in teaching, foster student motivation, and cultivate student interest in mathematics can potentially enhance the impact of teacher quality on student outcomes.

The findings of the study have several practical implications for educational practice. Firstly, the lack of a significant direct influence of perceived teacher quality on perceived students' mathematics achievement suggests that improving teacher quality alone may not lead to immediate improvements in student performance. This finding calls for a shift from viewing teacher quality as an isolated construct to understanding it as a catalyst that operates through instructional tools and learner-related factors. Instead, educators and policymakers should focus on understanding and leveraging the mediating factors identified in the study, such as technology, motivation, and interest. Additionally, our findings emphasize the importance of integrating technology in the classroom, as it mediates the relationship between teacher quality and mathematics performance. Educators should explore innovative approaches to leverage technology to enhance teaching and learning experiences. The study provides valuable insights into the complex relationships between teacher quality, technology, motivation, interest, and perceived mathematics performance.

While the direct influence of teacher quality on perceived mathematics performance was not significant, the mediating roles of technology, motivation, and student interest highlight avenues for further research and important considerations for educational practice. By offering theoretical explanations for the non-significant direct effect, this study contributes to a deeper understanding of how teacher quality functions within contemporary learning environments. By understanding these interrelationships, educators and policymakers can make informed decisions to promote effective teaching practices and enhance student learning in mathematics.

7. Conclusions

The results of this study suggest that the relationship between teacher quality and perceived mathematics performance is not direct but rather fully mediated by technology, motivation, and student interest. While teacher quality shows no direct effect on perceived mathematics performance, the significant indirect effects through technology, motivation, and student interest highlight the mechanisms through which teacher quality influences perceived mathematics performance. This finding aligns with self-determination theory and social cognitive theory, emphasizing that teacher quality primarily affects mathematics performance by shaping motivation, student interest, and technology. The mediating factors of technology integration, student motivation, and student interest all had significant positive effects on perceived mathematics performance, suggesting that interventions targeting these factors can amplify the impact of teacher quality on students' learning outcomes.

8. Recommendations

Based on the research findings, the following recommendations are proposed for the university's management: For policymakers, it is recommended to develop policies that prioritize the integration of technology in mathematics education and the fostering of student motivation and interest. Additionally, policymakers should allocate resources to support the implementation of these policies, including funding for teacher professional development and technology infrastructure. Given the non-significant direct effect of teacher quality, these interventions should focus on enhancing mediating factors rather than solely improving teacher quality in isolation. For educators, it is crucial to implement strategies that enhance student motivation and interest in mathematics, such as incorporating engaging and relevant learning activities.

Educators should also actively seek out opportunities for professional development to improve their skills in integrating technology and fostering student engagement. These approaches target the mediators identified in this study, thereby indirectly enhancing students' mathematics performance.

9. Limitations and Future Research Suggestions

This study has several limitations that warrant consideration when interpreting the findings. Firstly, the limited scope of the research, which focused on a single university and a specific geographic area, restricts the generalizability of the results. The findings may not be representative of the broader population of mathematics teachers and students, and caution should be exercised when attempting to apply these conclusions to other educational contexts or regions. Additionally, the cross-sectional nature of the data collection limits the ability to establish causal relationships between the variables. The study did not incorporate longitudinal data, which would have enabled researchers to observe the dynamic interplay between teacher quality, technology integration, student motivation, and mathematics achievement over time. Future research should also examine whether teacher quality has a direct effect on mathematics performance in other contexts or use longitudinal data to validate and extend the current findings, addressing the unexpected non-significant direct effect observed in this study. The lack of longitudinal analysis constrains the researchers' capacity to make inferences about the long-term impacts of the identified factors on student learning outcomes.

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Ethical approval: The authors stated that the study was approved by the Akenten Appiah-Menka University of Skills Training and Entrepreneurial Development Institutional Ethics and Research Committee with reference number AAMUSTED/IERC/2025/023. Written informed consent was obtained from heads of the departments and lecturers, as well as from students. The privacy and anonymity of the participants were respected.

Disclosure: Authors disclosed that all views and results of this study are only that of the authors.

Data sharing statement: Data supporting the findings and conclusions are available upon request from the corresponding author.

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