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The effect of the t-qual model on student's mathematics interest: Mediated by student's mathematics perceptions

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ABSTRACT

The study aimed to investigate the impact of the Teacher Quality Model (TQUAL-MODEL) on students' interest in mathematics, with a focus on the mediating role of students' perception of mathematics. A descriptive survey design was employed, targeting second and third-year students. Using a simple random sampling technique, questionnaires were administered to 300 students, yielding a complete dataset. The data were analyzed using a structural equation modeling approach with bootstrap samples. The findings revealed that students' perception of mathematics significantly and positively predicted their interest in the subject. Additionally, teacher empathy and teacher-student collaboration were identified as positive and significant predictors of mathematics interest. Furthermore, students' perception of mathematics partially mediated the relationship between teacher empathy and mathematics interest. Similarly, the relationship between teacher-student collaboration and mathematics interest was partially mediated by students' perceptions of mathematics.

Keywords: teacher quality, teacher empathy, teacher collaboration, students' perception, students' interest

INTRODUCTION

Mastering mathematics is challenging, as it requires addressing both cognitive and emotional factors that influence retention and achievement (Ni et al., 2018; Zuo et al., 2024). Research by Kaminski and Sloutsky (2020) and Ulandari et al. (2019) emphasizes that how students learn mathematics is as crucial as the material itself. Mathematics is not only vital for academic success but also for everyday life, as it is used by various professions, such as farmers, carpenters, and homemakers, often without conscious recognition. Mathematics supports advancements in science, the humanities, creativity, and numerous practical applications, such as administration, security, and technology development (Onoshakpokaiye, 2025). Its importance is reflected in how students' satisfaction with the subject is considered a measure of an institution's and a nation's intellectual health. In the modern scientific and technological era, mathematics influences every facet of life, from fundamental and applied sciences to engineering and technology, underscoring its universal relevance (Alam & Mohanty, 2024).

Mathematical abilities are applied in various fields, such as painting, music, management information systems, traffic control, and accounting, in addition to science and technology (Liston et al., 2022). Recognizing its significance, the Nigerian government made mathematics a compulsory subject at both the primary and secondary school levels, as stated in the national education policy (Olibie et al., 2017). Olibie et al. (2017) emphasized that mathematics forms the foundation for all legitimate scientific advancements. Bae (2025) also highlighted the importance of mathematics across various domains, including the arts, social sciences, business, and personal affairs, noting how it has contributed to developments in geometry, trade, and war-related innovations.

Mathematics is essential for academic success and achieving national goals (Jacob et al., 2017). Teacher quality is widely acknowledged as the most significant school-related factor affecting student performance (Paz, 2021). Schools play a crucial role in equipping individuals with knowledge, skills, and values needed to become productive citizens and realize their full potential (Wong & Wong, 2019). Dimosthenous et al. (2020) emphasizes that effective teachers enhance both short-term academic performance and long-term life quality. According to Snoek (2021), the knowledge and skills of teachers are critical to student learning, making teacher quality a key determinant. Sultanova et al. (2024) further asserts that the impact of teachers on student success is undeniable. **Figure 1** illustrates the conceptual framework of the study. From **Figure 1**, TE and TC are the independent variables, SPM is the mediating variable, and STD_INT is the dependent variable.

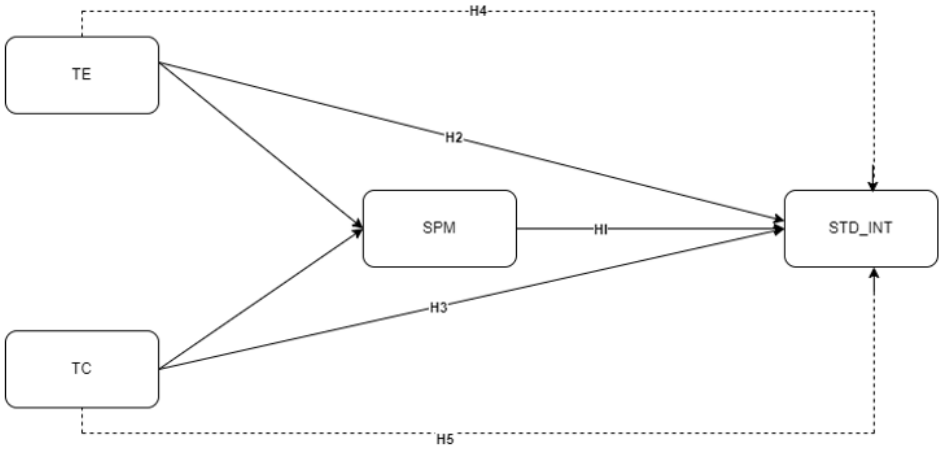

Figure 1. Conceptual framework (Source: Authors' own elaboration)

Fosu et al. (2022) assert that teacher quality significantly influences students' academic success, with teachers' academic background and experience playing crucial roles. Effective teaching enhances both short-term academic performance and long-term life quality (Ji et al., 2022). While empirical data supports this claim, the specific traits that contribute to student success remain unclear. Meyers et al. (2019a) identify several factors impacting student performance, including teacher empathy, responsiveness, and reliability. Furthermore, mathematics is recognized as essential for developing competent, efficient, and logical thinking (Lithner, 2017), which is why it is mandatory in West African educational systems, including Ghana's, from primary to postsecondary levels. Given this, educational scholars emphasize the need to enhance students' mathematical competencies and problem-solving skills. As a result, math teachers have developed strategies to identify and manipulate variables that can improve performance, while addressing those that hinder student progress. Consequently, governments have implemented various initiatives to boost senior high school students' mathematical performance.

Despite government efforts, there has been little improvement in mathematics performance among Senior High School (SHS) students, with consistently low results. The 2021 WASSCE Chief Examiner's Report revealed an 11% decline in the percentage of students passing mathematics compared to the previous year, with 65.71% achieving grades A1 to C6 in 2020, dropping to 54.11% in 2021 (WAEC, 2021). Factors related to schools are likely contributing to this poor performance in mathematics (Chand et al., 2021). This situation is concerning, as many SHS students continue to struggle with mathematics and perform poorly on their final exams. In contrast, students' interest in mathematics has been linked to their success in the subject. This issue has created significant distress for students, parents, and other educational stakeholders. Teaching quality, identified by instructional analysts and policymakers, is crucial to achieving the goals of the Instruction Plan 2030 (SGD 4).

The underperformance in mathematics can be attributed to several factors, prompting academics to develop strategies to improve student achievement. Research has highlighted that student perceptions, interest, and the quality of instruction are crucial for mathematics success. For instance, studies suggest that factors such as teaching quality and school-related mechanisms contribute significantly to enhancing students' math achievement (Chand et al., 2021). Student interest in mathematics is defined as an awareness of one's abilities, limitations, intellectual state, and self-esteem (Asare & Boateng, 2025b). Holenstein et al. (2022) emphasized that students' self-concept greatly influences their academic success, with effort in learning mathematics playing a critical role in shaping their perception of academic achievement. Teaching quality has also been found to strongly impact academic performance, with Xhaferi (2024) noting its significance. Boniface (2019) revealed that teaching quality directly influences math performance by 18.5%, further confirming the strong connection between the two. Tymms et al. (2018) argued that effective teaching leads to long-term improvements in students' academic outcomes, making teacher quality a key factor in advancing student achievement and narrowing performance gaps. Given these insights, the study aimed to explore the impact of the teacher quality model on student mathematics interest, with student perceptions serving as a mediator. The findings suggest that improving teacher quality can positively influence students' interest and success in mathematics.

Statement of Problem

The success of any academic program largely depends on the teacher, who plays a central role in implementing the curriculum. Research has shown that students' poor performance in mathematics is often linked to teachers' inability to effectively deliver math education (Abreh et al., 2018). Numerous studies have explored the relationship between teacher quality and students' mathematics interest and performance. For example, Dimosthenous et al. (2020) highlighted the significant impact of math teachers' effectiveness on student performance. Arthur et al. (2017) found that teacher quality plays a moderating role in the relationship between students' mathematics achievement and their interest in the subject, showing that both teacher quality and student interest significantly influence math performance. Further, Arthur et al. (2018) confirmed that the quality of a math teacher positively affects students' interest in the subject. However, previous studies have not explored the specific teacher characteristics that influence students' math performance and interest. To address this gap, the current research investigates the impact of teacher empathy and teacher collaboration on students' interest in mathematics, with students' mathematics perception as a mediating factor.

Purpose of the Study

The purpose of this research was to determine the effects of the T-Qual model on students' mathematics interests mediated by students' mathematics perceptions.

Research Objectives

1. Identifying the effects of students' perception on their mathematics interest
2. To determine the effect of teacher empathy on students' interest in mathematics
3. To determine the effect of teacher collaboration on students' interest in mathematics
4. To examine the mediating outcome of students' perception of mathematics in the relationship between teacher empathy and students' interest in mathematics
5. To examine the mediating outcome of students' perception of mathematics on the relationship between teacher collaboration and students' interest in mathematics.

Research Questions

RQ1 What ffect does students' perception of mathematics has on their interest in mathematics?

RQ2 What is the effect of teacher empathy on students' interest in mathematics?

RQ3 Does teacher collaboration have an effect on students' interest in mathematics learning?

RQ4 What is the mediating effect of students' perception of mathematics on the relationship between teacher empathy and students' interest in mathematics?

RQ5 What is the mediating effect of students' perception of mathematics on the relationship between teacher collaboration and students' interest in mathematics?

LITERATURE REVIEW

Teacher Collaboration and Student's Mathematics Interest

Teacher collaboration has increasingly been recognized as a powerful tool in improving instructional practices and fostering positive student outcomes, including interest in mathematics. Collaborative teaching practices such as co-planning lessons, joint reflection, peer mentoring, and sharing of pedagogical strategies lead to a more coherent and student-centered learning environment (Vangrieken et al., 2017). When mathematics teachers work together, they are better able to design engaging tasks that are contextually relevant and cognitively demanding, which has been shown to increase students' intrinsic motivation and interest (Ronfeldt et al., 2018). These collaborative efforts also help teachers differentiate instruction and apply culturally responsive pedagogy, allowing students from diverse backgrounds to connect more meaningfully with mathematical content (Cavanna et al., 2021).

Empirical studies have demonstrated that students taught by teachers who engage in frequent collaboration report higher levels of interest in mathematics. For instance, Kılınç and Yıldırım (2018) found that teacher collaboration positively influenced students' classroom engagement and interest by enhancing teachers' instructional efficacy and classroom management. Similarly, a longitudinal study by Yoon and Kim (2020) revealed that professional learning communities that encourage sustained collaboration among math teachers led to increased student enthusiasm and participation in mathematical problem-solving activities. Collaborative environments not only improve pedagogical alignment but also contribute to teacher well-being, which indirectly benefits students through more enthusiastic and committed teaching (Lomos et al., 2017).

Moreover, research within Sub-Saharan African contexts, including Ghana and Kenya, indicates that teacher collaboration tailored to localized educational challenges can significantly boost students' affective responses to mathematics. Owusu et al. (2022) noted that mathematics departments that fostered structured peer collaboration among teachers, through peer observations and shared reflections, reported greater student interest and confidence in mathematics. The integration of collaboration with targeted professional development has been particularly impactful in transforming classroom practices from traditional lecture models to more interactive and inquiry-based approaches (Nyarko & Amponsah, 2023). Thus, teacher collaboration emerges as a pivotal factor not only in promoting teacher growth but also in cultivating students' sustained interest in mathematics.

Teacher Empathy and Student's Mathematics Interest

Teacher empathy, defined as the ability of educators to understand and share the feelings of their students, plays a pivotal role in shaping the affective dimensions of learning, including interest in subjects like mathematics. Empirical research underscores that empathetic teachers create psychologically safe learning environments, which reduce student anxiety and foster a positive attitude toward learning (Meyers et al., 2019b). In the context of mathematics, a subject often associated with fear and anxiety, teacher empathy becomes particularly significant. When students perceive their teachers as understanding and supportive, they are more likely to engage meaningfully with mathematical content and develop sustained interest (Wahono et al., 2020). The relational approach of empathetic teachers nurtures student-teacher trust, allowing learners to take academic risks and explore mathematical ideas without fear of judgment or failure (Keller et al., 2021).

Several studies support the link between teacher empathy and students' interest. For example, Frolova and Tsevreni (2018) found that students taught by empathetic mathematics teachers exhibited significantly higher levels of engagement and curiosity toward math topics. Similarly, a longitudinal study by Liu et al. (2022) indicated that teacher-reported empathy was positively correlated with student-reported interest in mathematics, with teacher empathy serving as a buffer against disengagement in low-performing students. These studies suggest that teacher empathy promotes a sense of belonging and emotional security in the classroom, which are critical for fostering intrinsic interest in mathematics. Moreover, empathetic interactions, such as attentive listening, personalized feedback, and culturally responsive teaching, were found to be associated with higher student motivation and math task persistence (Santagata et al., 2020).

The growing body of literature affirms that teacher empathy is not only a soft skill but a pedagogical asset with a measurable impact on students' interest in mathematics. Incorporating empathy into teacher training programs may help educators develop affective and communication skills that encourage math curiosity and sustained engagement. Scholars like Davis and Summers (2023) advocate for integrating socio-emotional learning frameworks into mathematics instruction, highlighting the bidirectional relationship between emotional support and academic interest. Future research may explore how digital environments can support empathetic teacher-student interactions in mathematics learning, especially in post-pandemic hybrid classrooms. Overall, teacher empathy emerges as a key lever in reforming mathematics education by humanizing instruction and promoting student-centered learning climates that naturally foster interest and achievement.

METHODS

This study adopts the positivist research paradigm, which is grounded in deductive logic and focuses on quantifiable results. The study aligns with the four key assumptions of positivism outlined by Cohen et al. (2007):

1) Determinism,
2) Empiricism,
3) Parsimony, and
4) Generalizability.

These assumptions guide researchers in deriving meaningful conclusions. The research employed a descriptive survey method, which is used when the goal is to characterize the attitudes, opinions, behaviors, perceptions, or characteristics of a sample, as described by Peedikayil et al. (2023). This method involves collecting data through a questionnaire administered to the sample at a specific point in time.

Population of the Study

Ingleby (2012) define a population as a group of individuals or instances—such as people, things, or events, that share certain characteristics and to which research conclusions are applied. The study's population consisted of all Form Two and Form Three students from Sefwi Wiawso SHS, Saint Joseph SHS, and Sefwi Wiawso SHTS in the Sefwi Wiawso Municipality. The target population included students enrolled in General Arts, Home Science, and General Science programs, totaling 1,200 students across these schools.

Sample Size

A research sample, according to Moser and Korstjens (2018), is a population that actively participates in a study and is the subject of data collecting. The sample size for the current study was calculated with the used of Miller and Brewer's (2003) advice, who offered a formula for figuring out the ideal sample size for each survey design.

This is illustrated as:

$$n = \frac{N}{1 + Ne^{2r}} \tag{1}$$

when n is the sample size, N is the population size and e is the error (0.05) reliability level of 95%:

$$n = \frac{1200}{1 + 1200(0.05)^2} = 300 \tag{2}$$

Three hundred (300) students were chosen to complete the surveys were all chosen. The questionnaires were created to provide information on the research questions that the study is trying to address.

From **Table 1**, out of three hundred (300) students', 40.3% represents male students and 59.7% represents female students. Moreover, 17.3% represents the age range from eleven (11) years to fifteen (15) years. 79.3% represents the age range from sixteen (16) years to twenty (20) years. 3.0 representing the age range from twenty-one (21) years to twenty-five (25) years. And 0.3% representing the age of twenty-six (26) years or above. In addition, 93% were Christians. 5.7% were Muslim, 1% representing Traditionalist, and o.3% representing other believe. According to their level of education, 51.3% were form one (1) student's and 48.3% were for three (3) students. Finally, 33.3% of the students were General Science students, 48% of the students were General Arts students and 18.7% of the students were Home Science students.

Table 1. Demographics respondent of students

Demographics	Frequency	Percentage
Gender	300	100.0
Male	121	40.3
Female	179	59.7
Age	300	100.0
11-15 years	52	17.3
16-20 years	238	79.3
21-25 years	9	3.0
26 years or above	1	0.7
Religion	300	100.0
Christianity	279	93.0
Muslim	17	5.7
Traditionalist	3	1.0
Others	1	0.7
Level of Education	300	100.0
Form 2	154	51.3
Form 3	146	48.7
Program of study	300	100.0
General Science	100	33.3
General Arts	144	48.0
Home Science	56	18.7

Sampling Techniques

The current study used two sampling approaches, that is stratify and simple random sampling. Firstly, the study used stratified sample technique to classified the students according to their classes and course of study. After that, sample random sampling technique was employed to select respondents from each stratum.

Questionnaires and Measures

The study used structured questionnaires, adapted from an existing instrument, to collect data on students' mathematics perception, interest, and teacher quality (see **Appendix A**). Questionnaires were chosen for their efficiency in gathering data from large groups while ensuring confidentiality and anonymity. The instrument was based on modified versions of tools from Arthur et al. (2022), Sedán et al. (2020), and Asare and Boateng (2025a). The questionnaire consisted of 52 closed-ended items, divided into five sections corresponding to the research questions. Section A collected students' biographical data, while Sections B to F addressed the main variables. These sections focused on students' interest in mathematics (B), students' perception of mathematics (C), teacher empathy (D), teacher responsiveness (E), and teacher quality (F). Responses were measured on a 5-point Likert scale (ranging from Strongly Agree to Strongly Disagree), which is widely regarded as an effective tool for assessing attitudes and perceptions (Heuvelink & Webster, 2001).

Data Collection Procedure

The researcher personally distributed 300 questionnaires to students from three schools after obtaining permission from the school authorities. An introductory letter from the researcher's department was sent to the schools to request approval, and a suitable time was arranged with the authorities. Upon receiving consent, the researcher administered the questionnaires to the teachers, who then distributed them to the students. The respondents independently completed the structured, closed-ended questionnaires, as they were all capable of reading and understanding the questions.

Data Analysis

To ascertain whether the data analysis model is suitable for the intended use, preliminary analysis is performed. Exploratory manufacturing analysis was utilized to determine the quantity of observed variables loading on their accurate notion. Confirmatory factor analysis, reliability analysis, and discriminant validity were used to further evaluate the model's fitness.

Exploratory Factor Analysis

Exploratory Factor Analysis (EFA) is a statistical technique used to identify underlying latent factors that explain the correlation patterns among observed variables. Commonly applied in psychometrics and data analysis, EFA serves as a dimensionality reduction method, simplifying complex data by grouping highly correlated variables while minimizing correlations between different groups (Marsh et al., 2020) and Asare and Boateng (2025a). The goal is to uncover the underlying structure of a dataset and highlight the key factors driving the observed patterns. In this study, EFA was conducted using SPSS (ver. 23), examining how observed variables load onto their corresponding latent variables. Variables that did not align with the appropriate latent factor were reduced or removed. The final results are presented in **Table 2**, showing the alignment between observed variables and their respective latent factors.

The analysis results in **Table 2** show the number of observable variables loaded onto their corresponding latent variables. Variables with factor loadings above 0.5 were retained for further analysis, while those below this threshold were removed. For students' interest in mathematics, four out of ten measurement items had strong loadings, and six were discarded. For teacher

Table 2. Exploratory factor analysis (EFA)

Rotated component matrix				
Measurement items	Component			
	1	2	3	4
SMP2				.815
SMP4				.821
SMP5				.846
SIM3		.802		
SIM5		.837		
SIM6		.857		
SIM7		.756		
TE1			.914	
TE2			.910	
TE3			.907	
TC2	.878			
TC3	.875			
TC4	.883			
TC5	.877			
KMO and Bartlett's test				
Total Variance Explained			81.148%	
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.			.859	
Bartlett's Test of Sphericity		Approx. Chi-Square	3116.288	
		Df	91	
		Sig.	0.000	
Determinant			2.448E-5	

Table 3. Confirmatory factor analysis (CFA)

Model fit indices: CMIN = 124.355; DF = 67; CMIN/DF = 1.856; TLI = .975; CFI = .981; RMSEA = .054; RMR = .0336; PClose = .331	**Factor loadings**
Teacher Empathy (TE): CA = .922; CR = .922; AVE = .798	
TE1: Mathematics teachers do offer individual attention to students.	.906
TE2: Mathematics teachers have students' best interests at heart.	.902
TE3: Mathematics teachers understand students' mathematics learning challenges and needs.	.872
Teacher Collaboration (TC): CA = .925; CR = .925; AVE = .756	
TC2: Mathematics teachers work together with students in problem solving.	.860
TC3: Mathematics teachers assign roles to students in mathematics learning.	.869
TC4: Mathematics teachers discuss a course unit by giving a student's task to complete.	.887
TC5: Mathematics teachers share authority among students.	.863
Students' Perception in Mathematics (SPM): CA = .891; CR = .891; AVE = .732	
SPM2: Mathematics is abstract and boring.	.836
SPM4: There are so many formulas in mathematics.	.889
SPM5: Mathematics is full of rules and procedures.	.841
Students' Interest in Mathematics (Sim): CA = .886; CR = .888; AVE = .665	
SIM3: I do not often get confused in mathematics lessons.	.796
SIM5: I wish I had not met mathematics anymore during my further studies.	.873
SIM6: I like to persist in solving mathematics problems even if I am not readily able to solve them.	.859
SIM7: Attending math lessons is exciting for me.	.726

empathy, three out of ten measurement items met the threshold, with seven discarded due to poor loading. Similarly, for teacher collaboration, three out of seven measurement items had strong loadings, and six were removed. The Kaiser-Meyer Olkin (KMO) Measure of Sampling Adequacy was 0.859, indicating that 85.9% of the variance in observable variables was appropriately explained by the latent variables. Bartlett's Test of Sphericity yielded a significant result (Chi-square = 3116.288, df = 91, p = 0.000). The exploratory factor analysis (EFA) showed that the four latent variables explained a cumulative variance of 81.148%. Any variables misallocated in the rotated component matrix were removed. The final EFA results are presented in **Table 2**, with variables properly aligned to their respective latent constructs.

Confirmatory Factor Analysis

Confirmatory Factor Analysis (CFA) is a statistical technique used in psychometrics and social sciences to assess the reliability of a measurement model. It is a type of Structural Equation Modeling (SEM) that tests whether observable variables support a hypothesized structure of latent (unobserved) variables. CFA involves theoretical models proposed by researchers, where latent variables influence the observed variables, even though they cannot be directly measured. The main goals of CFA are to assess the model's fit to the data and determine if the data support the proposed structure. In this study, the CFA results showed that for teacher empathy, 10 observed variables were initially identified, but 7 were deleted due to poor factor loadings, leaving 3 with good loadings. For teacher collaboration, 10 variables were proposed, but 6 were deleted, leaving 4 with good factor loadings. In the case of students' perception of mathematics, 10 observed variables were considered, but 7 were deleted, leaving 3 with good

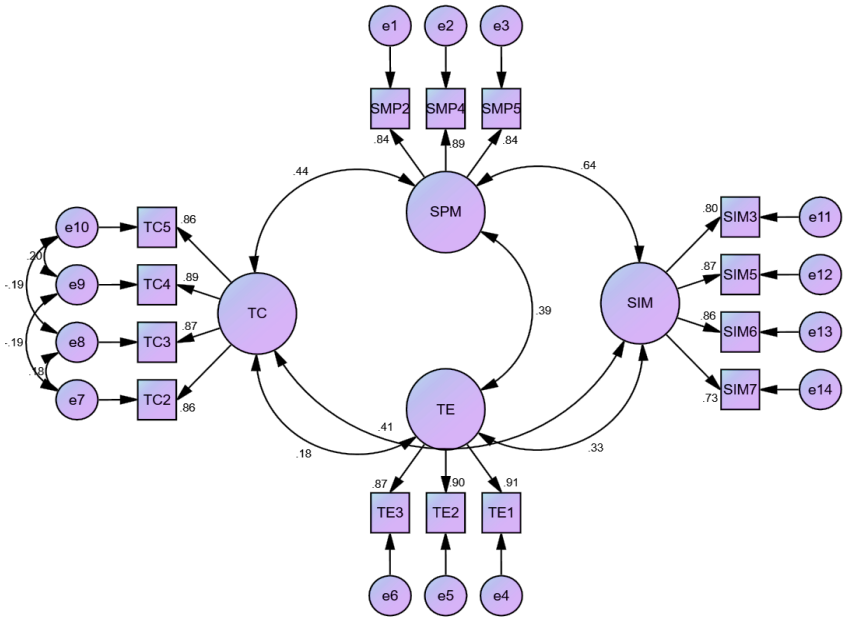

Figure 2. Conceptual framework (Source: Authors' own elaboration)

Table 4. Cronbach's alpha analysis

Variables	Number of items	Cronbach's alpha value
TE	3	.922
TC	4	.925
SPM	3	.891
SIM	4	.886

Table 5. Discriminant analysis

Variables	SPM	TE	SIM	TC
SPM	**.856**			
TE	.388***	**.893**		
SIM	.639***	.334***	**.815**	
TC	.443***	.185***	.408***	**.870**

***~p-value significant at 1% (0.01)

loadings. Similarly, for students' interest in mathematics, 10 observed variables were initially included, but 6 were deleted, leaving 4 with good factor loadings. **Figure 2** illustrates the graphical section of the confirmatory factor analysis (CFA).

Bamfo et al. (2018) assess the model fit of confirmatory factor analysis (CFA) using key indices: CMIN/DF, RMR, RMSEA, CFI, and TLI. They suggest that CMIN/DF should be less than 3, RMR and RMSEA should not exceed 0.08, and CFI and TLI should be at least 0.9. Dogbe et al. (2023) and Asare et al. (2024) highlight that RMR and RMSEA indicate how much the model deviates from hypothesized values, while CMIN reflects the degree of disagreement. TLI and CFI values are based on the normal theory of continuous data. Additionally, the PClose value must be greater than 0.05 to indicate statistical insignificance. In the study, the CFA model showed a CMIN/DF of 1.856, RMR of 0.0336, and RMSEA of 0.054 (see **Table 3**). The PClose value was 0.331, exceeding the 0.05 threshold. CFI and TLI values were both above 0.9, at 0.975 and 0.981, respectively. These model fit indices align with Shek and Yu (2014) recommendations, confirming that the data is suitable for further analysis.

Reliability Analysis

Reliability analysis was conducted using Cronbach's alpha in SPSS (ver. 23) to assess the internal consistency of the latent variables in the study. As summarized in **Table 4**, the reliability coefficients for student perception of mathematics, student involvement in mathematics, teacher empathy, and teacher collaboration were .922, .925, .891, and .886, respectively. All coefficients exceeded the minimum acceptable value of 0.6, indicating strong reliability for the constructs used in the analysis.

Discriminant Validity

In order to objectively analyze the convergent validity and reliability of the final observed variables that estimate the CFA, Average Variance Extracted (AVE) and Composite Reliability (CR) were discovered. According to Trochim and Donnelly (2006) and Asare and Larbi (2025), convergence validity assesses how closely two observable variables correlate with each other when applied to the same notion. The AVE and CR must each have an expected value of at least 0.5 and 0.7, respectively. The AVE and CR were calculated in order to further analyze the study and achieve convergence validity. The results support Otoo et al. (2021) and Asare et al. (2025) AVE and CR requirements with an AVE of 0.665 and a CR of 0.888, respectively. **Table 5** presents the discriminant analysis results for the study.

Table 6. Summary of direct effect results

Direct effect	Estimate	S.E.	C.R.	P-value
Gender → SIM	.132	.099	1.340	.180
Age → SIM	-.071	.109	-.654	.513
Religion → SIM	.081	.140	.581	.561
Level → SIM	.002	.039	.054	.975
Program → SIM	.032	.069	.463	.643
TC→ SPM	.418	.066	6.291	< 0.01
TE→ SPM	.287	.050	5.755	< 0.01
TC → SIM	.188	.066	2.841	.004
TE → SIM	.108	.052	2.095	.036
SPM →SIM	.559	.075	7.483	< 0.01
Indirect effect	Std. estimate	Lower BC	Upper BC	P-value
TE→ SPM→ SIM	.170	.040	.530	.035
TC→ SPM→ SIM	.162	.021	.073	.017

RESEARCH RESULTS

Path analysis was conducted to examine the impact of independent factors on the dependent variables, specifically how gender, age, religious affiliation, educational level, and program of study influenced students' interest in mathematics. **Table 6** presents the results of the path analysis, highlighting the direct effects of these factors. The analysis helps clarify the relationships between independent and dependent variables, supporting existing theoretical frameworks. This was carried out using Amos' Structural Equation Modeling (SEM) version 23.

Table 6 presents the following results: Students' gender had a positive but statistically insignificant effect on their interest in mathematics ($p = 0.132$; CR = 1.340). Similarly, students' age showed a negative but insignificant impact on their interest in mathematics ($p = 0.654$; CR = -0.071). Religious affiliation also had a positive but statistically insignificant effect ($p = 0.581$; CR = 0.081). The students' educational level showed a favorable but insignificant effect on mathematics interest ($p = 0.054$; CR = 0.002). The course of study also had a positive but statistically insignificant effect on mathematics interest ($p = 0.463$; CR = 0.032). However, teacher collaboration significantly positively influenced students' perception of mathematics ($p < 0.01$; CR = 6.291), and teacher empathy had a significant positive effect on students' perception of mathematics ($p < 0.01$; $\beta = 0.287$; CR = 5.755).

RQ1 What Effect does Students' Perception of Mathematics Have on Their Interest in Mathematics?

To find out how students' perceptions of mathematics affect their interest in the subject, research question one (1) looked at this. By analyzing (SPM SIM), it was possible to determine the direct impact of students' perception on students' interest in mathematics. According to the analysis's findings (**Table 6**), students' perceptions of mathematics had a direct positive effect and a statistically significant effect on their interest in the subject, with a p-value of less than 1% ($\beta = .559$; CR = 7.483). The findings also demonstrate a favorable effect of students' perceptions of mathematics on their interest in mathematics, which is estimated to be 55.9%.

RQ2 What is the Effect of Teacher Empathy on Students' Interest in Mathematics?

The purpose of the research question was to ascertain the impact of teacher empathy on students' mathematics interests. (TE SIM) was used to analyze the direct impact of teachers' empathy on students' interest in mathematics for learning, and the results show a statistically significant relationship between teachers' empathy and students' interest in mathematics with a p-value of less than 5% (= .287; CR = 5.755). This explains why teacher empathy has a favorable effect on students' interest in mathematics by roughly 28.7%.

RQ3 Does Teacher Collaboration Have an Effect on Students' Interest in Mathematics Learning?

The goal of the research question is to ascertain how teacher collaboration affects students' interest in mathematics. (TC→ SIM) was used to examine the direct impact of teacher collaboration on students' interest in mathematics. The analysis of **Table 6**'s data reveals that teacher collaboration has a direct, favorable effect on students' interest in mathematics with a p-value of less than 1% ($\beta = .188$; CR = 2.095). The outcome further explains that there was an 18.8% positive effect of teacher empathy on students' interest in mathematics.

RQ4 What is the Mediating Effect of Students' Perception of Mathematics on the Relationship between Teacher Empathy and Students' Interest in Mathematics?

Table 6 shows that there is a statistically significant direct relationship between students' perception of mathematics and their interest in the subject. The indirect effect, which examines the role of teacher empathy, students' perceptions of mathematics, and their interest, was assessed using **Table 6** (TE SPM SIM). A bootstrap method with 5000 samples was used in structural equation modeling (AMOS version 23) to determine the mediating effect. For the indirect effect to be considered significant, the lower and upper bounds of the bootstrap samples must have the same sign (either positive or negative) and not include zero. The results revealed a statistically significant indirect effect, with the lower and upper bounds ranging from 0.040 to 0.530. This indicates that students' perceptions of mathematics positively mediate the relationship between teacher empathy and

students' interest in mathematics, as all bounds were positive. Furthermore, the findings suggest that students' perceptions of mathematics account for 68% of the influence of teacher empathy on students' interest in mathematics. This highlights the partial mediation of students' perceptions in the relationship between teacher empathy and their interest in the subject.

RQ5 What is the Mediating Effect of Students' Perception of Mathematics on the Relationship between Teacher Collaboration and Students' Interest in Mathematics?

Table 6 shows a statistically significant direct relationship between student engagement in mathematics and teacher cooperation, as well as between student perception of mathematics and student interest in mathematics. To explore the indirect effects among these variables, student perception of mathematics, teacher collaboration, and student interest. **Table 6** was used for path analysis. A bootstrap of 5000 samples was performed using Amos (ver. 23) to evaluate the mediating impact. For the indirect effect to be significant, the lower and upper bounds must both have the same sign (positive or negative) and exclude zero. The results in **Table 6** confirmed a significant indirect effect of student perception of mathematics. The lower bound and upper bound for the indirect effect were 0.021 and 0.073, respectively, both positive, indicating that student perception of mathematics mediates the relationship between teacher collaboration and student interest in mathematics. Additionally, teacher collaboration was found to influence 16.2% of students' engagement in mathematics, with students' perceptions playing a partial mediating role in the relationship between teacher empathy and student interest in mathematics.

DISCUSSION OF RESULTS

The Effect of Student's Perception on Their Mathematics Interest

Student perception is one of the crucial components for success in mathematics, according to several practitioners and experts. According to the analysis that was done, the perception of mathematics was statistically significant, which lends credence to a number of texts and acts as a literary contribution. As an illustration, Arthur et al. (2018) The study looked at how student perception affects, among other things, students' interest in mathematics. They came to the conclusion that the perception of mathematics and interest in mathematics were strongly correlated. Deng et al. (2020) Conducted research to determine the relationship between senior high students' perceptions of mathematics and their academic achievement overall at the pre-tertiary level. The study's findings revealed an important relationship between students' perceptions of mathematics and academic achievement. This research on the immediate effects of students' perceptions of mathematics was helpful.

Teacher Empathy on Mathematics Interest

According to Ledley et al. (2021) students who are enrolled in mathematics classes believe their instructions are given immediately and have a higher beneficial effect on their teacher and the subject matter of mathematics. Additionally, Sedán et al. (2020) Examined how sensitive senior high school teachers are to mathematical material in play-based contexts. Once more, Koh et al. (2017) Found that correlations between teacher empathy, students' interest in mathematics, and their learning results were mediated by students' mathematics achievement emotions. In their research, Fragkaki et al. (2020) Discovered that female students' arithmetic performance is significantly impacted by their teachers' empathy. According to a study by Gulnaz and Fatima (2019) students' interests in mathematics are positively and significantly impacted by teacher empathy in mathematics instruction. According to Heck (2009) teachers who exhibit empathy toward their students foster a safe and encouraging emotional environment in the classroom.

Teacher-Students Collaboration on Students' Mathematics Interest

Collaboration between teachers and students has been shown in numerous studies to positively affect students' interests in mathematics. According to the current study, student interest in mathematics increased as a result of teacher-student collaboration and was statistically significant. Additionally, Abdul-Mutalib et al. (2015) discovered that teacher collaboration significantly affects kids' interest in mathematics and Junior Secondary Mathematics performance. A study on the effect of student-teacher relationships on academic achievement was done by Appiah et al. in the year 2023. The results of their study showed that the student-teacher interaction significantly improves students' academic performance. By giving students the chance to critically reassess how they draw conclusions from facts, collaborative activities can increase students' knowledge of mathematics. Fleener et al. (2002). According to Le et al. (2018) the interaction between teachers and students has no discernible impact on students' interest in and achievement in mathematics. Additionally, according to Huang et al. (2020). Working with teachers creates a good and encouraging learning environment. Together, instructors can foster a climate in the classroom that values cooperation, taking calculated risks, and learning from errors.

The mediating outcome of students' perception of mathematics in the relationship between teacher empathy and students' interest in mathematics

Additionally, the mediating analysis (indirect path) effect was a major emphasis of this study. A p-value of less than 1% was obtained for the student perception acting as the mediating factor of the teaching quality. The outcome demonstrates that there is a positive relationship between student perception of mathematics as a mediator that influences the relationship between teacher empathy and students' interest in mathematics, with all lower-bound and upper-bound values being positive. The results also showed that, through students' perceptions of mathematics, there is a 68% influence of teacher empathy on students' interest in mathematics. This demonstrates that the relationship between students' interest in mathematics and teachers' empathy is somewhat mediated by students' perceptions of mathematics. This had a 55% confidence interval, and it was

statistically significant. This explains why interest in mathematics was mediated by teaching quality. This research confirms the findings of Arthur (2019), who found that mathematical interest had an indirect impact on student performance when compared to peer-assisted learning, motivation, and teaching quality. They come to the conclusion that there was a strong indirect impact of mathematics interest on each of these variables, which partially mediated the relationship between the variables used to predict students' performance.

The mediating outcome of students' perception of mathematics in the relationship between teacher collaboration and students' interest in mathematics

The current study reveals that the relationship between teacher-student interactions and students' interest in mathematics is significantly mediated by collaborative learning. Specifically, cooperative learning partially mediates this relationship, meaning both the direct and indirect effects of teacher-student interactions on mathematics interest are statistically significant. Without collaborative learning, the teacher-student relationship negatively impacts mathematics interest. However, when collaborative learning is included as a mediator, it has a positive immediate effect on students' interest in mathematics, though it also shows a significant negative indirect effect on math achievement. This suggests that effective collaborative learning strategies can enhance students' mathematics performance, regardless of the quality of the teacher-student relationship. In contrast, poor teacher-student communication and ineffective collaborative learning can hinder math achievement. The study aligns with prior research, such as Castelyn (2018) and Moyano et al. (2020), which emphasized the positive impact of teacher-student relationships on academic success. However, it differs from Iddris et al. (2022), who found no link between teacher-student relationships and mathematics achievement, highlighting the complex nature of this relationship.

CONCLUSIONS

The study found that when students' perception of mathematics is positive, their performance tends to improve. In the Sefwi Wiawso Municipal, students reported a 66.8% improvement in their performance when they had a high interest in mathematics. The findings emphasized that teachers should adopt appropriate approaches to reduce negative perceptions of the subject, which can ultimately lead to better academic outcomes. The study highlighted the significant role of students' interest in mathematics as a key factor in their success. Additionally, the study revealed a strong correlation between students' interest in mathematics and their perceptions of the subject, suggesting that workshops and seminars should be organized to help students understand the importance of mathematics and effective teaching strategies. The teacher-student relationship was also found to be crucial, with motivational strategies like praise and awards helping to increase student interest. Furthermore, the study indicated that effective instructional strategies contribute to a 20% improvement in student performance. Teachers were encouraged to have the necessary academic qualifications and to attend workshops to stay updated on new teaching methods. The research also found that student perception acts as a mediator between teacher quality and mathematics interest, suggesting that students should be motivated and informed about the benefits of studying mathematics to overcome perceptions of it as a difficult subject.

RECOMMENDATION

The study's findings lead to the following recommendation:

1) Heads of teachers should ensure that mathematics teachers are well trained in the subject area and are well equipped to teach the subject.
2) Teacher must have the necessary academic qualifications, attend workshops and seminars on capacity building, and be willing to learn new methods of teaching mathematics.
3) Mathematics teachers consider students' interests when teaching mathematics.

Suggestions for Further Studies

The following are the suggestions for further studies:

1. It was suggested that additional research on the effect of teacher quality on students' interest in mathematics, which is mediated by students' perception of mathematics, be conducted in other districts and at different educational levels because there are various environmental factors and teaching methods that can use to influence their performance.
2. It was suggested that in order to improve students' performance, the school administration should use teaching quality strategies. Senior high schools should embrace teaching strategies that are of a high standard, such as classroom management, creating a supportive environment, and cognitive activation.
3. The study used causal analysis; hence, it was suggested that longitudinal data analysis be taken into account.

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APPENDIX A

Questionnaire

Dear Sir/Madam,

Please take a few moments to complete this questionnaire, which is solely for academic purposes. A high level of anonymity and secrecy is guaranteed. The study assessed. There are no correct or incorrect replies. Please mark (√) where applicable. It will take roughly 20 minutes to complete the entire questionnaire.

Section A: Demographics

1. Gender of the respondent: Male [ ] Female [ ]
2. Age of the respondent: 11-15 years [ ] 16-20 years [ ] 21-25 years [ ] 26 years or Above [ ]
3. Religious affiliation of the respondent:
   Christian [ ] Muslim [ ] Traditionalist [ ] Others [ ]
4. What is your level of education?
   Form 1 [ ] Form 2 [ ] Form 3 [ ]
5. What program are you pursuing?
   General Science [ ] General Art [ ] Home Science [ ]

Section B: Students' interest towards mathematics

Q6. Please indicate your level of agreement or disagreement with the statement below. They have been rated in the form 1-Strongly Agree, 2-Agree, 3-Neutral, 4-Disagree, and 5-Strongly Disagree.

Please Tick (√) in the box where appropriate.

CODE	STUDENTS INTEREST IN MATHEMATICS	1	2	3	4	5
SIM1	Teachers do not involve students in the teaching and learning of mathematics.					
SIM2	I like reading mathematics to other subjects.					
SIM3	I do not often get confused in mathematics class.					
SIM4	I am bored when working on mathematics.					
SIM5	I wish I do not involve meet mathematics anymore during my further education.					
SIM6	I like to persist in solving mathematics problems even if I am not readily able to solve it.					
SIM7	Attending math lessons is exciting for me.					
SIM8	I enjoy providing accurate responses to math questions.					
SIM9	I give up easily when working on mathematics.					
SIM10	Ever since elementary school, I have enjoyed math.					

Section C: Students' mathematics perception

Q7. Please indicate your level of agreement or disagreement with the statement below. They have been rated in the form 1-Strongly Agree, 2-Agree, 3-Neutral, 4-Disagree, and 5-Strongly Disagree.

Please Tick (√) in the box where appropriate.

CODE	STUDENT'S MATHEMATICS PERCEPTION	1	2	3	4	5
SMP1	Mathematics has not been my subject since primary school.					
SMP 2	Mathematics is abstract and boring.					
SMP 3	Mathematics is difficult to learn compared with other subjects.					
SMP 4	There are so many formulas in mathematics therefore I cannot do well in mathematics.					
SMP 5	Mathematics is full of rules and procedures.					
SMP 6	Mathematics has nothing to improve in my life.					
SMP 7	Mathematics is very complex to my understanding.					
SMP 8	Mathematics is meant for students who are brilliant students.					
SMP 9	The topic of mathematics is easy to learn.					
SMP 10	I rate mathematics higher as compared to other core subjects.					

Section D: Teacher empathy

Q8. Please indicate your level of agreement or disagreement with the statement below. They have been rated in the form 1-Strongly Agree, 2-Agree, 3-Neutral, 4-Disagree, and 5-Strongly Disagree.

Please Tick (√) in the box where appropriate.

CODE	TEACHER EMPATHY	1	2	3	4	5
TE1	Mathematics teachers do offer individual attention to students.					
TE2	Mathematics teachers have students' best interests at heart.					
TE3	Mathematics teachers understand students' mathematics learning challenges and needs.					
TE4	Mathematics teachers are interested in students and the cordial manner.					
TE5	Mathematics is willing to assist students outside of class hours.					
TE6	Mathematics teachers understand students' frustration in math learning.					
TE7	Mathematics teachers appreciate students' effort in mathematics learning.					
TE8	Mathematics teachers work together with students to solve their problems.					
TE9	Mathematics teachers guide judgment in mathematics learning.					
TE10	Mathematics teachers show reasonable concern and support for the student in every way possible to help their performance and growth.					

Section F: Teacher collaboration

Q9. Please indicate your level of agreement or disagreement with the statement below. They have been rated in the form 1-Strongly Agree, 2-Agree, 3-Neutral, 4-Disagree, and 5-Strongly Disagree.

Please Tick (√) in the box where appropriate.

CODE	TEACHERS COLLABORATION	1	2	3	4	5
TC1	Mathematics teachers work together with students in problem-solving.					
TC2	Mathematics assigns roles to students in mathematics learning.					
TC3	Mathematics teacher asks students to sit in groups of three in mathematics learning					
TC4	Mathematics teachers a course unit by giving a student's task to complete					
TC5	Mathematics teachers share authority with students.					
TC6	Mathematics teachers act as mediators in mathematics teaching and learning					
TC7	Mathematics teachers engage students in critical thinking					