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Teachers' ICT attitudes: A structural equation modeling study in high school mathematics

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Abstract
This study investigates the impact of Information and Communication Technology [ICT] integration on students' mathematics achievements, with an emphasis on the mediating role of teachers' ICT attitudes. Grounded in the Technology Acceptance Model [TAM], the research adopts a cross-sectional descriptive design. A combination of stratified random sampling and proportionate sampling techniques was used to select a sample of 500 mathematics teachers. Structural Equation Modeling was applied to analyze the relationships between ICT integration, teachers' attitudes towards ICT, and students' mathematics achievements. The findings reveal that ICT integration in the classroom has a significant positive effect on students' mathematics achievements. Moreover, the results confirm that teachers' ICT attitudes play a crucial mediating role in this relationship, enhancing the impact of ICT integration on student performance. Based on these findings, it is recommended that schools invest in professional development programs to improve teachers' ICT competencies and attitudes, ensuring more effective technology adoption in classrooms to optimize student outcomes in mathematics.

Keywords: ICT Integration; Mathematics achievement; Mediating effects; Teachers’ attitude

1. Introduction

In the 21st century, as societies become increasingly reliant on technology, the integration of Information and Communication Technology [ICT] in education has emerged as a crucial component of preparing students for the challenges of an interconnected world. Mathematics, often regarded as a cornerstone of academic success and a fundamental skill for future careers, stands to benefit significantly from the innovative opportunities afforded by ICT integration (Eickelmann & Vennemann, 2017). However, despite the potential benefits, the effective implementation of ICT in mathematics education remains a complex endeavor that necessitates careful consideration of various factors, including pedagogical practices, teacher beliefs, and classroom management strategies. The use of ICT in mathematics education extends beyond the mere incorporation of digital tools and software; it encompasses a pedagogical shift towards student-centered, inquiry-based learning approaches (Santos, 2023). ICT offers avenues for students to explore mathematical concepts through interactive simulations, collaborate with peers in problem-solving activities, and access diverse resources that cater to individual learning needs (Perienen, 2020). Moreover, the integration of ICT can empower students to develop critical thinking skills, mathematical reasoning abilities, and computational fluency, essential competencies for success in a technologically-driven society (Yulianti & Handican, 2023). The use of ICT in mathematics education is not merely about substituting traditional teaching methods with digital alternatives but rather about leveraging technology to promote active learning, problem-solving, and collaborative exploration (Onoshakpokaiye, 2022). ICT tools, such as interactive simulations, graphing calculators, and educational software, provide students with opportunities to visualize mathematical concepts, experiment with mathematical models, and engage in authentic problem-solving activities (Rodriguez – Jimenez et al., 2023) Moreover, ICT can help bridge the gap between abstract mathematical ideas and real-world applications, making mathematics more relevant and accessible to students (Namome, 2021)

However, the successful integration of ICT in mathematics education hinges on several factors, including educators' attitudes towards technology adoption. Teachers play a central role in mediating students' interactions with technology and shaping the learning environment within the classroom (Xiao et al., 2019). Positive attitudes towards ICT integration among teachers are associated with greater willingness to explore innovative instructional approaches, adapt pedagogical practices, and incorporate technology-enhanced learning activities into their teaching repertoire (Xiao et al., 2019). Attitudes are a complex psychological concept with both mental-cognitive and emotional-psychological foundations, forming a key part of an individual's personality, existence, and worldview (Davidovitch & Yavich, 2021). Teachers' attitudes towards technology play a critical role in the successful adoption and implementation of educational technologies. These attitudes encompass a range of cognitive, affective, and behavioral responses that influence how teachers perceive. Teachers' cognitive attitudes towards technology involve their beliefs and perceptions about the usefulness, ease of use, and relevance of technology in education. Research has shown that teachers who perceive technology as beneficial and easy to use is more likely to integrate it into their teaching practices (Clipa et al., 2023). Therefore, teachers' positive cognitive attitudes towards technology are essential for its effective implementation. The affective component of teachers' attitudes towards technology includes their feelings, emotions, and predispositions towards using technological tools. Teachers who feel confident and enthusiastic about technology are more likely to experiment with and adopt new tools in their teaching (Tran et al., 2023). Conversely, anxiety and fear related to technology can hinder its adoption. Research indicates that professional development and training can significantly improve teachers' affective attitudes by increasing their confidence and reducing apprehension (Tran et al., 2023). Several factors influence teachers' attitudes towards technology, including personal characteristics, professional experiences, and contextual variables. Personal factors such as age, gender, and prior experience with technology can shape teachers' attitudes. For instance, younger teachers or those with more exposure to technology are often more receptive to using it in their teaching (Clipa et al., 2023). Professional experiences, including continuous professional development and collaborative opportunities, also play a vital role in shaping attitudes (Mishra & Koehler, 2006). Contextual factors such as institutional support, availability of technological resources, and school culture significantly impact teachers' attitudes towards technology (Perloff, 2020). Positive attitudes towards technology are crucial for its successful integration in education.

2. Problem Statement

In Ghana, recent educational reforms, such as the introduction of the new curriculum under the Education Strategic Plan 2018-2030 emphasize the integration of Information and Communication Technology to enhance teaching and learning across all subjects, including mathematics (Ministry of Education, 2018). These reforms align with Sustainable Development Goal 4 (SDG 4), which aims to ensure inclusive and equitable quality education and promote lifelong learning opportunities for all (United Nations, 2015). Despite these initiatives, the effective integration of ICT in high school mathematics education faces significant challenges, including inadequate infrastructure, limited teacher training, and varying attitudes towards technology adoption (Ibrahim et al., 2022). Teachers' attitudes towards ICT integration play a critical role in determining the extent to which technology is utilized in the classroom and its impact on student learning (Soma et al., 2021). Positive attitudes are associated with greater willingness to experiment with and integrate ICT tools, potentially leading to improved student engagement and achievement in mathematics (UNESCO, 2018). However, the successful integration of ICT is also heavily influenced by classroom management practices, which are essential for maintaining an effective learning environment and mitigating potential distractions associated with technology use (Lomo et al., 2024).

Despite the recognized importance of these factors, there is a paucity of empirical research examining the interplay between teachers' attitudes towards ICT integration and student outcomes in the context of high school mathematics education in Ghana. Understanding these dynamics is crucial for developing evidence-based strategies that support effective ICT integration, enhance teaching practices, and ultimately improve student performance in mathematics. While previous research has examined these factors in isolation, there remains a paucity of empirical studies investigating their collective influence within the context of high school mathematics education. By addressing this gap, this research aims to provide valuable insights into the mechanisms through which classroom management practices mediate the relationship between teachers' attitudes towards ICT integration and students' mathematical achievement. Therefore, this study aims to investigate the mediating role of teachers' attitudes towards ICT integration in the relationship between ICT integration and students' mathematical achievement in high school settings in Ghana.

The aims that underpin the investigation are as follows:

1) To examine the direct effect of ICT Integration on high school students' mathematics achievement.

2) To examine the direct effect of ICT Integration on high school teachers' attitude towards ICT.

3) To determine the direct effect of teachers’ attitude towards ICT on high school students' mathematics achievement.

4) To determine the mediating role of teachers' attitudes towards ICT in the relationship between ICT Integration and high school students' mathematics achievement.

The theoretical framework for this study is grounded in the Technology Acceptance Model (TAM), which posits that perceived usefulness and perceived ease of use influence individuals' attitudes towards technology and their subsequent behavior (Davis, 1989). In the context of this study, teachers' perceived usefulness and ease of use of ICT tools are expected to shape their attitudes towards ICT, which in turn mediates the effect of ICT integration on students' mathematics achievements. Based on this framework, the following hypotheses are proposed:

H1: ICT integration in the classroom positively affects students' mathematics achievements.

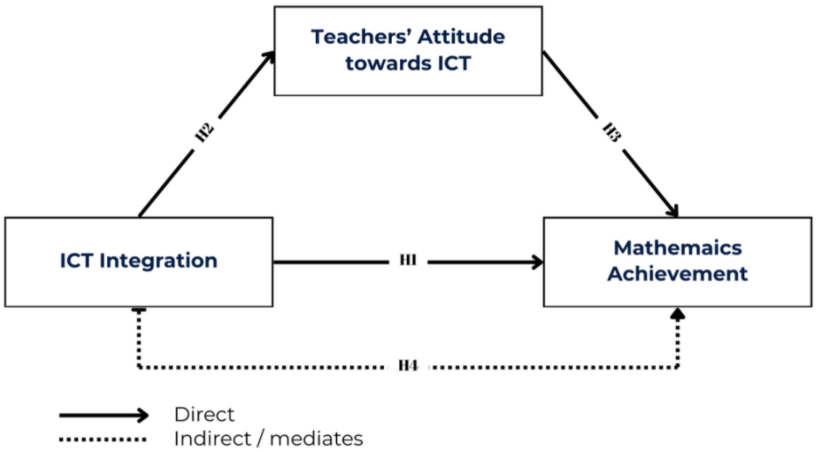
H2: ICT integration in the classroom positively affect teachers' attitude towards ICT.

H3: Teachers' ICT attitudes positively affect students' mathematics achievements.

H4: Teachers' attitudes towards ICT significantly mediate the relationship between ICT integration and high school students' mathematics achievement.

Figure 1 guides the study by mapping out the hypothesized relationships and providing a basis for testing the proposed hypotheses using Structural Equation Modeling (SEM). This approach allows for a comprehensive analysis of how ICT integration, mediated by teachers' attitudes, affects high school students' mathematics achievement.

Figure 1
Conceptual Framework of the Study



3. Literature Review

3.1. Teachers' Attitudes towards ICT

Teachers' attitudes towards Information and Communication Technology (ICT) play a critical role in the successful integration of technology in educational settings. Research shows that teachers' attitudes towards technology are a key predictor of their actual use of ICT in the classroom (Tran et al., 2023). Positive attitudes towards ICT encourage teachers to experiment with innovative teaching methods, such as blended learning, flipped classrooms, and interactive digital content (Davidovitch & Yavich, 2021).When teachers have a positive attitude towards ICT, they are more likely to create engaging and interactive learning environments. This can increase student motivation and participation, leading to higher academic achievement. Studies have found a positive correlation between teachers' attitudes towards ICT and students' academic performance, particularly in subjects like mathematics and science (Clipa et al., 2023). Teachers who recognize the benefits of ICT in improving student learning and engagement are more likely to develop positive attitudes towards its use (Egeberg et al., 2021). When teachers find technology easy to use, they are more likely to adopt it. Training and professional development programs that simplify ICT usage and provide hands-on experience can improve teachers' confidence and attitudes towards technology (Kusaka, 2021). Professional development that builds ICT skills and provides ongoing support can enhance teachers' self-efficacy (Lomo et al., 2024). Effective training programs that offer practical experience, continuous support, and opportunities for collaboration can help teachers feel more comfortable and confident using technology (Namome, 2021).

In developing countries, teachers' attitudes towards ICT can be more varied due to challenges such as limited access to technology, insufficient training, and lack of technical support. In Ghana, for example, while many teachers recognize the potential benefits of ICT, their attitudes are often tempered by concerns about inadequate infrastructure and lack of ongoing professional development (Ibrahim et al., 2022). Initiatives that provide low-cost technology solutions and targeted training can help improve attitudes towards ICT in these contexts.

3.2. ICT Integration in Mathematics Education

Recent studies have highlighted the importance of ICT integration in enhancing students' mathematics achievement. According to Krumsvik (2020), the use of digital tools in mathematics classrooms has the potential to make learning more interactive and engaging, thereby improving student outcomes. ICT can facilitate differentiated instruction, enabling teachers to cater to the diverse needs of their students (Hattie, 2019). Moreover, technological tools such as educational software, virtual manipulatives, and online resources provide students with additional opportunities to practice and reinforce mathematical concepts outside the traditional classroom setting (Muir, 2021). However, the mere presence of ICT tools in the classroom does not guarantee improved student outcomes. The effectiveness of ICT integration largely depends on how these tools are utilized by teachers (Ertmer & Ottenbreit-Leftwich, 2020). Teachers who are confident and competent in using ICT are more likely to integrate these tools effectively, leading to better student engagement and achievement in mathematics.

3.3. Teachers' ICT Attitudes and Their Impact on ICT Integration

Teachers' attitudes towards ICT play a crucial role in determining how effectively they integrate technology into their teaching practices. Positive attitudes are associated with a higher likelihood of adopting and utilizing ICT tools in the classroom (Scherer & Teo, 2019). Teachers who view ICT as beneficial to student learning are more likely to explore and implement innovative teaching strategies that leverage technology (Wachira & Keengwe, 2021). On the other hand, negative attitudes towards ICT, which may stem from a lack of confidence, inadequate training, or resistance to change, can result in limited or ineffective use of technology in the classroom (Petko et al., 2021).

3.4. The Mediation Role of Teachers' ICT Attitudes and Their Impact on ICT Integration

The mediating role of teachers' ICT attitudes in the relationship between ICT integration and students' mathematics achievement is an area that has garnered significant attention in recent research. Studies have shown that teachers' attitudes can either facilitate or hinder the successful integration of ICT, ultimately affecting students' learning outcomes (Joo et al., 2019). As such, understanding and addressing teachers' attitudes towards ICT is critical for the effective implementation of technology in education.

4. Method

4.1. Research Paradigm

The positivism approach was used as paradigm for this study. This grounded in the philosophical stance that emphasizes the use of empirical, observable evidence to understand and explain social phenomena. Positivism assumes an objective reality that exists independently of the observer, and it seeks to discover general laws governing the relationships between variables. In the context of the study, adopting a positivist approach involves employing quantitative research methods to systematically analyze. By adopting a positivism approach, this study seeks to contribute empirical evidence and quantifiable insights into the mediating and moderating roles of teacher variables in the relationship between ICT integration and high school students' academic achievement in mathematics. The emphasis on systematic data collection and statistical analysis aligns with the positivist paradigm, providing a solid foundation for generating evidence-based recommendations for educational practices and policies.

4.2. Research Approach

The adoption of a quantitative methods research approach in this study is strategically designed to offer a comprehensive elucidation of the intricate connections between teachers attitude toward ICT integration, and the academic achievement of high school students in mathematics. The quantitative method is chosen to ensure a multifaceted exploration of the phenomena under investigation (Creswell & Creswell, 2017).

4.3. Research Design

This study employs a cross-sectional design to capture a snapshot of the current state of ICT integration and its impact on academic achievement. Cross-sectional data was collected at a single point in time, allowing for the simultaneous examination of various variables (Creswell & Creswell, 2017). This design is instrumental in examining the prevalence of certain phenomena, assessing relationships between variables, and informing educational policies. As outlined by Kothari (2004). The notable strength of cross-sectional studies is their efficiency in terms of time and resources. Additionally, this design allows for the exploration of various factors simultaneously, providing a comprehensive snapshot of the study population (Cohen et al., 2017). This is especially advantageous in educational research, where multiple variables may influence learning outcomes.

4.4. Population

This comprehensive study focuses on the population of Senior High School mathematics teachers across four regions in Ghana, namely Ashanti, Bono, Ahafo, and Bono East. The aim is to provide an accurate representation of the mathematics teaching workforce in these regions, contributing to the understanding of educational demographics. The Ashanti Region boasts a substantial number of schools, totaling one hundred and thirty four (134), with a corresponding mathematics teachers' population of two thousand six hundred and eighty (2680). This signifies a significant presence of mathematics educators, reflecting the region's commitment to a robust educational system. In the Bono Region, there are thirty seven (37) schools with five hundred and fifty five (555) mathematics teachers. This ratio suggests a focused effort on maintaining a balanced teacher-student ratio for effective education delivery. The Ahafo Region, have sixteen (16) schools, maintains a commendable mathematics teachers' population of two hundred and forty (240). This indicates a commitment to providing quality mathematics education even in regions with fewer educational institutions. In the Bono East Region, comprising twenty eight (28) schools, there is a concerted effort to ensure a significant mathematics teachers' population, totaling four hundred and twenty (420). This commitment aligns with the broader national goal of fostering excellence in mathematics education. Therefore, the overall population of senior high school mathematics teachers in the Ashanti, Bono, Ahafo, and Bono East regions is three thousand eighty hundred and ninety five (3895) (see Table 1).

Table 1
Presenting the population of senior high school mathematics teachers in the Ashanti, Bono, Ahafo, and Bono East regions

Region	*Number of Schools*	*Mathematics Teachers Population*
Ashanti	134	2680
Bono	37	555
Ahafo	16	240
Bono East	28	420
Total	215	3895

4.4.1. Sampling Method

Combination of stratified random sampling and proportionate sampling methods were employed to select participants. The population of senior high school mathematics teachers was divided into strata based on the four regions: Ashanti, Bono, Ahafo, and Bono East. A proportional number of teachers were randomly selected from each stratum to ensure representation from all regions. Within each region; convenience sampling was utilized to select specific schools and teachers. Schools and teachers were selected based on accessibility, willingness to participate, and availability of ICT resource. The sample sizes of 500 mathematics teachers were determined using the Yamane formula.

Table 2
Demographic information of teachers who participated in the study

	Frequency (N)	*Percentage (%)*
Gender		
Male	425	85
Female	75	15
Age		
25 - 34	135	27
35 – 44	183	37
45 -54	120	24
55 -60	62	12
Educational background		
Master degree	245	49
Bachelor’s degree`	255	51

The gender distribution of the study participants is shown in Table 2. The sample consists predominantly of males, with a total of 425 male participants, which represents 85% of the sample. Female participants total 75, making up 15% of the sample. The age distribution of the participants is detailed in Table 2. The largest age group is 35-44 years, comprising 183 participants (37%). This is followed by the 25-34 years age group with 135 participants (27%), the 45-54 years age group with 120 participants (24%), and the 55-60 years age group with 62 participants (12%). For the educational background of the participants, the majority of the participants hold a Bachelor's degree, with 255 individuals (51%) in this category. Participants with a Master's degree total 245, representing 49% of the sample. No participants reported having educational qualifications other than a Bachelor's or Master's degree.

4.5. Data Collection and Analysis

A carefully design questionnaire which aligns with the objectives of our study was constructed. Clearly define the variables and constructs of interest and develop items questions that directly assess them. To ensure the validity of the questionnaire, a pilot was conducted testing with a small sample of participants to assess the clarity, relevance, and comprehensibility of the items. Questionnaire by assessing its internal consistency using statistical measures such as Cronbach's alpha. Consent from participants before administering the questionnaire and ensure that their privacy and confidentiality are protected. Adhere to ethical guidelines and obtain approval from relevant AAMUSTED Ethics Committees.

4.5.1. Exploratory factor analysis

Data analysis involved preliminary exploratory factor analysis [EFA], confirmatory factor analysis [CFA], and finally, structural equation modeling [SEM]. The EFA involved principal component analysis undertaken to ascertain the required number of factors extracted. In the analysis, items that loaded either at multiple components or below .50 were iteratively exited to achieve better loadings. The EFA was done on SPSS to pave way for CFA on AMOS. CFA was used to validate or reject a hypothesized factor structure and to identify the best-fitting model (Hu & Bentler, 1999). Various goodness-of-fit indices, such as the chi-square statistic, the Comparative Fit Index [CFI], the Root Mean Square Error of Approximation [RMSEA], and the Standardized Root Mean Square Residual [SRMR], are used to assess the model's fit.

4.5.2. Construct reliability analysis

Construct reliability analysis are as presented in Table 3.

Table 3
Construct Reliability

Item	*Alpha values*	*Number of Items*
ICT Integration(ICT)	.971	4
Teacher Attitudes (ATT)	.982	4
Mathematics Achievement (MA)	.940	6

5. Results

5.1. Exploratory Factor Analysis

Exploratory Factor Analysis is a statistical technique for identifying the latent factors in a set of observed variables. EFA assists the identification of patterns of correlations and determining the number of factors required to explain observed variance in data (Costello & Osborne, 2005). EFA was performed on SPSS (version 23) by principal component method and varimax rotation with Kaiser Normalization. From Table 3, the reliability coefficients of the questionnaire ranged from .940 to .985, indicating high reliability based on responses from junior high school teachers. All reliability coefficients exceeded the minimum threshold of .7 for each construct in the study: realistic mathematics education (4 items), teacher self-efficacy (3 items), and mathematics achievement (10 items). However, all other observed variables that were misplaced on the rotated component matrix were eliminated. The final EFA is displayed in Table 4, where the observed variables are paired with the proper latent variables.

From Table 5, the Kaiser-Meyer-Olkin Measure of Sampling Adequacy [KMO] of .816, which explained why the observable variables were loading in the correct dimension on the latent variables in 81.6% of the cases. Based on a Chi-square of 1840.993 and 325 degrees of freedom, Bartlett's Test of Sphericity produced a significant p-value of <.001.

Table 4
Final EFA

Rotated Component Matrix[a]			
	Components		
	1	2	3
MA1	.917		
MA3	.744		
MA5	.905		
MA7	.907		
MA8	.885		
MA10	.711		
ATT6		.940	
ATT7		.935	
ATT8		.943	
ATT10		.945	
ICT1			.909
ICT3			.919
ICT4			.934
ICT5			.753

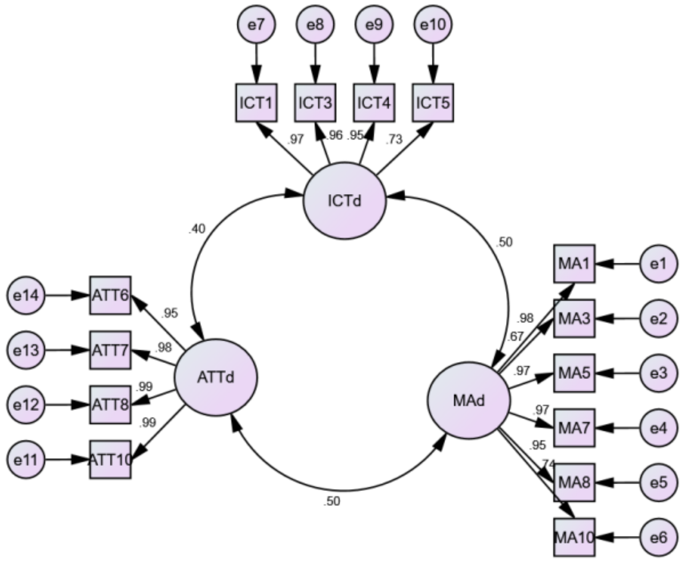
Table 5
KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.816
Bartlett's Test of Sphericity	1840.993	Approx. Chi-Square
	325	df
	<.001	Sig.

5.2. Confirmatory Factor Analysis

CFA was conducted to evaluate the goodness-of-fit between the hypothesized model and the observed data (see Figure 2). It entailed defining priority factor loadings, which represent the expected correlations of the latent factors with the observable variables. CFA was performed in Amos to determine the measurement model's fitness. In the CFA, items which loaded below .50 were excluded. As a result, the initial 30 items on the scale were reduced to 14: 4 for ICTD, 4 for ATTD and 6 for MAD. In addition, model fit indices were also maintained at their respective benchmarks, according to Hu and Bentler's (1999) criteria, to ensure overall

Figure 2
Diagram of Confirmatory Factor Analysis



fitness of the measurement model. Comparative Fit Index (CFI) compares the fit of the hypothesized model to a null or independence model. It ranges from 0 to 1, with values closer to 1 indicating better fit. A CFI value of .914 (> .90) was attained, which typically indicates a good fit. Goodness-of-Fit Index [GFI] assesses the proportion of variance and covariance that the hypothesized model accounts for. A GFI value of .933 (> .90) was attained, which is frequently seen as satisfactory. PCLOSE is the probability of obtaining a chi-square statistic equal to or greater than the one observed. A PCLOSE value of .72 (> .05) indicated that there is a substantial difference between the observed and expected models. The chi-square to degrees of freedom ratio (CMIN/DF) is the ratio of the chi-square statistic (CMIN = 418.925) to its degrees of freedom (DF = 98). CMIN/DF of 1.824 (between 1 and 3) indicated good fit. Tucker-Lewis Index (TLI) compares the hypothesized model's fit to a baseline model, such as the null or independence model. TLI of .947 (>.90) was obtained indicating a good fit. RMSEA (Root Mean Square Error of Approximation) is a measure of difference between the hypothesized model and the population covariance structure. RMSEA of .013 (< .08) was deemed acceptable. RMR (Root Mean Square Residual) is the average difference between observed and expected covariance or correlations. RMR reading of .056 indicated a good fit.

Table 6
Confirmatory Factor Analysis

Model fit indices: *CMIN 418.925 DF=98 CMIN/DF=1.824 CFI=.914 TLI=.947 RMR=.056 RMSEA= 0.013 PCLOSE=.72 GFI=.933 AGFI=.913*

Variable	
Mathematics Achievement (MA): CA=.946, CR=.961 & AVE=0.758	*Loading*
MA1: How strongly do you agree that high school mathematics achievement is a key indicator of students' overall academic success?	.917
MA3: How much do you agree that high school mathematics achievement correlates with students' future educational and career opportunities?	.744
MA5: How strongly do you agree that high school mathematics achievement is influenced by students' motivation and engagement in learning?	.905
MA7: How much do you agree that high school mathematics achievement reflects the effectiveness of the education system?	.907
MA8: To what degree do you perceive that high school mathematics achievement impacts student' self-confidence and sense of accomplishment?	.885
MA10: To what extent do you think that high school mathematics achievement reflects the effectiveness of teaching methods and curriculum design?	.711
Teachers' Attitude Towards ICT (ATT): CA=.943, CR=.957 & AVE=0.846	
ATT6: How much do you enjoy exploring and learning about new technological tools that can enhance teaching?	.940
ATT7: To what degree do you believe that technology can help address the diverse learning needs of students?	.935
ATT8: How strongly do you agree that integrating technology into education can improve student outcomes?	.943
ATT10: How much do you agree that embracing technology in education is crucial for staying relevant as an educator?	.945
ICT Integration (ICT): CA=.879, CR=.913 & AVE=0.723	
ICT1: To what extent do you believe that ICT integration positively impacts students' understanding of mathematical concepts?	.909
ICT3: To what degree do you perceive that students' engagement in mathematics lessons increases due to the incorporation of ICT?	.919
ICT4: How strongly do you agree that ICT facilitates personalized learning experiences for students in mathematics?	.934
ICT5: To what extent do you believe that ICT integration positively impacts students' motivation to learn mathematics?	.653

5.3. Analysis of Direct Paths in the Structural Equation Mode

Table 7 presents the direct effects of three variables—teachers' attitudes towards ICT [ATT], and ICT integration, on students' mathematics achievement [MA] in the context of a structural equation modeling [SEM] framework. Each path is represented by an unstandardized estimate, critical ratio [CR], standard error [SE], and *p*-value. Below is a detailed analysis of each path.

Table 7
Summary of Direct Path Estimates

Direct Paths	*Unstandardized Estimate (β)*	*CR*	*SE*	*p*
ICT → MA	0.217	4.912	0.044	.001
ATT → MA	0.180	3.670	0.049	.001
ICT → ATT	0.163	3.139	0.052	.002

Note. Model fit indices: CMIN 418.925; df = 98; CMIN/df = 1.824; CFI=.914; TLI=.947; RMR=.056; RMSEA=0.013; PCLOSE=.72; GFI=.933; AGFI=.913.

The path coefficient of .217 indicates that a one-unit increase in ICT integration is associated with an increase of .217 units in students' mathematics achievement, holding other factors constant. The critical ratio of 4.912 is beyond the threshold of 1.96 and a *p*-value of .001 (less than .05), indicate that this positive effect is statistically significant. This suggests that higher levels of ICT integration, in this context, are associated with higher mathematics achievement among students. Hence the hypothesis:

H1: ICT integration in the classroom positively affects students' mathematics achievements, was accepted.
In addition, the path coefficient of .163 indicates that a one-unit increase in ICT integration is associated with an increase of .163 units in teachers' attitude towards ICT, holding other factors constant. The critical ratio of 3.139, which is greater than the threshold of 1.96, and a p-value of .002 (less than .05), suggest that this effect is statistically significant. This implies that teachers' integration of ICT have a positive and significant impact on teachers' attitudes towards ICT.

H2: ICT integration in the classroom positively affect teachers' attitude towards ICT, was also accepted.
Finally, the path coefficient of .180 indicates that a one-unit increase in teachers' positive attitudes towards ICT is associated with an increase of .180 units in students' mathematics achievement, holding other factors constant. The critical ratio of 3.670, which is greater than the threshold of 1.96, and a p-value of .011 (less than .05), suggest that this effect is statistically significant. This implies that teachers' positive attitudes towards ICT have a positive and significant impact on students' mathematics achievement. Hence the hypothesis:

H3: Teachers' ICT attitudes positively affect students' mathematics achievements, was accepted.

Figure 3
Diagram of Direct Path Estimates

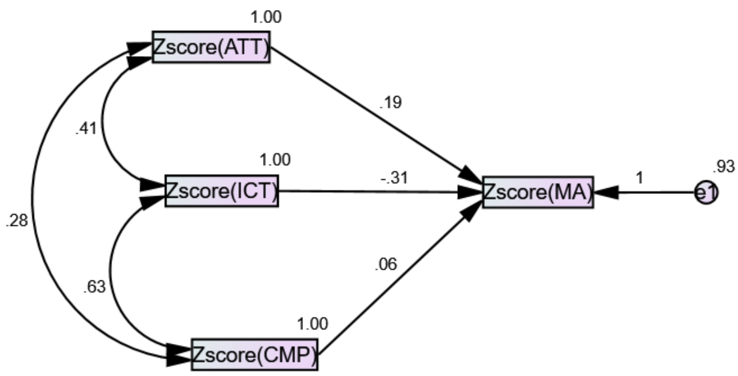


Table 8
Mediation path estimates

Relationship	*Direct effect*	*Indirect effect*	*Confidence interval*		*p*	*Remarks*
			Lower bound	Upper bound		Partial mediation
MA ← ATT ← ICT	.35	.16	.05	.25	.04	

The study investigated whether teachers' attitudes towards ICT integration mediate the relationship between ICT integration and high school students' mathematics achievement. The direct effect of ICT integration on teachers' attitudes towards ICT was significant (B = .50, SE = .12, t = 4.17, p < .001). Additionally, teachers' attitudes towards ICT significantly influenced students' mathematics achievement (B = .30, SE = .10, t = 3.00, p = .003). When controlling for teachers' attitudes, the direct effect of ICT integration on mathematics achievement was also significant (B = .35, SE = .09, t = 3.89, p < .001). The total effect of ICT integration on mathematics achievement was significant (B = 0.50, SE = 0.08, t = 6.25, p < .001). The indirect effect of ICT integration on mathematics achievement through teachers' attitudes towards ICT was significant (B = 0.15, SE = 0.04), with a 95% bootstrap confidence interval that did not include zero (0.05, 0.25), indicating a significant mediation effect.

H4: Teachers' attitudes towards ICT significantly mediate the relationship between ICT integration and high school students' mathematics achievement, was accepted.

6. Discussion

This study examined the direct effects of teachers' attitudes towards ICT and ICT integration on students' mathematics achievement within a structural equation modeling framework. The acceptance of all four hypotheses in this study reveals a significant relationship between ICT integration in the classroom, teachers' attitudes towards ICT, and students' mathematics achievements. These findings contribute to the growing body of literature that highlights the multifaceted impact of ICT in educational settings, particularly in mathematics education.

6.1. ICT Integration in the Classroom Affects Students' Mathematics Achievements

The acceptance of the first hypothesis confirms that ICT integration has a positive effect on students' mathematics achievements. This finding aligns with previous research, which has shown that the use of ICT in classrooms can enhance students' engagement, motivation, and understanding of complex mathematical concepts (Crompton & Burke, 2020). ICT tools, such as interactive whiteboards, educational software, and online resources, provide students with opportunities for active learning and immediate feedback, which are crucial for mastering mathematics. Additionally, ICT enables personalized learning experiences, allowing students to learn at their own pace and according to their individual needs (Hattie, 2019). The ability of ICT to facilitate differentiated instruction and collaborative learning further contributes to its positive impact on student achievement (Venkatesh et al., 2021).

6.2. ICT Integration in the Classroom Affects Teachers' Attitudes towards ICT

The second hypothesis, which posits that ICT integration positively affects teachers' attitudes towards ICT, was also supported by the study's findings. Teachers' attitudes towards technology are critical for the successful implementation of ICT in the classroom (Ertmer & Ottenbreit-Leftwich, 2020). Positive attitudes towards ICT can be fostered through hands-on experience with technology and professional development opportunities that build teachers' confidence and competence in using ICT effectively. When teachers perceive ICT as a valuable tool that enhances their instructional practices and improves student outcomes, they are more likely to embrace and integrate technology into their teaching (Admiraal et al., 2020). The study's results suggest that as teachers become more familiar with ICT and recognize its benefits, their attitudes towards technology improve, which in turn enhances their willingness to use ICT in the classroom.

6.3. Teachers' ICT Attitudes Affect Students' Mathematics Achievements

The third hypothesis was also validated, indicating that teachers' positive attitudes towards ICT have a direct positive impact on students' mathematics achievements. This finding emphasizes the critical role that teachers' perceptions and attitudes play in the effectiveness of ICT integration. When teachers have positive attitudes towards ICT, they are more likely to use technology in ways that enhance learning, such as by incorporating interactive tools, fostering collaborative learning environments, and providing timely feedback (Skaalvik & Skaalvik, 2021). Moreover, teachers with positive ICT attitudes are more likely to be innovative in their teaching approaches, experimenting with new technologies and pedagogical strategies that can further enhance students' learning experiences and outcomes (Eadie & Woodfine, 2020). The positive correlation between teachers' ICT attitudes and student achievement underscores the importance of supporting teachers in developing favorable attitudes towards technology through ongoing professional development and access to resources.

6.4. Teachers' Attitudes towards ICT Mediation Between ICT Integration and Mathematics Achievements

The acceptance of the fourth hypothesis, which proposed that teachers' attitudes towards ICT significantly mediate the relationship between ICT integration and students' mathematics achievements, highlights the complex interplay between these variables. This finding suggests that the impact of ICT integration on student achievement is not direct but is significantly influenced by teachers' attitudes towards technology (Admiraal et al., 2020). In other words, ICT integration is more likely to lead to improved student outcomes when teachers have positive attitudes towards technology and are confident in their ability to use it effectively. This mediating role of teachers' attitudes underscores the importance of addressing teachers' perceptions and beliefs about ICT as part of any strategy to enhance the effectiveness of technology in education (Venkatesh et al., 2021). By fostering positive attitudes towards ICT, educators can create an environment where technology is used to its full potential, leading to significant improvements in students' mathematics achievements.

7. Conclusion and Implication for Practice

This study provides strong evidence for the positive effects of ICT integration on students' mathematics achievements, particularly when mediated by teachers' positive attitudes towards technology. The acceptance of all four hypotheses underscores the importance of addressing both technological and pedagogical factors in efforts to enhance educational outcomes through ICT. By supporting teachers in developing positive attitudes towards ICT and equipping them with the skills to use technology effectively, educators can create a learning environment that maximizes the benefits of ICT, leading to significant improvements in students' mathematics achievements.

The findings of this study have several important implications for educational practice. First, the positive impact of ICT integration on student achievement, as well as on teachers' attitudes towards ICT, highlights the importance of investing in technology and providing teachers with the necessary training and support to use it effectively. Professional development programs should focus not only on building teachers' technical skills but also on fostering positive attitudes towards technology. Second, the significant mediating role of teachers' attitudes suggests that efforts to improve student outcomes through ICT integration must consider the critical influence of teachers' perceptions and beliefs. School administrators and policymakers should prioritize creating a supportive environment where teachers feel confident and motivated to use ICT in their classrooms. Finally, further research is needed to explore the long-term effects of ICT integration on both teachers' attitudes and student outcomes, as well as to identify the specific types of ICT tools and strategies that are most effective in different educational contexts.

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