



Modeling the role of competence motivation in linking historical mathematical fallibility and student interest in mathematics

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Abstract

This study investigates the mediating role of competence motivation in the relationship between exposure to the history of mathematical fallibility and students' mathematics interest (SMI). A cross-sectional survey design was employed using a quantitative approach. The sample comprised 285 undergraduate students of mathematics education in Ghana. Structural equation modeling and bias-corrected percentile bootstrapping were employed, and the analysis was conducted in AMOS (version 23). The results indicate that historical fallibility has a positive and significant effect on students' competence, motivation, and mathematics interest. Competence motivation partially mediated the relationship between the variables. The current study contributes to the existing body of knowledge by filling a gap in the literature. Previous studies have established the relationship between history and interest, but this study isolated fallibility as a motivational variable. The results also indicate that educators should draw on historical accounts of struggles to validate students' errors and foster interest. The findings suggest that integrating narratives of mathematical struggle and historical fallibility into mathematics instruction may contribute to more sustainable forms of mathematics education by promoting long-term student motivation, emotional resilience, and continued engagement with mathematics. The study further implies that humanizing mathematics through historical perspectives can support inclusive and psychologically supportive learning environments within digitally transforming higher education systems.

Keywords: Competence motivation; History of mathematical fallibility; Mathematical interest

1. Introduction

In educational systems worldwide, maintaining SMI has been an enduring concern (Asare & Boateng, 2025). Findings from international large-scale assessments and studies have consistently documented a decline in students' interest and affective engagement with mathematics as they progress through the educational system (Boadu & Bonyah, 2024; Brantlinger, 2022; Kjeldsen & Carter, 2014). Mathematics has historically been viewed as an elite activity, suitable only for a small group of naturally talented individuals. Such a position perpetuates the myth of genius, which holds that mathematical ability is an innate talent that most students cannot hope to acquire (Felgner, 2023; Zbiek & Conner, 2006). Research has demonstrated that students' negative attitudes toward mathematics can reduce motivation, interest, and participation, even among those who are mathematically capable (Hidi & Renninger, 2006; Raj & Aithal, 2020; Ryan & Deci, 2000).

To overcome this problem, the importance of the History of Mathematics as a means of fostering a more positive and rich connection with the subject has been increasingly emphasized in the literature on the teaching and learning of mathematics (Blåsjö, 2024). Empirical research from global and African perspectives has shown the value of the History of Mathematics in enhancing students' understanding, interest, and attitudes toward mathematics (Arthur et al., 2022; Gyasi Alfred et al., 2024). Specifically, the study by Arthur et al. (2022) demonstrated the instructional benefits of the History of Mathematics on student understanding and engagement with mathematics.

More recently, Asare and Boateng (2025) advanced this line of argument by testing, using data, whether motivation lies between History of Mathematics (HoM) integration and SMI. Their data support this, as a conduit through which HoM can increase SMI, marking a shift from purely descriptive to mediation-oriented analysis. However, both Arthur et al. (2022) and Asare and

Boateng (2025) treated HoM as a general concept, without distinguishing specific historical facets that may affect students' motivation in different ways.

Moreover, there is a developing theory in mathematics education that one facet of the history of mathematical fallibility, errors, false starts, debates lasting decades, and intellectual struggle, may be particularly powerful but underexplored in its impact on students' motivation. The theory that mathematical progress is achieved through an endless cycle of failure, revision, and struggle rather than an inevitable progression towards truth (Glas, 1998) offers a vision of mathematics as a human activity, subject to fallibility. This is consistent with current understandings of ability as non-deterministic and of learning as an effortful, developmental process. Although theoretically interesting, this particular facet of HoM has not been teased apart or modeled in previous research, including previous mediation-oriented research.

From a motivational psychology perspective, competence motivation provides a theoretically well-supported channel through which the experience of math fallibility can affect student interest. The concept of competence is a fundamental psychological need in Self-Determination Theory, which gives rise to intrinsic motivation, engagement, and persistence (Ryan & Deci, 2000). Learning about times when people have struggled with mathematics can give a student greater confidence in their own ability to learn it. Research has consistently demonstrated that students' self-efficacy, or their sense of competence, is one of the strongest predictors of their interest in mathematics (Boadu & Boateng, 2024; Bright et al., 2024). However, existing studies in the History of Mathematics literature have not examined competence motivation as a mediating variable arising from students' experience of mathematical fallibility, although mediation analysis has been applied in related contexts. Again, the literature on the development of student interest indicates that enduring interest is shaped by ongoing experiences of the subject matter's value and competence, rather than by a single teaching event (Hidi & Renninger, 2006). Although the literature has shown a direct and indirect relationship between the History of Mathematics and student interest, there is a lack of theoretical models that specify the particular teaching event in the History of Mathematics that triggers the motivational process. The use of Structural Equation Modeling (SEM), which allows for the simultaneous examination of latent constructs and indirect effects, remains limited in studies that disaggregate HoM into theoretically meaningful components.

Against this backdrop, the present study extends existing HoM research by examining the mediating role of competence motivation in the relationship between exposure to the history of mathematical fallibility and SMI using a Structural Equation Modeling approach. By moving beyond the general integration of HoM and specifically identifying fallibility as a distinct construct of teaching and learning, this research remedies a clear gap in both theory and methodology. It advances our theory by integrating historical perspectives with motivational psychology and strengthens the empirical component by providing sound evidence from SEM to inform the design of mathematics education.

The present study is also important within the context of sustainable education because sustainable learning systems require instructional approaches that maintain students' long-term engagement, emotional resilience, and motivation toward difficult subjects such as mathematics. Contemporary discussions on sustainable education increasingly emphasize not only academic achievement but also psychologically supportive and inclusive learning environments that sustain learners' participation over time (Davor, Asare, et al., 2026). By positioning mathematical struggle and fallibility as normal components of learning, the study provides a human-centered instructional perspective capable of reducing mathematics anxiety, strengthening persistence, and fostering enduring interest in mathematics. Such approaches are particularly relevant within digitally transforming educational systems, where sustaining students' motivation and engagement remains a major educational challenge (Davor, Asare, et al., 2026).

Accordingly, the study sought to answer the following research questions:

RQ 1) To what extent does exposure to the history of mathematical fallibility influence SMI?

RQ 2) How does exposure to the history of mathematical fallibility affect students' competence motivation in mathematics?

RQ 3) What is the effect of competence motivation on SMI?

RQ 4) Does competence motivation mediate the relationship between exposure to the history of mathematical fallibility and SMI?

2. Theoretical Framework

The present study is grounded in Self-Determination Theory and the Four-Phase Model of Interest Development (Hidi & Renninger, 2006), while also considering that the history of mathematics is a uniquely human and error-prone process. The combined effect of these theories is that examining historical mathematical errors and their corrections may enhance SMI by bolstering their sense of competence. Competence is one of the three basic psychological needs that drive students' intrinsic motivation to learn (Ryan & Deci, 2000). In mathematics, where students often believe that only the talented can succeed, studying the history of mathematical missteps and corrections can help students feel that mathematics is attainable, thereby increasing their self-confidence. Competence motivation is defined in this study as students' perception that they can overcome the challenges of mathematics, and is the key mediating variable.

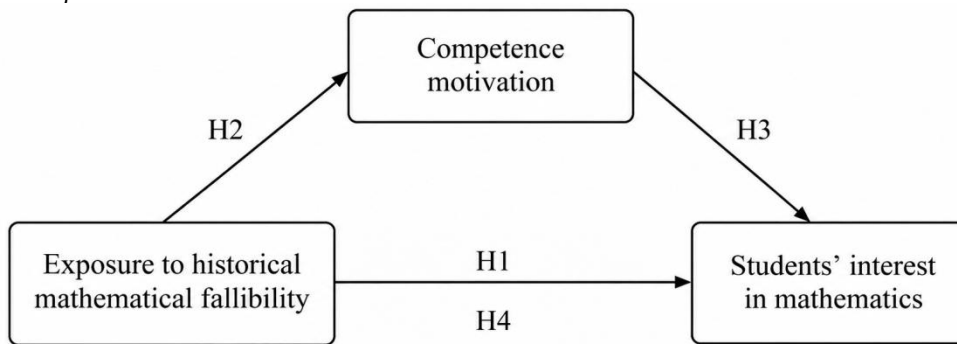
The history of mathematical fallibility focuses on the mistakes, struggles, and corrections that were necessary to the development of mathematical concepts, thus showing that the history of math is not one of perfect truths, but rather one of dynamic human endeavours (Glas, 1998). According to Arthur et al. (2022) and Gyasi Alfred et al. (2024), using the history of mathematics as a dynamic narrative can reduce students' anxiety, break the fixed-ability mindset, and make mathematics more approachable. Using social-cognitive theory, the missteps and struggles of expert mathematicians can serve as powerful vicarious learning experiences, enhancing students' sense of competence (Bandura, 1986). In this study, we propose that using the history of mathematical fallibility will enhance students' competence motivation.

We base our study of SMI on the Four-Phase Model of Interest Development, which distinguishes between situational interest, generated by students' instructional experiences, and individual interest, which is more intrinsic and can be generated by perceiving value and competence (Hidi & Renninger, 2006). Research indicates that seeing one's own competence is vital for developing interest in mathematics from situational interest to individual interest (Boadu & Boateng, 2024; Boateng et al., 2024). Using the above theories, we propose a mediation model in which exposure to the history of mathematical fallibility enhances students' competence motivation, which, in turn, increases their interest in mathematics. Although there is also a direct effect, whereby exposure to the history of mathematical fallibility enhances interest in mathematics, the main effect is mediated by the satisfaction of students' competence needs. This theoretically grounded model is tested using Structural Equation Modeling (SEM) to examine both direct and indirect effects among the study variables.

3. Conceptual Framework

Figure 1 illustrates the conceptual framework for this study. Three constructs were used in this study, namely, exposure to historical mathematical fallibility (HMF), competence motivation (SCM), and SMI. In Figure 1, exposure to historical mathematical fallibility (HMF) is the independent variable, competence motivation (SCM) is the mediating variable, and SMI is the dependent variable. Moreover, exposure to historical mathematical fallibility (HMF) shows a direct effect on SMI and students' competence motivation (SCM). In addition, competence motivation (SCM) shows a direct effect on SMI.

Figure 1
Conceptual Framework



Note. SCM = Students' competence motivation; HMF = Historical mathematical fallibility; SIM = Student interest in mathematics. Source. Authors' Creation, 2026.

4. Method

4.1. Research Design

The study adopted a quantitative approach using a cross-sectional survey design. Quantitative research is well-suited to examining how latent variables relate to one another and to examining theory-driven relationships among variables using numerical data. The method enables researchers to examine direct and indirect relationships among variables using Structural Equation Modeling (SEM) (Sterner et al., 2024). The data was collected using a structured questionnaire from undergraduate students.

4.2. Participants and Sampling Procedure

The study involved 285 first-year undergraduate students enrolled in the BSc Mathematics Education programme at Akenten Appiah-Menka University of Skills Training and Entrepreneurial Development (AAMUSTED), Kumasi, Ghana. The participants comprised both male and female students within the age range typically associated with first-year university education. Of the 285 participants, 162 (56.8%) were male and 123 (43.2%) were female. All participants were first-year undergraduate mathematics education students enrolled in foundational mathematics and pedagogy courses during the period of data collection. First-year mathematics education students were selected because they are at a critical stage in developing mathematical confidence, motivation, and long-term interest in mathematics. The final sample of 285 participants was considered adequate for covariance-based structural equation modeling and exceeded recommended minimum thresholds for stable parameter estimation (Wolf et al., 2013). Stratified sampling followed by simple random sampling was employed. Students were first grouped according to programme structure to ensure proportional representation across instructional groups, after which respondents were randomly selected within each stratum. This procedure was intended to improve sample representativeness and reduce sampling bias.

4.3. Instrument and Measures

A structured questionnaire served as the primary data-gathering instrument for the study. The questionnaire was designed in line with the study's conceptual framework and research questions and was developed to measure students' exposure to the history of mathematical fallibility, their competence motivation, and their interest in mathematics. The survey consisted of two major sections. Section A requested respondents' basic demographic information: gender, age, and academic program. Section B was designed to measure the underlying factors of History of Mathematical Fallibility (HMF), Student Competence Motivation (SCM), and Math Interest (SMI). All the items in the questionnaire were based on a five-point Likert scale ranging from strongly agree (1) to strongly disagree (5).

The History of Mathematical Fallibility construct comprised six items. These items are based on the history of mathematics and mathematical humanism, which focus on errors, paradoxes, and

the development of mathematical ideas over time (Asare & Boateng, 2025). Examples of the items are: *"Knowing that mathematicians made mistakes makes me feel less pressured when learning mathematics,"* *"Seeing how mathematical ideas developed through mistakes gives me confidence in my own learning process,"* and so on. These items are expected to shed light on students' understanding of the value of history in viewing mathematics as a human science rather than a collection of facts.

In the Competence Motivation section, six items were developed in accordance with the competence motivation literature, in which self-determination is considered the foundation (Ryan & Deci, 2000). The items assess students' intrinsic motivation for learning mathematics, particularly their ability to make it easier through their own efforts. Sample items are: *"I am motivated to learn mathematical concepts that I initially find difficult,"* and *"I learn mathematics to prove to myself that I can learn it."*

For the measurement of Mathematics Interest, six items were adopted from existing scales (Boateng et al., 2024; Bright et al., 2024). The items measure situational and personal interest in mathematics. Sample items are: *"Mathematics is one of the most interesting subjects I study,"* and *"I would study mathematics even if it were not required."* The study employed a theory-driven pre-existing scale to ensure reliability and validity, as recommended by Kalavasis and Moutsios-Rentzos (2023) and Roth (2008). The study also avoided creating items from scratch, as recommended by Raj and Aithal (2020). Although the questions were derived from previous well-established research, some adjustments were made to enhance their clarity and appropriateness for the study's objectives in the Ghanaian university context.

4.4. Data Analysis Procedure

The analysis was done using SPSS (version 23) and AMOS (version 23). The analysis procedure was done in five steps. First, descriptive statistics were used to assess the missing data and participant demographics. Second, Exploratory Factor Analysis (EFA) was employed to assess the factor structure and item loadings. The analysis was done using a 0.50 threshold. Third, Confirmatory Factor Analysis (CFA) was employed to assess the measurement model, including construct reliability, convergent validity, and discriminant validity. Fourth, the model was tested using various indices, including the chi-square statistic, chi-square/df, CFI, TLI, and RMSEA. Fifth, the direct and mediating relationships between HMF, CM, and MI were tested using SEM.

5. Results

5.1. Data Validity and Reliability

To ensure that the questionnaire measured the intended construct, content validity was employed. The questionnaire was first validated by five experts, consisting of three senior researchers and two lecturers from the Department of Mathematics Education, all of whom were knowledgeable in quantitative research. They assessed the extent to which the instrument clearly measured the History of Mathematical Fallibility (HMF), the Students' Competence Motivation (SCM), and the Students' Mathematics Interest (SMI). Following the review, minor adjustments were made to the instrument to improve its clarity and reduce ambiguity, thereby increasing its relevance to Ghanaian higher learning institutions.

Internal consistency reliability was assessed using SPSS 23. Although Cronbach's alpha is the most commonly used, McDonald's Omega (ω) was used in preference to Cronbach's alpha, given its robustness in the measurement of latent variables (Davor et al., 2025; Dunn et al., 2014). Table 1 shows that all constructs met the acceptable reliability standard, with all omega values exceeding 0.70. From the study results, the History of Mathematical Fallibility (HMF) had an omega value of 0.856; Students' Competence Motivation (SCM) had 0.857, and the Students' Mathematics Interest (SMI) had 0.865.

Table 1 indicates that all study constructs demonstrated satisfactory internal consistency reliability. The omega coefficients for HMF, SCM, and SMI all exceeded the recommended threshold of 0.70, suggesting that the measurement items consistently captured their respective latent constructs.

Table 1
The Reliability Analysis

Variables	Number of items	McDonald's Omega (ω)
History of Math Fallibility (HMF)	6	.856
Students' Competence Motivation (SCM)	5	.857
Students' Mathematics Interest (SMI)	6	.865

5.2. Exploratory Factor Analysis and KMO and Bartlett's Test

First, we assessed whether the measurement model was appropriate for factor analysis using SPSS v23. To ensure that EFA was appropriate, the data were also checked using the KMO measure and Bartlett's Test of Sphericity before any factors were extracted. As shown in Table 2, the KMO value is 0.875, indicating adequate sampling adequacy. Moreover, the result of the Bartlett's Test of Sphericity is significant: $\chi^2 = 2146.950$, $df = 136$, $p < .001$. Thus, the correlation matrix is appropriate for factor analysis. As expected, the results supported our model in all three dimensions: HMF, SCM, and SMI. Additionally, all items were strongly related to their respective factors, with loadings well above the 0.50 threshold (Boateng et al., 2026; Marsh et al., 2020). Furthermore, the three factors accounted for a total variance of 60.46%, which is acceptable in educational research. Additionally, the determinant of the matrix is 0.001, which is well below the threshold and thus indicates that multicollinearity is not severe.

Table 2
Exploratory Factor Analysis (EFA) and KMO and Bartlett's Test

Measurement Items	Rotated Component Matrix		
	Component		
	1	2	3
HMF1			.782
HMF3			.791
HMF4			.736
HMF6			.847
HMF7			.650
HMF8			.700
SCM1		.807	
SCM2		.726	
SCM3		.792	
SCM4		.811	
SCM6		.795	
SMI1	.749		
SMI4	.772		
SMI5	.768		
SMI6	.778		
SMI7	.764		
SMI8	.742		
KMO and Bartlett's Test			
Total Variance Explained (TVE)			60.460%
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.			.875
Bartlett's Test of Sphericity	Approx. Chi-Square		2146.950
	df		136
	Sig.		<.001
Determinant			0.001

The EFA results confirmed the three-factor structure underlying the study constructs. All retained items loaded strongly on their respective components with no substantial cross-loadings,

supporting the construct validity of the instrument. The total variance explained further indicates that the extracted factors adequately represented the underlying dimensions of the study variables.

5.3. Confirmatory Factor Analysis

Confirmatory Factor Analysis (CFA) run in Amos (v. 23) was performed after EFA analysis. The measurement items were used to conduct CFA. After performing the CFA, we observed that all measurement items' loadings exceeded the minimum threshold of 0.5, as recommended by Hair et al. (2019). Marsh et al. (2020) model-fit criteria were used to assess whether the measurement items fit the model. CFA is reported in Table 3.

Table 3

The model fit indices

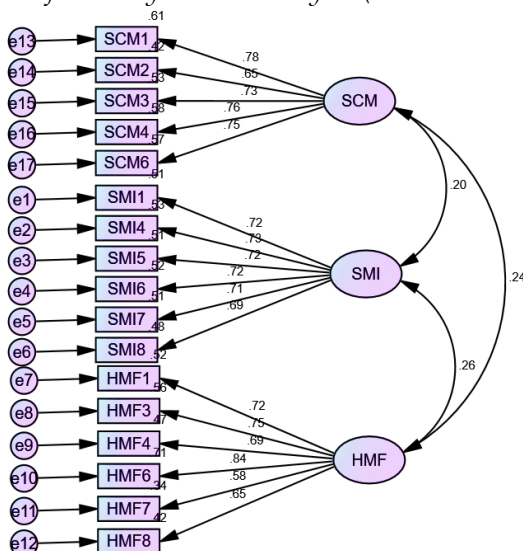
Measures	Estimates	Standard	Interpretation	Source
CMIN	152.750	The smaller the better		
DF	116	The smaller the better		
CMIN/DF	1.317	Between 1 and 3	Excellent	Hu and Bentler (1999)
TLI	.978	> 0.95	Excellent	Hair et al. (2019)
CFI	.981	> 0.95	Excellent	Hu and Bentler (1999)
NFI	.927	> 0.90	Excellent	Hu and Bentler (1999)
GFI	.944	> 0.90	Good fit	Hu and Bentler (1999)
RMSEA	.032	< 0.08	Excellent	Hu and Bentler (1999)
PClose	.795	> 0.05	Excellent	Hair et al. (2019)
SRMR	.064	< 0.08	Good fit	Hu and Bentler (1999)

5.3.1. Model fitness measures

The chi-square test compares the observed covariance matrix to the modeled or theoretical covariance matrix. However, the chi-square test is highly sensitive to sample size and can yield significant results even when the model fits well. The chi-square statistic also depends on the degrees of freedom, which are determined by the number of observed variables and the number of model parameters. The CMIN/DF ratio should typically range from 1 to 3. As the CMIN/DF ratio exceeds 1.000, as shown in Table 3, the model fit is excellent. Model quality is compared with the baseline using the Comparative Fit Index (CFI). The CFI is 0.981, which is excellent and well above the 0.95 threshold. The SRMR is 0.064, well below the 0.08 threshold, indicating that the residuals are negligible and that the model is a good fit. For the RMSEA, the result is 0.032, which is close to the ideal value of 0.06. For the PClose p-value, the result is 0.795, which is still within the acceptable range and not significantly different from the standard value (see Figure 2).

Figure 2

Confirmatory Factor Analysis (Source: Authors' Creation, 2026)



The model fit indices presented in Table 3 indicate that the measurement model achieved satisfactory fit across all major criteria. The values of CFI, TLI, RMSEA, and SRMR all met recommended thresholds, suggesting that the proposed measurement structure adequately represented the observed data.

Figure 2 presents the Confirmatory Factor Analysis (CFA) model for the three latent constructs examined in the study: History of Mathematical Fallibility (HMF), Students' Competence Motivation (SCM), and Students' Mathematics Interest (SMI). The standardized factor loadings indicate that the observed items adequately loaded onto their respective latent constructs, thereby supporting the construct validity of the measurement model.

Table 4 presents the standardized factor loadings, composite reliability (CR), and average variance extracted (AVE) values for the study constructs. All factor loadings exceeded the recommended threshold of 0.50, indicating satisfactory item reliability. Additionally, the CR values exceeded 0.70 and the AVE values were above 0.50, thereby supporting the convergent validity and internal consistency reliability of the measurement model.

Table 4

Confirmatory Factor Analysis (CFA)

Items	Loadings
History of Math Fallibility (HMF); CR = .857; AVE = .502	
HMF1: Knowing mathematicians made mistakes makes me feel less pressured	.718
HMF2: Historical struggles in math make the subject feel more relatable.	.749
HMF3: Seeing how geniuses failed encourages me to keep trying.	.687
HMF4: Learning about wrong historical ideas makes math feel more creative.	.841
HMF5: Historical debates show me it is okay to question math rules	.582
HMF6: Seeing math evolve from errors gives me confidence in my journey	.648
Competence Motivation (CM): CR = .855; AVE = .542	
SCM1: I am driven to master math concepts that I find difficult	.783
SCM2: I believe I have the skills to solve tough math problems	.646
SCM3: I practice math to prove to myself that I can understand it	.730
SCM4: I feel a sense of power when I solve a complex math challenge	.761
SCM5: My goal is to master math, not just pass the test	.753
Mathematics Interest (SMI): CR = .863; AVE = .512	
SMI1: I find the logic of mathematical discovery fascinating	.716
SMI2: I enjoy talking about math outside of my school work	.730
SMI3: Math is one of the most interesting subjects I study	.717
SMI4: I am curious about real-world uses of the math I learn	.723
SMI5: I would study math even if it weren't a required subject	.711
SMI6: Learning about the origins of math has increased my interest	.694

5.4. Discriminant Validity Analysis

Discriminant validity was assessed using the Fornell-Larcker criterion. This approach compares the square root of the Average Variance Extracted (AVE) of each construct to the correlations of that construct with the others. When the square root of the AVE of a construct is greater than its highest correlation with any other construct, then the discriminant validity is established. This is because the construct correlates more with its own indicators than with any other latent construct (Fornell & Larcker, 1981). As shown in Table 5, the square roots of AVE for History of Mathematical Fallibility (HMF), Students' Mathematics Interest (SMI), and Students' Competence Motivation (SCM) were 0.709, 0.715, and 0.736, respectively. Overall, these values exceeded the inter-construct correlations. Furthermore, for each construct, the Maximum Shared Variance (MSV) and Average Shared Variance (ASV) were less than their respective AVEs, thereby supporting discriminant validity. This pattern indicates that the constructs are distinct and that discriminant validity is established for the measurement model.

The discriminant validity results in Table 5 indicate that each construct was empirically distinct from the others. The square roots of the AVE values exceeded the inter-construct correlations,

while both MSV and ASV remained lower than the AVE values for each construct, thereby supporting discriminant validity.

Table 5
Discriminant Validity

Variables	CR	AVE	MSV	ASV	HMF	SMI	SCM
HMF	0.857	0.502	0.066	0.061	0.709		
SMI	0.863	0.512	0.066	0.053	0.257***	0.715	
SCM	0.855	0.542	0.056	0.047	0.236***	0.198***	0.736

Note. ***Denotes p-value less than 1% significance level; $\sqrt{AVE}$ values are in bold and italic.

5.5. Path Results

A covariance-based structural equation modeling (CB-SEM) analysis was conducted using AMOS (version 23). CB-SEM is especially effective for evaluating theoretical models, enabling researchers to define and examine the intricate relationship between observed and latent variables, thereby confirming its suitability for examining theoretical relationships among latent variables. The estimate was calculated using the Bias-Corrected (BC) percentile method of bootstrapping, which involved 5,000 bootstrap samples and a 95% confidence interval. Table 6 displays the proposed results.

Table 6
Path Summary

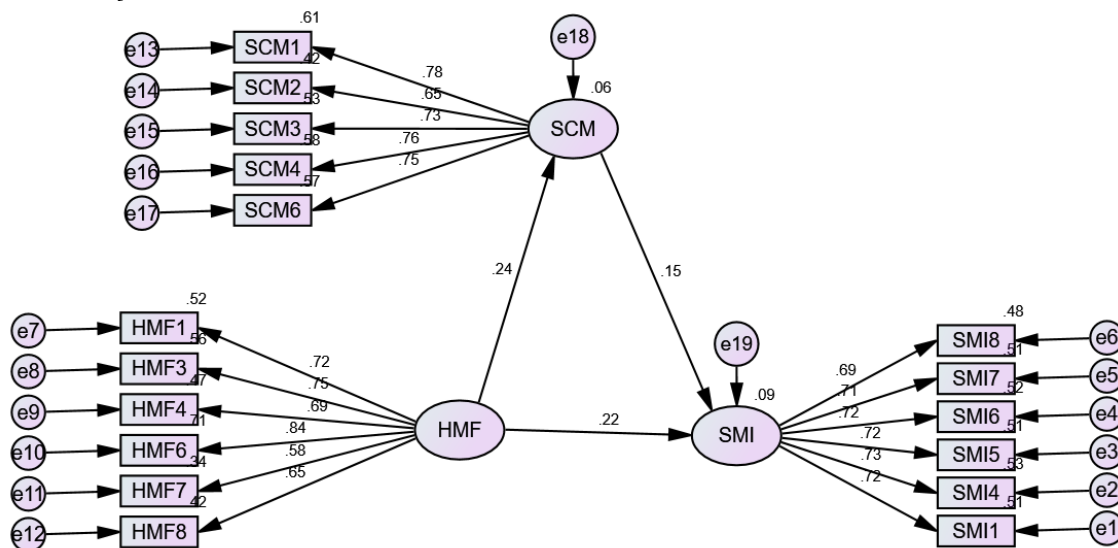
Direct Effect	Std. Est.	S.E.	C.R.	p-value
HMF→ SMI	.217	.073	3.247	.001
HMF→ SCM	.243	.073	3.513	***
SCM→ SMI	.152	.066	2.157	.031
Indirect Effect	Std. Est.	L. B	U. B	p-value
HMF→SCM→SMI	.037	0.016	.109	.001

Note. *** $p < .001$.

Figure 3 illustrates the structural path model showing the direct and indirect relationships among History of Mathematical Fallibility (HMF), Students' Competence Motivation (SCM), and Students' Mathematics Interest (SMI). The model demonstrates that exposure to historical mathematical fallibility positively predicts students' competence motivation and mathematics interest, while competence motivation also positively predicts SMI.

Figure 3

Path Analysis (Source: Authors' Creation, 2026)



5.5.1. Effect of historical mathematical fallibility on SMI

From Table 6, History of Mathematical Fallibility demonstrated a positive and statistically significant direct effect on Students' Mathematics Interest, with a standardized coefficient of $\beta = 0.217$. The standard error was 0.073, the critical ratio was 3.247, and the p -value was .001. The findings indicate that History of Mathematical Fallibility positively influences Students' Mathematics Interest.

5.5.2. Effect of historical mathematical fallibility on competence motivation

As shown in Table 6, History of Mathematical Fallibility demonstrated a significant positive effect on Students' Competence Motivation (SCM) ($\beta = 0.243$). The corresponding standard error was 0.073, the critical ratio was 3.513, and the effect was statistically significant at $p < .001$. The findings therefore indicate that exposure to historical mathematical fallibility positively influences students' competence motivation. This finding indicates that the experience of mathematical fallibility can actually enhance students' confidence in their ability to succeed, not only in mathematics but in general. By making this uncertainty more normal and reminding students that ability increases with effort and perseverance, students may become more confident in their abilities.

5.5.3. Effect of competence motivation on SMI

The research results revealed that feelings of competence and motivation in mathematics are significant predictors of SMI ($\beta = 0.152$; $SE = 0.066$; $t = 2.157$; $p = .031$). The findings indicate that competence motivation positively predicts SMI. In brief, students who feel competent and motivated in mathematics have a high level of interest in the subject. In a sense, motivation is the driving force behind students' emotional engagement in mathematics learning.

5.5.4. Mediating role of competence motivation

There is a significant indirect effect of the history of mathematical fallibility on students' math interest via students' competence motivation ($\beta = 0.037$, 95% CI [0.016, 0.109], $p = .001$). Because the confidence interval does not include zero and the direct effect from HMF to SMI remains significant, the findings confirm a significant partial mediation effect of competence motivation. This implies that while historical perspectives on mathematical fallibility directly enhance students' interest, they also do so indirectly by strengthening students' competence-related motivational beliefs.

6. Discussion

6.1. Effect of Historical Mathematical Fallibility on SMI

The notion that the History of Mathematical Fallibility can increase SMI supports the long-held assertion that when mathematics is made more human, people become more emotionally engaged with it. When math is presented as a body of knowledge developed from conjecture, error, correction, and ongoing debate, rather than as a completed set of absolute truths, it no longer feels so remote. For a long time, many people have argued that the way math is presented as an absolute, unchanging truth drives students away from it and kills their curiosity (Carter, 2019; Davis, 2003; Eccles & Wigfield, 2002; Glas, 1998). When students are exposed to the real challenges and failures that even mathematicians have encountered, mathematics is no longer abstract but is imbued with life. Using the history of mathematics to portray mathematics to students can spark their interest and foster a positive attitude by grounding mathematical concepts in the real-world struggles of real people (Kjeldsen & Carter, 2014). In Ghana's higher education sector, where mathematics is already perceived as rigid and test-oriented, this approach to mathematics becomes all the more significant (Asare & Boateng, 2025; Arthur et al., 2022).

The findings also align with recent international discussions emphasizing the importance of humanizing mathematics instruction to sustain learners' emotional engagement and participation in mathematics education. Research increasingly shows that students demonstrate stronger engagement when mathematics is presented as a socially constructed and intellectually dynamic

discipline rather than a rigid collection of procedures (Blåsjö, 2024; Davor, Asare, et al., 2026; Felgner, 2023). Within sustainable education discourse, instructional approaches that normalize uncertainty and intellectual struggle are considered important for fostering resilient and lifelong learners capable of persisting in cognitively demanding environments.

6.2. Effect of Historical Mathematical Fallibility on Competence Motivation

Recognizing that even the best math students make mistakes, struggle with concepts, and are not perfect themselves helps them to develop new ways of thinking about their own competence. Recognizing that struggle is part of the normal learning process helps students see that competence develops over time rather than being an innate gift. This approach is consistent with mastery-oriented theories of motivation (Eccles & Wigfield, 2002; Ryan & Deci, 2000). Research indicates that teaching methods that emphasize effort, the learning process, and intellectual challenges can increase students' motivation to learn mathematics (Carter, 2019; Gyasi Alfred et al., 2024). The study extends these findings by demonstrating that providing a historical account of fallibility in mathematics can serve as an incidental motivational tool to increase students' confidence in their potential to succeed. This is particularly important in math learning environments in which a high failure rate undermines students' self-confidence.

The findings additionally support recent perspectives in motivational psychology suggesting that instructional environments emphasizing growth, struggle, and revision strengthen students' adaptive motivational beliefs and academic resilience. Studies within higher education contexts have shown that students develop stronger competence beliefs when failure is framed as part of the learning process rather than evidence of inability (Boadu & Boateng, 2024). This suggests that historical narratives of mathematical fallibility may function as psychologically supportive instructional tools capable of sustaining learners' confidence in challenging mathematical environments.

6.3. Effect of Competence Motivation on SMI

The finding that competence motivation is a strong predictor of math interest is consistent with expectancy-value theory, which holds that when students believe they can succeed at a task and value the outcomes, they will become more interested (Eccles & Wigfield, 2002). When students believe they are competent in mathematics, they tend to challenge themselves more, find the subject more enjoyable, and remain interested in it over time. Past research has established that the belief about one's competence is the most powerful predictor of interest and persistence in math across various educational levels (Ryan & Deci, 2000). This is also the case in the math class, implying that interest is also a function of one's perception of their own motivation.

6.4. Mediating role of competence motivation

The mediation results suggest that competence motivation mediates the effect of the History of Mathematical Fallibility intervention on math interest. In other words, the math interest-enhancing effect of the intervention is due not only to the increase in the enjoyment of math as a subject but also to the increase in the perception of one's competence to perform math. This is consistent with general motivational and learning theories suggesting that the effectiveness of learning interventions is partly explained through underlying motivational and self-regulatory processes (Davor, Boateng, Osei-Wusu, et al., 2026). When instructional approaches normalize fallibility, fear may decrease while confidence increases, thereby increasing SMI. However, because the mediation is partial, other factors, such as students' epistemological beliefs or their emotional responses to mathematics, may also play a role and warrant further investigation. From a sustainable education perspective, the mediation effect is particularly important because it demonstrates that long-term SMI is not generated solely through curriculum exposure but through motivational processes that support learners' psychological needs. Sustainable mathematics education increasingly requires pedagogical approaches capable of maintaining students' persistence, confidence, and emotional engagement over time, especially within rapidly transforming digital learning environments.

7. Conclusion

This research examined the influence of the history of mathematical fallibility on SMI, both directly and indirectly, through competence motivation. The results demonstrate that treating mathematics as a trial-and-error endeavour in mathematics instruction positively influences SMI. Moreover, the findings suggest that such instructional approaches may strengthen students' competence-related beliefs and academic confidence. This is because competence motivation partially mediates the relationship between mathematics history and interest in mathematics. This suggests that integrating historical perspectives into mathematics instruction may enhance students' perceived relevance of mathematics while simultaneously strengthening their confidence in learning the subject. The results of this research demonstrate the potential benefits of using history to teach mathematics. This is important for teachers because it provides a free, theoretically grounded method for enhancing motivational and affective outcomes in mathematics. This research provides empirical support for psychologically supportive instructional approaches capable of strengthening students' motivational engagement in mathematics within higher education contexts, consistent with recent mathematics education research emphasizing the importance of instructional support and learner-centered pedagogies (Davor, Boateng, & Akweitley, 2026). The study therefore contributes to sustainable education discourse by demonstrating that mathematics instruction grounded in historical human experiences may support emotionally sustainable and motivationally supportive learning environments. Integrating narratives of mathematical struggle into instruction may help universities promote long-term student engagement and persistence in mathematics within contemporary digitally transforming educational systems.

8. Limitations and Future Research

This study has some limitations that should be considered when interpreting the findings. First, the cross-sectional design limits causal interpretation of the relationships among the study variables. Future studies may employ longitudinal or experimental designs to examine how exposure to historical mathematical fallibility influences students' motivation and interest over time. Second, the study relied on self-reported questionnaire data, which may be affected by social desirability and response bias. Third, the study was conducted among undergraduate mathematics education students within a single Ghanaian university context, which may limit the generalizability of the findings to other educational settings. Future research may therefore replicate the study across different educational levels, cultural contexts, and disciplinary areas to strengthen external validity.

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