Research Article

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Examining the mediating role of teachers' self-efficacy on realistic mathematics education: A structural equation modeling approach

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ABSTRACT

This study aimed to examine how teachers' self-efficacy mediates the relationship between realistic mathematics education and learners' mathematics achievement, which involved 396 junior high school math teachers and a sample of 7621 students. The study employed a quantitative approach with a correlational cross-sectional descriptive survey design. The questionnaires were developed with consideration for the three main constructs that the study identified. The structural equation model was used to analyze the questionnaires. The findings demonstrated that the application of realistic mathematics teaching methods directly improves students' mathematical achievement. Once more, students' achievement in mathematics is directly positively impacted by teachers' self-efficacy. Ultimately, there was a positive and statistically significant mediation effect of teacher self-efficacy on the relationship between learners' mathematical achievement results and realistic mathematics education.

Keywords: mathematics achievement, realistic mathematics education, teacher self-efficacy

INTRODUCTION

Learning mathematics is an essential part of everyday life (Akosah et al., 2024). Recognized globally as a fundamental tool for national development, mathematics is integrated into the core curricula of many countries (Japelj Pavešić et al., 2022). In Ghana and other countries, mathematics is mandatory for all learners at the basic education level and serves as a prerequisite for advanced studies (Ampofo, 2019). Despite its importance, mathematics is often viewed as a problematic subject (Eze, 2021). Eze (2021) highlighted the persistent struggle for Ghanaian learners to excel in mathematics. Over the years, their performance has remained consistently low. Recent data from Nugba et al. (2021) reveals that between 2016 and 2022, about 3,669,138 learners took the Basic Education Certificate Examination (BECE), with 1,562,270 (43%) failing to meet the criteria for secondary or vocational education (Ghana Education Service [GES], 2022). In August 2023, out of 602,457 BECE candidates, 36,849 (8%) were not admitted to senior high school due to poor grades in English or Mathematics (Ansah et al., 2023). This ongoing issue raises concerns about the country's educational system and its implications for the science and technology sectors (Ampofo, 2019). Addressing the low mathematics performance is crucial, necessitating an investigation into the factors that can enhance learners' academic success in this subject. Effective mathematics teaching requires appropriate strategies and methods.

Numerous classroom factors have been identified as influential in learners' mathematics success (Hepburn et al., 2020; Owusu et al., 2022). For example, Hepburn et al. (2020) emphasized the importance of classroom management and learner interest in mathematics. Fadda et al. (2022) similarly noted the significance of classroom organization and management. Arthur et al. (2017) pointed out that teacher quality, motivation, instructional effectiveness, and self-efficacy are critical to learners' mathematics achievement. Teachers as well as learners contribute to the teaching and learning process, and examining variables that impact mathematics learning is essential. Innovations in pedagogy, teacher characteristics, and learners' mathematical performance are among these critical variables (Gkontelos et al., 2023). Chand et al. (2020) argue that teachers play a crucial role in innovative teaching by integrating classroom and real-world experiences.

Mathematics curricula are continually adapted to meet evolving educational needs. The new junior high school mathematics curriculum in Ghana is standards-based and features a constructivist approach (NaCCA, 2019). According to the Ministry of Education (2020), this curriculum includes diverse teaching activities and assessment methods, aiming to build learners' confidence and foster creative problem-solving skills. Realistic Mathematics Education (RME) principles underpin this approach, promoting practical skills and critical thinking (Aksu & Colak, 2021). Research indicates that RME-based educational materials can enhance learning outcomes (Aksu & Colak, 2021). Laurens et al. (2017) describe RME as an innovative teaching strategy that makes mathematics relevant to learners' lives. Bayles et al. (2021) further explain that RME encourages active engagement and discovery in mathematics through the use of real-world contexts.

RME was developed by Hans Freudenthal, who believed that mathematics originated from real-life problem-solving (Aksu & Colak, 2021). Teaching should prioritize sense-making at all stages, aligning with Freudenthal's view of mathematics as a human invention (Bildircin, 2012). By applying RME principles, learners can address real-world problems, discuss solutions, and develop logical conclusions collaboratively. This approach can transform the challenging nature of mathematics into a positive learning experience (Aksu & Colak, 2021). RME allows for the use of real-life and fantasy-based problems, making mathematics engaging and accessible (Batlolona et al., 2019).

Teaching mathematics involves more than imparting knowledge; it addresses various challenges, such as low student motivation, inadequate teacher preparation, and diverse classroom abilities (Burić & Kim, 2020). Effective teaching requires dedication, capability, and self-efficacy (Bandura, 1997). Teachers' self-efficacy is crucial for improving learners' academic, emotional, and social outcomes (Arthur et al., 2022). High self-efficacy beliefs among teachers lead to better educational results (Hosseini & Haghighi Shirazi, 2021; Turkoglu et al., 2017). Teachers' self-efficacy encompasses their confidence in their ability to achieve educational goals (Suren & Ali Kandemir, 2020; Turkoglu et al., 2017). In Ghana, teachers' self-efficacy beliefs are vital for educational success but often overlooked (Nugba et al., 2021). Without confidence in their abilities, teachers may struggle to meet educational standards (Owusu et al., 2022).

This research aims to explore the link between classroom variables and the effect of JHS mathematics teachers' self-efficacy on learners' mathematics achievement and the RME pedagogical approach. Specifically, it examines how teachers' self-efficacy influences learners' mathematics attainment and engagement during classroom discussions.

Statement of the Problem

This study explores the effects of RME principles in Ghanaian junior high schools during the 2023–2024 academic year. Various classroom factors can influence the mathematics performance of JHS learners, either positively or negatively. Previous research (Adamoah & Acquah, 2016; Fletcher, 2018; Gichuru & Ongus, 2016) has largely concentrated on JHS learners' poor performance in internal and external examinations, often neglecting other crucial factors such as learners' backgrounds and prior knowledge, which could affect their mathematics achievement. Further studies have investigated factors influencing mathematics performance related to teachers, students, and cognitive processes (Akpo, 2012; Anney & Bulayi, 2020; Ewetan & Ewetan, 2015; Gichuru & Ongus, 2016; Yusuf & Dada, 2016).

This study argues that focusing solely on cognitive factors may not adequately predict mathematics achievement. Other classroom variables, including pedagogical strategies like RME and teacher self-efficacy, play a critical role in learners' mathematics success (Gkontelos et al., 2023). Given their established relevance to mathematics teaching and learning, both RME and teacher self-efficacy are likely to have a direct effect on learners' mathematical performance. While significant research has addressed RME, teacher self-efficacy, and learners' mathematics achievement, this study aims to delve into the mediating role of teacher self-efficacy in the relationship between RME and mathematics achievement. Therefore, the purpose of this study is to examine how the integration of RME implementation and teacher self-efficacy influences learners' mathematics achievement during classroom interactions.

Research Objectives

1. "To find out the impact of realistic mathematics education principles on learners' mathematics achievement".
2. "To find out the impact of realistic mathematics education principles on teachers' self-efficacy".
3. "To find out the impact of teachers' self-efficacy on learners mathematics achievement".
4. "To determine the mediating effect of teachers' self-efficacy on the relationship between realistic mathematics education principles and mathematics achievement".

Significance of the Study

Honestly, mathematics education can never thrive well if we do not critically look at the teachers who are supposed to implement the curriculum, mentor, facilitate and teach our learners (Edo et al. 2024). This is one of the main reasons why it is necessary to conduct a study on the pedagogical approaches and teacher variables that influence learners' mathematics achievement in Ghana. Educators and policy makers' understanding of these teacher variables is key to making informed decisions about future educational practices. The results on realistic mathematics education and teacher self-efficacy will not only contribute to academic research but also provide valuable deeper understanding for teachers, enhance their classroom practices and above all benefiting learners.

LITERATURE REVIEW

Theoretical Framework

The theoretical framework for this research is grounded in Bandura's Social Cognitive Theory (SCT) and Constructivist Learning Theory. These theories provide a comprehensive understanding of how educational approaches, teacher beliefs, and knowledge influence student achievement.

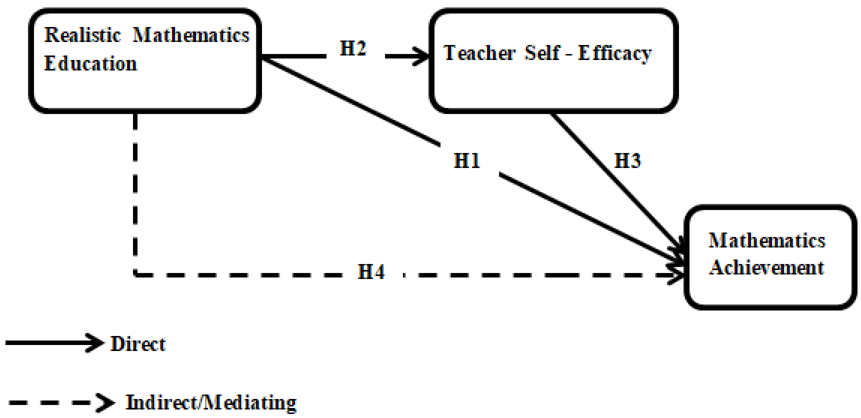

Figure 1. Conceptual framework of the study (Source: Field survey, 2024)

Bandura's Social Cognitive Theory (SCT)

Self-efficacy, as defined by Bandura (1997), refers to an individual's belief in their capability to execute actions required to achieve specific performance outcomes. In the educational context, teachers' self-efficacy pertains to their confidence in addressing teaching challenges and their ability to learn continuously from their surroundings and experiences to be successful educators (Musadad et al., 2022). This belief in one's capabilities plays a significant role in shaping instructional practices and learners' learning outcomes (Musadad et al., 2022). Teachers with high self-efficacy tend to employ more effective teaching methods, which positively influence student performance (Sánchez-Rosas et al., 2023).

Constructivist Learning Theory

Constructivist approaches to teaching emphasize the value of students actively participating in problem-solving and critical thinking tasks. Realistic Mathematics Education (RME) aligns with this theory by emphasizing real-world problem-solving and contextual learning, which are intended to make mathematical concepts more meaningful and understandable for students. Piaget (1970) and Vygotsky (1978) developed this theory, which holds that learners construct knowledge through interactions with their environment and through social interactions.

Conceptual Framework

A conceptual framework was created to direct the study following a thorough evaluation of the literature. The theoretical ideas and study factors were shown in **Figure 1** in a visual way. In this study, mathematical achievement (MA) served as the dependent variable, realistic mathematics education (RME) served as the primary independent variable, and teachers self-efficacy (TSE) served as the mediating variable. According to the conceptual framework, RME directly affects JHS learners' MA. RME is also thought to have an indirect effect on MA through its favorable effect on TSE in mathematics.

Effect of Realistic Mathematics Education (RME) on Mathematics Achievement

Since the 1960s, Realistic Mathematics Education (RME) has significantly influenced mathematics education worldwide. This approach engages students by presenting them with contextual problems that capture their interest, while teachers facilitate their rediscovery of mathematical concepts (Freudenthal, 1991). Each student requires unique support, and mathematics teachers must tailor their assistance to individual needs, thereby enhancing classroom interactions and fostering positive attitudes toward mathematics (Hwang & Son, 2021). Numerous empirical studies highlight the benefits of RME on students' mathematical achievement. For example, Tamur et al. (2020) conducted a meta-analysis on 72 studies in Indonesia, finding that RME-based teaching methods significantly improved student performance. Trung et al. (2019) argue that contextualized learning in RME enhances students' mathematical reasoning and problem-solving skills. This approach has been demonstrated to enhance students' motivation and comprehension of mathematical concepts (Arthur, 2019). Bildircin (2012) investigated the impact of RME on students' attitudes and success in learning "length, area, and volume." The study involved 37 fifth graders, divided into experimental and control groups. Data were collected using a mathematics achievement test, an attitude scale, and open-ended questionnaires to gather students' opinions on the RME approach. The findings indicated that RME-based activities were more effective than traditional teaching methods for these concepts. Research by Gravemeijer and Stephan (2017) demonstrated that students taught using RME outperformed their peers on standardized mathematics tests, indicating better retention and understanding of mathematical concepts when taught through real-world applications. Karaca and Özkaya (2019) emphasized the need for curricular alignment to successfully implement RME in mathematics classrooms.

H1: *"Realistic mathematics education principle has a direct positive effect on learners' mathematics achievement".*

Effect of Realistic Mathematics Education Principles on Teachers' Self-Efficacy in Mathematics

One of the most important aspects of instructional practices is teachers' self-efficacy, which is determined by how much they believe they can influence learners' learning and teach effectively. It has been demonstrated that implementing RME increases teachers' self-efficacy. According to Bandura's (1997) theory of self-efficacy, teachers' confidence in their ability to instruct learners can be increased by assigning them meaningful and contextually relevant tasks. According to Aksu and Colak (2021), teachers who used RME expressed greater levels of self-efficacy, especially when it came to fostering learner-centered learning environments. Better learner results and more efficient teaching methods were linked to this higher self-efficacy. Arhin and Gideon (2020) found that RME-focused professional development programs in Ghana greatly increased teachers' self-efficacy. Higher levels of learner accomplishment and more effective instruction resulted from teachers feeling more competent and confident while interacting with students on real-world mathematical problems.

H2: *"Realistic mathematics education approach has a direct positive effect on teachers' self-efficacy in mathematics".*

Effect of Teachers' Self-Efficacy on Learners' Mathematics Achievement

Learner achievement is strongly influenced by teachers' self-efficacy. High self-efficacy teachers are more likely to use creative teaching techniques, successfully handle problems in the classroom, and persevere in the face of setbacks (Choi & Kang, 2021). According to research by Asare et al. (2023), learners who get instruction from teachers who have a high degree of self-efficacy typically fare better academically and have more favorable attitudes toward learning. Peker's (2016) study, which indicated that instructors' self-efficacy was a strong predictor of student engagement and achievement, lends even more credence to this. According Arhin and Gideon (2020), in Ghana, teachers who had a high level of self-efficacy were more likely to use student-centered instructional strategies, which improved math performance.

H3: *"Teachers' self-efficacy has a direct positive effect on learners' mathematics achievement".*

Teachers' Self-Efficacy Mediates the Relationship Between Realistic Mathematics Education Principles and Mathematics Achievement of Learners

Numerous research has examined the mediating function of teachers' self-efficacy in the relationship between learners' mathematics achievement and RME. According to Thomson et al. (2017), teachers' self-efficacy affects how they interact with students and use instructional practices. Higher self-efficacy teachers are more likely to implement and maintain RME techniques, which will enhance student performance. According to research by Marsh et al. (2019), teachers' self-efficacy acted as a mediator between RME's beneficial effects on student accomplishment. Better student outcomes resulted from teachers who were more inclined to apply RME faithfully and who had faith in their ability to teach mathematics. This implies that raising teacher self-efficacy can increase RME's advantages and result in better learning outcomes.

H4: *"Teachers' self-efficacy mediates the relationship between realistic mathematics education principles and mathematics achievement".*

METHODOLOGY

Research Design

The study employed a quantitative approach with a correlational cross-sectional descriptive survey design, which entailed data collection from a single point in time without manipulating it and was based on the research hypothesis. The effectiveness with which it examines correlations between variables at a specific time supports this strategy (Babbie, 2016). This design was effective for exploring the relationships between variables and establishing the validity of the structural equation model (SEM). According to Kline (2018), correlational cross-sectional descriptive design data can be used to evaluate the SEM fit to the connections that were detected.

Respondents and Procedure

The 7621-person study on junior high school math teachers was carried out in four districts of Ghana: Ashanti, Bono East, Greater Accra, and Volta. The study included 396 junior high school math teachers as a sample. A sample of three hundred and seventy (370) should be chosen for the study with a confidence level of 95% and a margin of error (degree of accuracy) of .05 for a population size of seven thousand, six hundred and twenty-one (7621) according to Gill et al. (2017) sample selection tables. The study's sample size was also determined using the Slovin's method subsequent to the Gill et al. (2017) sample selection. Using Slovin's technique, the minimum sample size was similarly found to be 380. Due to the researcher's assessment of the likelihood of inaccurate or incomplete questionnaire responses as well as an increase in external validity, the predicted sample size was increased to 400 junior high school mathematics teachers. Since the mathematics teachers were already in their various zones of study, the sample size to be picked in each stratum (Region) was then determined using the proportionate stratified sampling technique.

Non-Response

A survey was sent out to 400 junior high school math teachers. Of those, 4 could not return the questionnaires within 2 days, which was considered a non-response. In the end, 396 JHS math teachers returned the surveys.

Table 1. Demographic characteristics of the study group (Source: Field survey, 2024)

Demographics		Frequency	Percentage (%)
Gender	Male	276	70
	Female	120	30
	Total	396	100
Age	< 30	33	8
	30-40	121	31
	41-45	144	36
	46 and above	98	25
	Total	396	100
Years of Teaching Experience	1-5 years	69	17
	6-10 years	111	28
	> 10 years	216	55
	Total	396	100
Highest Qualification	Cert A	12	3
	Diploma	230	58
	Bachelor's degree	152	38
	Master's	2	1
	Total	396	100

Based on **Table 1**: in terms of the gender distribution, 70% (276) were males, and 30% (120) were females; in terms of age distribution, 8% (33) were less than 30 years old, 31% (121), were 30–40 years old, 36% (144), were 41–45 years old, and 25% (98), were 46 years and above; in terms of years of teaching experience variables, 17% (69), had taught for 1–5 years, 28% (111), had taught for 6–10 years, and 55% (216), had taught for more than 10 years; in terms of highest qualification variables, 3% (12) had Cert A, 58% (230) had diploma, 38% (152) had bachelor's degree and 1% (2) had masters.

Instrument and Procedures

The researchers created a structured questionnaire form that was employed as data collection tool. Thirty – five (35) items made up the structured questionnaire, which were organized into four sections: demographic information, realistic mathematics education (RME), teachers' self-efficacy (TSE) and mathematics achievement (MA). Section A was used to collect background information about the respondents (name, gender, Age, years of teaching experience and teachers' highest qualification). Section B was used to gather information on teachers' engagement, interaction, and teaching experiences with the RME teaching technique. Sample items included "I often use hands-on activities that connect mathematics to real-life situations in my teaching", "In my own opinion, realistic mathematics education contribute to students' understanding of abstract mathematical concepts" and "I frequently update my teaching materials to include real-world applications of mathematical concepts". Section C was intended to get information on TSE which included items like "My self-efficacy impacts my willingness to try innovative teaching methods including RME in many ways", "I feel that my self-efficacy is influenced by the support I receive from colleagues and administrators" and "My self-efficacy influences my decision-making in adopting new teaching approaches". Section D was used to gather data on teachers' junior high school learners' MA. Sample items included "my students usually do well in mathematics", "Realistic mathematics education helps my students to understand mathematics and other subjects" and "My students feel happy when answering mathematics questions". Variables in sections B through D were scored on a likert scale of 1 for strongly disagreeing and 5 for strongly agreeing. The head teachers of the selected schools were sent an introduction and a cover letter. Questionnaires were issued after approvals were given. The administration of the questionnaires took place after class time. RME, TSE, and MA were the three main research variables.

Table 2. Construct reliability (Source: Field survey, 2024)

Constructs	Cronbach Alpha	Composite Reliability	Number of Items
Realistic Mathematic Education (RME)	.945	.913	4
Teacher Self-Efficacy (TSE)	.931	.892	3
Mathematics Achievement (MA)	.981	.941	10

Reliability Analysis

"Reliability" of a measurement pertains to its ability to yield consistent outcomes over time and when applied by different researchers. The questionnaire's internal consistency was assessed using Cronbach's alpha reliability testing after a pilot test to guarantee reliability. Using Cronbach's alpha (CA) analysis in SPSS (v.23) software, the internal consistency of the measuring items was evaluated. Pomegbe et al. (2020) stated that an alpha score of .7 or higher is considered to indicate internal reliability or consistency. **Table 1** shows that the mathematics achievement (MA) had a CA of .981, the realistic mathematics education (RME) had a CA of .945, and the teacher self-efficacy (TSE) had a CA of .931.

Exploratory Factor Analysis (EFA)

Exploratory Factor Analysis (EFA) was performed using SPSS version 23. This analysis helped identify the relationships between observed variables and their corresponding latent variables. Specifically, EFA was employed to evaluate the components and determine the factor loadings for each observed variable. This process aimed to eliminate any variables that did not load appropriately onto the corresponding latent factors. The results of the analysis are presented in **Table 2**, which shows the number of observed variables loaded onto each latent variable. For further analysis, only those observed variables with factor loadings greater than .5 were considered. The reliability of the questionnaire, as reported by junior high school teachers, showed high internal consistency, with reliability coefficients ranging from .931 to .981. All three constructs in this study demonstrated reliability coefficients exceeding the minimum acceptable value of .7. Specifically, the study found that four items corresponded to realistic mathematics education, three items to teacher self-efficacy, and ten items to mathematics achievement. The determinant's coefficient was found to be 1.06E-07, with a Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy of .886, indicating that 88.6% of the variance in the data could be explained by the latent variables. Bartlett's Test of Sphericity yielded a significant chi-square value of 4457.787 with 136 degrees of freedom and a p-value of .000. The EFA revealed that the four latent variables accounted for a cumulative variance of 87.137%. Any observed variables that did not align correctly on the rotated component matrix were removed from the final analysis. The results, showing the alignment of observed variables with the appropriate latent variables, are presented in **Table 3**.

Confirmatory Factor Analysis

Using confirmatory factor analysis (CFA), researchers can assess the hypothesis regarding the existence or absence of a link between the variables under investigation and the burden factor. Researchers employ theoretical knowledge, empirical study, or both to construct a priority connection pattern (Hair et al., 2010). After that, the hypothesis is assessed using statistical techniques. The study employed AMOS (version 23) to conduct the CFA as part of the reliability and validity assessment. Because CFA can estimate a wide range of statistical tests, it has more applications than other statistical research (Dogbe et al., 2020; Lahey et al., 2012). According to Lahey et al. (2012), CFA computes the error variance to be separate from the unexplained variation in the constructs, with the measurement latent variables having fewer errors than the network's regions of interest. The measurement model was tested using the principal component estimate in a confirmatory factor analysis using IBM SPSS Amos (v.23) software.

Table 3. Final EFA (Extraction method: Principal component analysis; Rotation method: Varimax with Kaiser normalization)

Rotated Component Matrix		Components			
		1	2	3	4
Realistic mathematics education (RME)	RME1			.920	
	RME2			.934	
	RME3			.901	
	RME4			.892	
Teacher self-efficacy (TSE)	TSE1				.912
	TSE2				.931
	TSE3				.909
Mathematics achievement (MA)	MA1	.921			
	MA2	.926			
	MA3	.927			
	MA4	.909			
	MA5	.896			
	MA6	.915			
	MA7	.903			
	MA8	.910			
	MA9	.893			
	MA10	.918			

Table 4. Confirmatory factor analysis (Source: Survey data, 2024)

Variable	**Factor Loadings**
Realistic mathematics education: CA = .946; CR = .928; & AVE = .765	
RME1: I often use hands-on activities that connect mathematics to real-life situations in my teaching.	.910
RME2: In my own opinion, realistic mathematics education contributes to students' understanding of abstract mathematical concepts.	.944
RME3: I frequently update my teaching materials to include real-world applications of mathematical concepts.	.890
RME4: I assess the effectiveness of realistic mathematics education in improving students' conceptual understanding.	.862
Teacher self-efficacy: CA = .913; CR = .922; & AVE = .797	
TSE1: My self-efficacy impacts my willingness to try innovative teaching methods including RME in many ways.	.888
TSE2: I feel that my self-efficacy is influenced by the support I receive from colleagues and administrators.	.944
TSE3: My self-efficacy influences my decision-making in adopting new teaching approaches.	.844
Mathematics achievement: CA = .927; CR = .981; & AVE = .837	
MA1: I believe my self-efficacy influences students' mathematics achievement in my class.	.922
MA2: I think my teaching methods contribute to students' understanding of realistic mathematics concepts.	.931
MA3: Per my experience, self-efficacy played a role in mediating the relationship between realistic mathematics education and students' mathematics achievement.	.934
MA4: I employ realistic mathematics education strategy to support students in overcoming challenges in mathematics learning.	.909
MA5: Am aware of the impact of my self-efficacy on the overall quality of my teaching and its potential mediation effect on students' achievement.	.900
MA6: My teaching experience makes my student get good marks in mathematics.	.920
MA7: My students usually do well in mathematics.	.906
MA8: Realistic mathematics education helps my students to understand mathematics and other subjects.	.912
MA9: My students feel happy when answering mathematics questions.	.891
MA10: I often foster a growth mindset among my students, and this usually impact the mediation of self-efficacy in mathematics achievement.	.923

Table 4 displays the CFA results. Variables that were observed but had unsatisfactory factor loadings (less than .5) were not included in further analysis. Measurement items having factor scores of less than .5 were eliminated since it was anticipated that factor values of at least .5 would be obtained (Amoako et al., 2022; Arthur et al., 2022). RME, TSE, and MA all started with 10 measurement items. Following the CFA method, the observed variables in RME and TSE, were each reduced by 6, and 7, respectively. Hence, factor loadings were

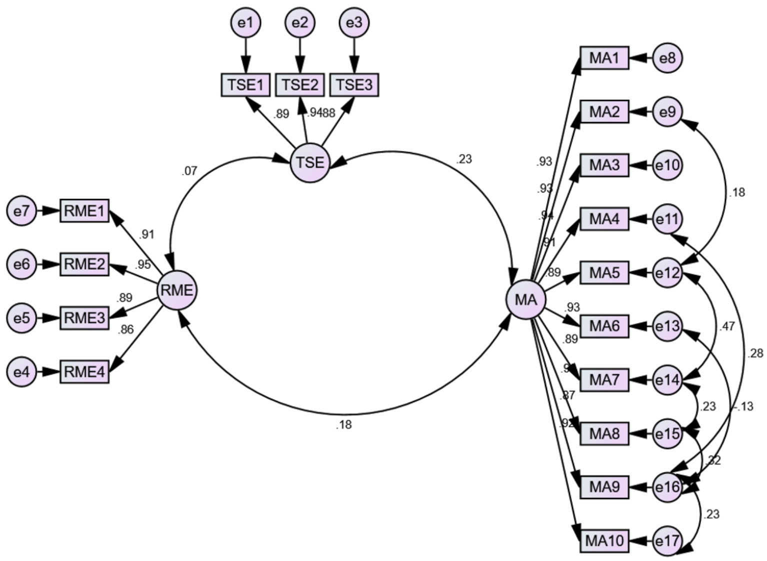

Figure 2. Diagram of confirmatory factor analysis

Table 5. Convergent validity assessment (Source: Field survey, 2024)

Construct	CR	AVE
RME	.928	.765
TSE	.922	.797
TK	.944	.740
MA	.981	.837

evaluated for each indication on the scale throughout the CFA. Factor loadings over .50 (>.50) were guaranteed. 13 items were taken out because they had lower factor loadings. Increasing the model's fitness was a crucial issue taken into account. The measurement model analysis was performed, and all resulting fit indices met their respective benchmark values: CMIN/df was 1.373 (≤3.000), TLI was .994, CFI was .949, RMSEA was .128, RMR was .063, P-close was .000, and GFI was .949. Consequently, the model shows a good fit with the collected data. **Table 4** and **Figure 2** summarize the fit indices for the measurement model.

The CFA findings are shown in **Table 5**. We did not include in our analysis any variables that were detected but had factor loadings that were less than .5. Since it was expected that factor values of at least .5 would be achieved, measurement items with factor scores of less than .5 were deleted (Amoako et al., 2022; Arthur et al., 2022). While MA began with twelve measurement items, RME and TSE began with ten each. The observed variables in RME, TSE, and MA were all reduced by 6, 7, and 2, respectively, after applying the CFA approach. Therefore, throughout the CFA, factor loadings were assessed for every indication on the scale. Guaranteed were factor loadings greater than .50 (>.50). Twenty-one items were removed due to their lower factor loadings. One important consideration was making the model more fit.

Convergent and Discriminant Validity Analysis

Convergent validity

The degree of correlation between two measures of the same idea is evaluated by convergent validity. Composite reliability (CR) and average variance extracted (AVE) were used to evaluate the convergent validity. Composite reliability (CR), according to Hair et al. (2010), is an important indicator of convergent validity and should be more than .70. The average variance extracted (AVE), which needs to be more than .50, is another crucial metric. By using these criteria, it is ensured that a significant amount of the variance is captured and

Table 6. Discriminant validity assessment (Source: Field survey, 2024)

Construct pair	Correlation (r)	Squared correlation (r^2)	AVE1	AVE2
RME ↔ TSE	.120	.014	.765	.797
MA ↔ TSE	.253	.064	.837	.797
MA ↔ RME	.153	.023	.837	.765

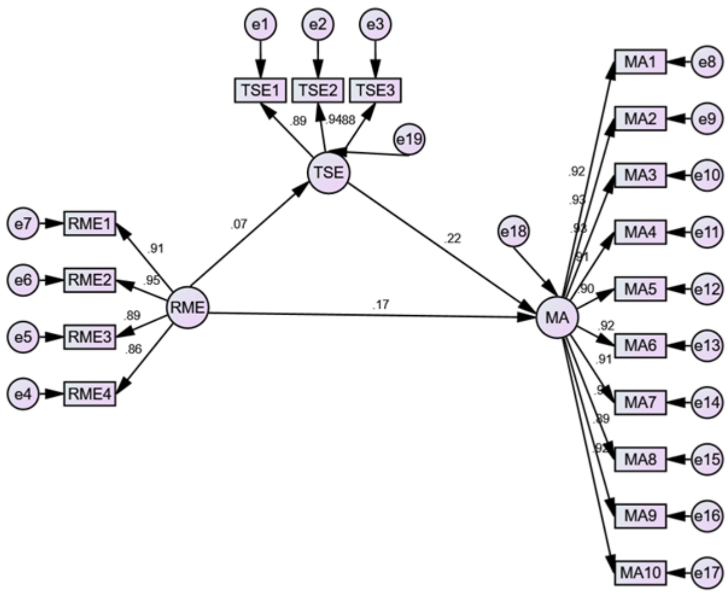

Figure 3. Diagram of mediating path estimates

that the items used to test a construct are appropriately associated. In the provided data, the CR and AVE values for the constructs were as follows:

Discriminant validity

Discriminant validity compares the AVE values with the squared correlations (r^2) of constructs to determine how different a construct is from other constructs. Comparing the correlation coefficients with the AVE, Bamfo et al. (2018)'s research investigated discriminant validity (DV). Fornell and Larcker (1981) demonstrated that discriminant validity is established by comparing the squares of the AVE values for each construct with the distinct inter-construct correlations, as illustrated in **Table 3**. DV is reached when the lowest AVE is greater than the greatest correlation coefficient (Arthur et al., 2021). It was found that every squared AVE value exceeded every inter-construct correlation. For example, the AVE of RME (.765) and TSE (.797) is significantly higher than the squared correlation of RME and TSE, which is .014. It is confirmed that each construct shares more variation with its indicators than with other constructs when these comparisons are made for all other pairings of constructs. The study's measuring methodology is robust, as evidenced by the convergent and discriminant validity analyses. Since the largest correlation coefficient was also less than.7, which might have introduced confounding effects into the model estimation process, it was concluded that there was no multicollinearity (Dogbe et al., 2020). **Table 6** shows a summary of the constructs' discriminant validity analysis.

Structural Model

After assessing the fit of the measurement model, further analysis was conducted to explore the hypothesized relationships between the endogenous and exogenous variables within the study's framework. This involved estimating several models using IBM SPSS Amos 23 to test the direct relationships. The results of these tests are illustrated in **Figure 3** and summarized in **Table 7**.

Table 7. Direct path estimate

Direct paths	Unstandardized estimate (β)	CR	SE	p-value
RME → MA	.400	1.093	.183	.001
TSE → MA	.194	3.909	.050	.001
RME → TSE	.25	11.205	.045	.002

Note. Model Fit Indices: CMIN = 219.758; df = 160; CMIN/df = 1.373; CFI = .960; TLI = .994; RMR = .063; RMSEA = .128; PCLOSE = .000; GFI = .949

Table 8. Mediating path estimates

Mediating Path	Estimate (β)	Standard Error	p-value
RME → TSE → MA	.20	.03	< .01

Path Estimates

Direct effect

Path analysis is a method for analyzing correlations or covariance's between two variables in a model of SEM to ascertain the proportion of this covariance that is due to a theoretically implied causal influence of one variable on another. Covariance-based SEM Amos (v.23) software was employed to determine the route coefficients. A bootstrapping technique called bias-corrected (BC) percentile was utilized, using 5,000 bootstrap samples and a 95% confidence level. **Table 8** displays the outcomes of the independent factors' direct influence on the dependent variable MA. The direct path arrows indicates that, realistic mathematics education (RME), teacher self-efficacy (TSE), and teacher knowledge (TK) have a direct effect on mathematics achievement (MA).

The route estimate of .40 for the postulated paths for RME →MA was found to show a statistically highly significant positive direct influence of RME on MA ($\beta = .40$; $p > .05$) indicating that as learners become more involved in RME learning approach, their mathematics achievement is expected to increase by roughly 40%, and the opposite is also likely to be true.

H1: "*Realistic mathematics education principle has a direct positive effect on learners' mathematics achievement"* was therefore accepted by this study.

Additionally, the analysis demonstrated a significant positive direct effect of Realistic Mathematics Education (RME) on Teacher Self-Efficacy (TSE) in mathematics. Specifically, the route estimate of $\beta = .25$ ($p < .05$) indicates that the relationship is statistically significant. This suggests that when teachers engage students more frequently with RME teaching techniques, their self-efficacy in teaching mathematics is likely to increase by approximately 25%. Consequently, the hypothesis

H2*:* *"Realistic mathematics education approach has a direct positive effect on teachers' self-efficacy in mathematics*" is supported by the findings of this study.

Furthermore, the study revealed that the path estimate of .194 for SE→MA similarly indicates a statistically highly significant positive direct effect of TSE on MA ($\beta = .194$; $p > .05$). This suggest that 19.4% increase in teachers' self-efficacy is likely to assist learners to attain mathematics achievement. Hence the hypothesis:

H3: "*Teachers' self-efficacy has a direct positive effect on learners' mathematics achievement"* was accepted.

Mediating Path Estimate of Self-Efficacy

The mediation impact of TSE was calculated as additional hypothesis path in the exploration. The association between RME and the influence of RME towards MA was initially explored to determine the mediating role of students' TSE. **Table 8** indicates that the association between RME and MA may have a statistically highly significant positive mediating impact of TSE in mathematics (β = .20; p > .01). This suggests that using RME in the classroom increased learners' MA by roughly 20% and vice versa. Hence the hypothesis:

H4: "*Teachers' self-efficacy mediates the relationship between realistic mathematics education principles and mathematics achievement"* was confirmed.

DISCUSSION

This study explored the effect of Realistic Mathematics Education (RME) on students' mathematics achievement (MA) and teacher self-efficacy (TSE). The findings underscore the crucial role of TSE in improving students' MA and demonstrate the advantages of integrating RME into the mathematics curriculum. This research contributes new insights to the existing literature on educational methods in Ghanaian mathematics education by analyzing the interplay between these variables. The key results of this study are summarized as follows:

1. **Accepted Hypothesis 1**: "*Realistic mathematics education principle has a direct positive effect on learners' mathematics achievement"*.
2. **Accepted Hypothesis 2**: "*Realistic mathematics education approach has a direct positive effect on teachers' self-efficacy in mathematics"*.
3. **Accepted Hypothesis 3**: "*Teachers' self-efficacy has a direct positive effect on learners' mathematics achievement"*.
4. **Accepted Hypothesis 4**: "*Teachers' self-efficacy mediates the relationship between realistic mathematics education principles and mathematics achievement"*.

The research showed the effect of RME on learners' MA. This study's results shed light on the role of TSE in learners' MA as well as the potential benefits of incorporating RME into mathematics education. The study has also added originality to the body of research on educational approaches of Ghanaian mathematics education. While earlier studies looked at how RME individually affected mathematics outcomes, the current study added value by illuminating how these variables, RME and TSE were combined. Specifically, the study demonstrated that TSE mediates the nexus between RME and MA, illuminating a complex interplay between these factors. The study was distinctive since it concentrated on the Junior high school environment in Ghana. In this study, a unique strategy was used to combine SEM with a cross-sectional correlational descriptive design to capture intricate interactions between variables. The rigor of the results is improved by this methodological addition.

Influence of RME on Students' Mathematics Achievement

The results of this study demonstrated that the implementation of RME directly improves MA in junior high school students. In accordance with the results of our study, Nursiddik et al. (2017) earlier showed that students' mathematical understanding abilities in the 7th grade of Junior high school 14 Cirebon were impacted by the use of RME. Additionally, a study by Patullayeva (2022) showed that the mathematics lesson taught according to the RME principles is significantly more effective than the traditional teaching approach among the achievements of the experimental and control groups. Moreover, a thorough meta-analysis of studies on the effectiveness of RME was undertaken by Harahap et al. (2018), and they discovered consistent evidence that RME improved MA. Similar to this, Ulandari et al. (2019) also revealed significant gains in students' MA after conducting a study on the deployment of RME in middle schools. RME's emphasis on contextual and practical applications of mathematical ideas is in line with research by Gravemeijer and Stephan (2017) which found that RME significantly improved learners' performance on standardized mathematics tests; in fact, learners taught using RME outperformed their peers who received traditional instruction; this suggests that learners learn and retain mathematics better when it is grounded in real-world problems. Tamur et al. (2020) looked at the impact of RME-based teaching on learners' achievement in Indonesia and found out that using this method will increase learners' motivation to learn mathematics as well as their conceptual understanding. Finally, Piaget (1970) and Vygotsky (1978) underlined the necessity of students' actively building knowledge through problem-solving in real-life circumstances, which RME correlated with.

Influence of RME on Teacher Self-Efficacy

The results also showed that RME positively affects TSE in mathematics, highlighting that RME encourages teachers to feel more capable of successfully teaching mathematics. This result is in line with earlier studies examining the relationship between teaching strategies and teachers' SE. According to Bandura's (1997) self-efficacy theory, mastery experiences, which RME provides through real-world problem-solving situations, enhance teachers' beliefs in their capabilities. Bandura (1997) suggested that performing challenging and contextually relevant tasks increases self-efficacy beliefs. Sharp et al. (2022) also found that self-efficacy directly contributes to developing teacher innovation like RME. Additionally, Javed et al. (2021) found that teaching methods encouraging active participation positively affect teachers' self-perceptions of their abilities. Similarly, Wulandari et al. (2019) said teachers who used RME expressed greater levels of self-efficacy, especially when it came to fostering learner-centered learning environments. Better learner results and more efficient teaching methods were linked to this higher self-efficacy. Arhin and Gideon (2020) found that RME-focused professional development programs in Ghana greatly increased teachers' self-efficacy.

Influence of Teacher Self-Efficacy on Mathematics Achievement

Our study's results support the notion that Junior high school learners' academic progress in mathematics is directly influenced by their teachers' self-efficacy. This highlights the critical role of teachers' beliefs in student achievement in mathematics. We argue this result of a potential self-enhancement effect of TSE on a more direct measure, such as RME in accordance with social learning theory (Bandura, 1997). Teachers must have confidence, work commitment, enthusiasm at work, and persistence in tackling the challenges of carrying out their duties as a teacher to make their learners to succeed in future. The substantial corpus of research on TSE in education and its beneficial effects on MA are consistent. Alfayez (2022), disclosed a significant correlation between academic success and TSE beliefs. A meta-analysis of 191 papers was also carried out by Gkontelos et al. (2023). They discovered a high positive correlation between TSE and academic success in a variety of areas, including mathematics. Similar to this, Ansley et al. (2021) highlighted the significance of TSE as a major factor influencing students' academic success. Teacher self-efficacy is a crucial predictor, but it is not the only factor that affects how well a student performs in mathematics. Academic outcomes are also affected by additional variables such as prior knowledge, motivation, and educational quality. As a result, future research should examine how these elements interact and how they together affect learner's mathematics ability.

Mediating Role of Teacher Self-Efficacy

This study confirmed that the association between realistic expectations and MA is mediated by TSE. The framework of Bandura (2006) revealed that self-efficacy beliefs served as a mediating mechanism between educational interventions and performance outcomes. This study's results that self-efficacy mediates the relationship between RME and MA aligns with this framework. Holenstein et al. (2022) asserted that SE fully mediated the impact of academic performance on mathematical modeling, while Sharp et al. (2022) supported the idea that TSE plays a mediating role in the connection between educational techniques and student performance. Turkoglu et al. (2017) highlighted the reciprocal relationship between TSE and MA, suggesting that improved TSE leads to better performance and vice versa. Better educational outcome is only possible when teachers have a high level of self-efficacy beliefs on their teaching-learning activities (Turkoglu et al., 2017).

CONCLUSION AND IMPLICATION

This research brought new results to the existing literature in the field of mathematics education. These results contributed to a deeper understanding of the interplay among RME, TSE, and MA. According to the major results of the study, supported by the acceptance of Hypothesis 1, underscores the positive and direct effect of RME on learners' MA. This aligns with previous studies highlighting the efficacy of RME in fostering improved mathematics outcomes by grounding mathematical concepts in real-world contexts and problem-solving. Building upon this, our second results, supported by Hypothesis 2, which confirmed that RME also has a direct positive influence on Teachers' SE in mathematics. This is in harmony with self-efficacy theory of Bandura, which suggests that when teachers are engaged in contextually meaningful and challenging tasks, their confidence in their mathematical abilities tends to develop. Thirdly, our study affirms the significant relationship between TSE and MA (Hypothesis 3). Teachers who possess higher SE beliefs in mathematics tend carrying out their duties as a teacher to make their learners to perform better. A result that is consistent with a substantial body of research in educational psychology and mathematics education. Lastly, the acceptance of Hypothesis 4 reveals the mediating role of TSE in the relationship between RME and MA.

This present study unveils how RME impacted on MA was partially or wholly explained by its influence on TSE beliefs. This nuanced understanding offers a fresh perspective on the mechanisms through which educational approaches such as RME can lead to improved performance. This result suggests that teachers with knowledge about RME would benefit from using RME as educational tool. Therefore, it is essential for teachers to tailor their lessons based on RME to increase students' performance. By connecting Bandura's self-efficacy theory with the practical application of RME, this research bridges the gap between educational theory and classroom practice. It demonstrates how psychological theories could inform educational approaches and positively impact student outcomes. This promotes lasting behavioral changes by engaging students through the use of RME teaching methods. Furthermore, to foster harmony between educators and students, by embracing RME principles, such as contextualized problem-solving and real-world applications, to create engaging and meaningful learning experiences for students. This approach makes mathematics more accessible and enjoyable for students, leading to increasing their enthusiasm for the subject.

In future studies, the effectiveness of RME with other educational approaches in diverse context could be compared. This is due to the fact that applying lessons from related studies to real-world situations is the only way to attain desired outcomes in higher education. Additionally, understanding when and where RME is most effective compared to other methods can guide educators in selecting the most appropriate approach for their specific context. The Ghana Education Service and the Ministry of Education in Ghana are advised to incorporate RME into the curriculum for training mathematics teachers.

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