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Investigating the effect of socio-constructivist mathematics teaching on students' mathematics achievement: The mediating role of mathematics self-efficacy

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ABSTRACT

This study examines the influence of Socio-Constructivist Mathematics Teaching on students' mathematics achievement with mathematics self-efficacy serving as a mediating factor. This study employed a quantitative research approach within a descriptive survey design framework utilizing the stratified and simple random sampling techniques. Data from 260 students in a Senior High School in the Talensi District of the Upper East Region of Ghana were analyzed using Structural Equation Modeling (SEM). Results indicated that Socio-Constructivist Mathematics Teaching significantly enhanced both mathematics achievement and self-efficacy. Additionally, mathematics self-efficacy positively impacted students' achievement and mediated the relationship between teaching methods and academic performance. This suggests that the instructional approach directly improves achievement, and its effect is further strengthened when students feel confident in their mathematical capabilities. The study highlights the importance of integrating socio-constructivist pedagogy to foster both academic success and self-confidence in mathematics.

Keywords: socio-constructivist teaching, mathematics achievement, self-efficacy, mediation, structural equation modeling (SEM)

INTRODUCTION

The purpose of education is to impart knowledge and skills that will help individuals realize their full potential (Ghafar, 2020). As stated by Tanzi Neto et al. (2020), education is seen as the man's praxis, reflection, and action in transforming the world, just as Vygotsky acknowledges that education is the subject's potential development as well as the expression and development of human culture. This underscores the transformative nature of education, which must be assumed in all circumstances (Drajati et al., 2021).

However, if this is not sufficiently promoted, it will lead to a number of issues concerning the quality of education and mathematics cannot be left out in this.

Hadi Mousavi (2020), further broaden the discussion by pointing out that Mathematics literacy is key when it comes to the transformative nature of education as acknowledged by Drajati et al. (2021) and it is the capability of a person to read, understand, analyze, and make sense of elaborate numerical and quantitative data that are present in various facets of daily life. It also allows the person with critical thinking who could solve problems and develop valid and defendable decisions on issues concerning one's normal day-to-day living. According to Hadi Mousavi (2020), mathematics is important in the building of responsible citizenship who reason using data. Additionally, the solution of global challenges such as climate change and technological advancement requires mathematically literate people who will develop appropriate and sustainable solutions through innovation and other skills (Hendrycks et al., 2021). Hendrycks et al. (2021) added that mathematics literacy is a skill that needs to be empowered far more in education, which is amplified by a rising global demand for skilled mathematicians. Poorer levels of attainment in mathematics skills persist, which blunt the ability of people in the workforce, especially in those fields such as data science, engineering, and technology. Mathematics literacy, if given the seriousness it deserves, would enable societies to build a cadre of people who will work on critical social and environmental challenges and ensure that new technological shifts are matched with cautious judgment and responsible action toward sustainable development. Moreno (2022) further concurred with Ghafar (2020) that good mathematics education is necessary to address issues like population growth, agriculture, health, and climate change, among others. Understanding the fundamentals of these issues can be effectively accomplished through the use of mathematics.

In contrast, Schatz Oppenheimer and Dvir (2018) view student engagement in mathematics in general, and particularly within the socio-constructivist setting, as far from satisfactory. Indeed, the theory underlying this approach views learning as an active process whereby knowledge is built up by the students themselves through activity, interaction, and cooperation, yet three major factors hamper this process. For one, there is a lack of provision in affording the students adequate opportunity for collaborative research and problem-solving practices as recommended by socio-constructivist learning. The second instance is that it lacks research activities that can stimulate peer interaction and critical thinking processes among students. Finally, freshmen university students largely lack the necessary prior research skills to enter into this collaborative learning environment to help students effectively. As long as these issues remain an international concern, sharp contrasts in the student experience concerning socio-constructivist learning occur between countries.

Notably, socio-constructivist approaches have lately gained momentum, as emphasized by Schatz Oppenheimer and Dvir (2018) especially in the teaching of mathematics. Traditional mathematics teaching methods have increasingly been criticized for their propensity to foster a superficial understanding of mathematical concepts, causing anxiety and lack of motivation in many students. In contrast, socio-constructivist teaching methods enable students to engage in profound inquiry of mathematics, together with sharing ideas with others and relating new information with prior experiences. Socio-constructivist learning theory holds that knowledge can only be established in concert with others through social interaction. This means students are supposed to be the active builders of an understanding of concepts through discussion, problem-solving, and shared experiences within a learning community, rather than just being passive recipients of information. It majors in contextual importance, peer interaction, and real-life experiences in shaping learning (Blackmore et al., 2021). Eronen (2019) then added that this makes mathematics more interesting, applicable, and approachable while the learner-centered nature of this approach hopefully raises the students' mathematical achievements.

Mathematics self-efficacy is, therefore, an important aspect in the investigation of the relationship between socio-constructivist mathematics teaching and students' mathematics achievement. According to Hanifah et al. (2020), mathematics self-efficacy is a belief described by a student's perception of his or her ability in

solving particular mathematical challenges or problems. They further add that self-efficacy is an ingredient of relevance in effective learning. Indeed, prior research on self-efficacy has proved that such a construct would lead students to view tasks as challenging but not beyond their reach and, therefore, invest more in persistence. This results in higher performance (Arifin & Kuningan, 2021; Blackmore et al., 2021; Holenstein et al., 2022). Bandura's social cognitive theory has accorded much significance to self-efficacy in educational contexts, such as mathematics, where it influences the attitude, participation, and academic accomplishment of students (Blackmore et al., 2021). Blackmore et al. (2021) noted that socio-constructivist teaching methods are related to mathematics achievement in a very complex and multi-dimensional way. Socio-constructivist approaches promote active learning and critical thinking, which positively influence students' mathematical understanding and skills. Some studies suggest that mathematics self-efficacy may act as a mediating factor in the effectiveness of these instructional strategies (Bhati & Priyadarshini, 2022; Shah et al., 2023). Given the collaborative and interactive nature of socio-constructivist teaching, students with higher confidence in their mathematical abilities tend to benefit more from such methods (Holenstein et al., 2022). Since math self-efficacy is the critical variable being studied here, it has to be clear how the self-efficacy directly impacts learning results, particularly in mathematics. Self-efficacy is about believing in one's capability of further success with specific tasks, which is one of the essential psychological factors motivating overcoming difficulties and realizing achievements in such challenging subjects as mathematics. Within the socio-constructivist mode of instruction, students engage themselves in problem-solving, collaboration, and critical thinking-all encapsulated within mathematics self-efficacy. Students who possess higher self-efficacy participate willingly, try difficult problems, and apply persistence in light of challenges-things that are at the very heart of the effectiveness of socio-constructivist learning environments.

Thus, the current study investigates whether socio-constructivist teaching supports students' mathematics achievement not only with its teaching methods but also via its influence on students' self-efficacy acting as a mediator in boosting students' motivation and effort to improve their mathematics performance. The involvement of self-efficacy creates a bridge between teaching method and students' academic performances since it explained how and why the teaching methods may turn out to be more effective for some students.

Problem Statement

A generalized problem in mathematics education is that it has long been perceived as a challenging and anxiety-provoking area, which significantly influences students' motivation to perform well at school. Indeed, research has shown that traditional teacher-centered approaches, resting on rote memorization and passive learning, have failed to develop sustained interest in mathematics (Cipora et al., 2022; Maul, 2017). According to Ibanez and Pentang (2021), the challenges can be addressed by socio-constructivist teaching strategies that put an emphasis on active learning, collaboration, and knowledge construction by social interaction. The authors present such approaches as an effective way of allowing students to go deeper into meaningful contact with mathematical ideas and thus develop critical thinking and problem-solving skills.

Yet, despite the possibilities of benefits, little is known about how well effective socio-constructivist mathematics teaching methods are prepared to enhance mathematics achievement, in particular with respect to the role of students' self-efficacy (Ibanez & Pentang, 2021). The available studies point out the important role of self-efficacy, which is understood as students' confidence in their ability to carry out activities that will be helpful in producing the described results in reaching success in mathematics (Bouffard et al., 2005; Etherton et al., 2022; Lynam et al., 2024; Mahyuddin et al., 2006; Thurm et al., 2024; Verma & Bhandari, 2022). High self-efficacy in mathematics is associated with greater perseverance, effort, and resilience in overcoming challenges, whereas low self-efficacy can lead to avoidance and disengagement (Bryant, 2017; Kwami Apoenchir et al., 2023; Smith, 2021).

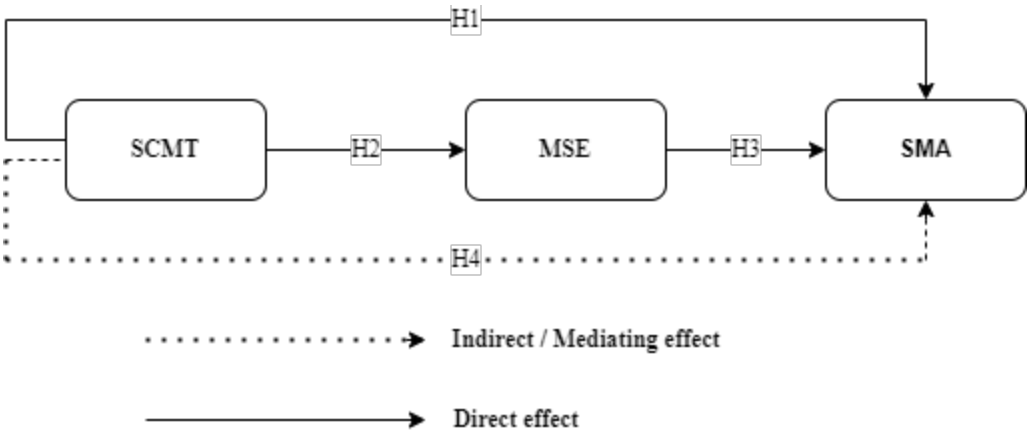

Figure 1. The research framework (Source: Researcher's construct, 2024)

Nonetheless, little is known about the specific mechanisms through which socio-constructivist teaching affects students' self-efficacy and, subsequently, their mathematics achievement (Lynam et al., 2024) Furthermore, the role of mathematics self-efficacy as a mediator between socio-constructivist instruction and students' performance in mathematics is still unclear, despite existing literature underscoring its importance in enhancing mathematical achievement.

This study seeks to address the current gap in empirical data regarding the impact of socio-constructivist mathematics instruction on students' achievement, focusing on the mediating effect of mathematics self-efficacy. By examining this mediating role, the research aims to shed light on the interaction between instructional approaches and psychological factors in shaping mathematics learning outcomes. The findings are expected to contribute to the development of teaching strategies that not only improve students' understanding of mathematics but also enhance their confidence in their ability to succeed in the subject.

Given that improving mathematical proficiency is critical to students' academic and career success, this issue is of significant importance. Enhanced mathematical skills are vital for success in various fields, particularly in science, technology, engineering, and mathematics (STEM). Therefore, identifying effective teaching methods that enhance both mathematics achievement and self-efficacy is crucial for preparing students to meet the challenges of the modern world.

Conceptual Framework of the Study

Figure 1 comprises of three variables namely, SCMT – Socio-Constructivist Mathematics Teaching, MSE – Mathematics Self-Efficacy and SMA – Students Mathematics Achievement. The direction from SCMT to SMA indicates the relationship between the Socio-Constructivist Mathematics Teaching and Students' Mathematics Achievement. The variable MSE is acting as a mediator between SCMT and SMA.

LITERATURE REVIEW

Theoretical Framework

The theoretical foundation of this study is based on two key theories: Socio-Constructivist Learning Theory and Self-Efficacy Theory. These frameworks offer valuable perspectives on the connection between instructional methods and students' achievement in mathematics, while also highlighting the mediating influence of mathematics self-efficacy.

Socio-Constructivism Theory of Learning

Socio-constructivist learning theory is largely harnessed on the work of Lev Vygotsky, emphasized through his argument that knowledge is constructed through social interaction. This process, as specified, thus occurs when students are able to interact with peers and teachers so as to construct meaning through activities collaboratively. This practice conforms to modern trends in education that emphasize learner-centered approaches, wherein the learners themselves are involved actively in their own learning processes (Smith et al., 2022). Such socio-constructivist methods find especial relevance in mathematics education due to their fostering the skills of critical thinking and problem solving through shared learning processes (Smith et al., 2022), which proved that students involved in socio-constructivist learning environments have deeper and longer-lasting formation of mathematical knowledge compared to traditionally taught peers. This would explain why mathematics requires active concrete experiences and social contact to be fully comprehended (Ibanez & Pentang, 2021). SCMT thus provides the theoretical framework through which an investigation into collaborative and interactive teaching methods can be applied to students' mathematics achievement. According to the theory, during socio-constructivist practices, students develop essential skills that enhance their mathematics achievement along with improvement in conceptual understanding.

Self-Efficacy Theory

Albert Bandura's Self-Efficacy Theory, which originated in 1977, suggests that a person's belief in his or her ability to complete an activity is a major contributor to motivating him or her towards any particular behavior. In academic settings, this concept of self-efficacy may find its most practical application when considering how students go about handling problems or difficult situations. As Bryant (2017), points out, students who view themselves as more efficacious are more likely to undertake challenging tasks, work harder on them, and therefore attain higher performances. Mathematics self-efficacy has been pinpointed as one of the strongest contributors to students' performance in mathematics. Students possessing a higher mathematics self-efficacy level are more willing to engage in challenging problems and less likely to develop anxiety in mathematic situations, as research expounds. For instance, Hanifah et al. (2020) recorded that students who are confident in their mathematical competencies are more engaged with the content, deploy effective learning strategies, and solicit help where necessary. Other related studies reported that self-efficacy can also act as a mediating factor to influence teaching strategies onto students' performance (Arifin & Kuningan, 2021). These may suggest that fostering self-efficacy with another effective instructional approach, such as socio-constructivist mathematics teaching, or SCMT, can enhance students' mathematics achievement.

Socio-Constructivist Mathematics Teaching and Students' Mathematics Achievement

Socio-constructivist learning theory, developed to a great extent by Vygotsky (1978), is based on the premise that learning is a matter of social interaction. This theory postulates that students build knowledge through interaction with others, such as peers and teachers, and knowledge will be understood and retained more effectively. In mathematics education, socio-constructivist approaches would afford opportunities for active participation and collaboration among students to engage in problem-solving and discussion in mathematics. Previous studies have identified the socio-constructivist teaching methods as very beneficial in improving mathematics achievement among students. Eronen (2019) found that students who experience collaborative learning activities tend to solve problems better and also have a better conceptual understanding of mathematics as compared to the traditional or lecture-based method of teaching. Ayeni and On (2022), indicated that classrooms providing collaborative environments with peer support end up posting better academic performances in mathematics. Given the theoretical grounding and empirical support for the positive impact of socio-constructivist teaching on academic outcomes, we hypothesize:

H1: Socio-Constructivist Mathematics Teaching has a direct positive effect on students' mathematics achievement.

Socio-Constructivist Mathematics Teaching and Mathematics Self-Efficacy

According to self-efficacy theory, proposed by Bandura (1977), the level of one's belief in their capability for success in certain tasks drives them both motivationally and behaviorally. Self-efficacy in school is associated with heightened engagement and persistence, leading to enhanced academic achievements. In other words, it is those students who feel confident that they can succeed in mathematics who will probably invest much in learning tasks and face challenges with confidence. The literature has also verified the fact that socio-constructivist teaching practice bears positive effects on enhancing students' self-efficacy. Students who take part in collaborative learning very often, for example, report their peers being successful in solving a problem and, correspondingly, develop their belief in their own capabilities. Besides, supportive interaction with teachers and peers provides an enabling learning environment which nurtures self-efficacy. In light of this evidence, we propose the following hypothesis:

H2: Socio-Constructivist Mathematics Teaching has a direct positive effect on mathematics self-efficacy.

Mathematics Self-Efficacy and Students' Mathematics Achievement

The role of self-efficacy in relation to academic achievement has been one of the most topical issues within the bounds of psychology and pedagogics. Students with higher mathematics self-efficacy set higher goals for themselves, employ a whole gamut of effective learning strategies, and even display more persistence than ever. Consequently, self-efficacy becomes important for the development of mathematics performance because one's view determines his or her approach towards tasks and ways of solving problems. There is a visible body of evidence displaying the same positive relationship between mathematics self-efficacy and academic success. For example, Arifin and Kuningan (2021) found that students who perceived themselves to be more self-efficacious engaged more in challenging mathematics tasks and hence are better placed to perform well in mathematics tests and assessments. In the same vein, Schunk and DiBenedetto (2021) noted that targeted interventions aimed at enhancing the self-efficacy of students could lead to dramatic gains in their mathematics performance. Drawing from this body of literature, we propose the following hypothesis:

H3: Mathematics self-efficacy has a direct positive effect on students' mathematics achievement.

The Mediating Role of Mathematics Self-Efficacy

Research suggests that self-efficacy is an intervening factor between teaching strategies and academic performance. It is during the socio-constructivist learning of students' active participation in collaborative problem-solving that promotion of students' self-efficacy can most easily be made through mastery experience and social modeling, as stated by Liljedahl (2014). If the students feel more confident about their capabilities, it will make them much capable of reaping more benefits from the opportunities provided by an effective teaching methodology to enhance their academic performance. Bhati and Priyadarshini (2022) believe that self-efficacy is a mechanism by which teaching practices influence learning outcomes. According to them, socio-constructivist approaches promote not only knowledge acquisition but also students' confidence in their math capability, thereby making the process self-reinforcing and increasing achievement. Thus, we propose the following hypothesis:

H4: Mathematics self-efficacy mediates the relationship between Socio-Constructivist Mathematics Teaching and students' mathematics achievement.

Table 1. Demographics of the Respondents

Demographics		Frequency (N)	Percent (%)
Gender	Male	123	47.3
	Female	137	52.7
	Total	**260**	**100**
Age	15 to 16 years	33	12.7
	17 to 18 years	121	46.5
	19 to 20 years	101	38.8
	21 and above	5	1.9
	Total	**260**	**100**
Course	General Science	66	25.4
	General Art	80	30.8
	Business	67	25.8
	Home Economics	47	18.1
	Total	**260**	**100**

METHODOLOGY

Research Design

This study employed a quantitative research approach within a descriptive survey design framework. This design was appropriate for examining relationships between variables, particularly the impact of Socio-Constructivist Mathematics Teaching (SCMT) on students' mathematics achievement (SMA) and the mediating role of mathematics self-efficacy (MSE) (Magolda, 2007). By utilizing this design, the study gathered numerical data that was statistically analyzed to determine the significance of the proposed hypotheses.

Participants and Sampling

The target population for this study consisted of second-year students from a Senior High School in the Talensi District of the Upper East Region of Ghana. There was a total of 740 students across various academic disciplines, including Science, Arts, Business, and Home Economics.

Using Yamane's (1967) formula for sample size determination, this is illustrated as follows: $n = \frac{N}{1+Ne^2}$, where n is the sample size, N is the population size, which is 740 and e is the error (0.05) confidence level 95%. Given $N = 740$, the population of the SHS 2;

$$n = \frac{N}{1+Ne^2} = \frac{740}{1+740\times(0.05)^2} = \frac{740}{1+740\times(0.0025)} = \frac{740}{1+1.85} = \frac{740}{2.85} = 259.649 \approx 260.$$

A representative sample of 260 students was selected for participation in the study. The sample was drawn using stratified random sampling to ensure that students from each academic track were proportionally represented. This method enhances the generalizability of the findings across different student backgrounds and reduces sampling bias.

A total of 260 students participated in this study (see **Table 1**), representing a diverse group in terms of gender, age, and academic course. The sample consisted of 47.3% male (123) and 52.7% female (137) participants, indicating a fairly balanced representation of genders. In terms of age distribution, the majority of participants fell within the 17 to 18 years age range, comprising 46.5% (121) of the sample. Following this, 38.8% (101) of participants were aged 19 to 20 years, while those aged 15 to 16 years accounted for 12.7% (33). Only a small portion, 1.9% (5), were aged 21 years or older. Regarding academic courses, participants were enrolled in various tracks. The General Art course had the highest representation at 30.8% (80), followed closely by Business at 25.8% (67) and General Science at 25.4% (66). The Home Economics track accounted for 18.1% (47) of the participants.

Data Collection Instrument

The main data collection tool for this study was a structured questionnaire designed to assess the three core variables: Socio-Constructivist Mathematics Teaching (SCMT), Mathematics Self-Efficacy (MSE), and Students' Mathematics Achievement (SMA). The questionnaire was developed through an extensive review of relevant literature and past research, ensuring its content validity. It comprised four sections: Sections A to D.

Section A covered the demographics of the respondents.

Section B focused on Socio-Constructivist Mathematics Teaching (SCMT), assessing students' perceptions of the socio-constructivist practices employed in their mathematics classes. Items in this section targeted collaborative learning, peer interactions, and problem-solving strategies. The SCMT section included ten (10) items adapted from established instruments previously used in educational research, ensuring they reflected current best practices in socio-constructivist teaching methodologies (So & Brush, 2008).

Section C addressed Mathematics Self-Efficacy (MSE), evaluating students' beliefs in their mathematical abilities. The MSE scale included ten (10) items measuring students' confidence in solving various types of mathematical problems and their persistence when faced with challenges. These items were adapted from the Mathematics Self-Efficacy Scale developed by Chan and Abdullah (2018), a well-validated instrument widely used in prior studies. Adaptations were made to ensure cultural relevance and context specificity for Ghanaian students while maintaining the original scale's integrity.

Section D focused on Students' Mathematics Achievement (SMA). Achievement was assessed through self-reported measures of performance in mathematics, allowing students to reflect on their academic experiences and outcomes. This section included ten (10) questions regarding students' grades in mathematics courses to provide a comprehensive picture of their achievement levels. The items were adapted from the works of Arthur et al. (2022a, 2022b).

The questionnaire employed a 5-point Likert scale, ranging from 1 (Strongly Disagree) to 5 (Strongly Agree), allowing respondents to express their level of agreement or confidence regarding the statements presented. This scaling method facilitated quantitative analysis and provided a nuanced understanding of students' perceptions and beliefs.

The adaptation of established scales enhanced the reliability and validity of the data collected, as these measures had been tested in previous research contexts and shown to effectively capture the constructs of interest. In total, the questionnaire included 30 items, with ten items for each construct.

Data Collection Procedure

Prior to administering the questionnaire, the researchers addressed ethical considerations, including obtaining informed consent from participants and ensuring anonymity. The researchers personally distributed the questionnaires during class sessions and provided instructions on how to complete them. To maximize response rates, follow-up reminders were issued. The entire process, including data collection and follow-ups, was conducted by the researchers.

Data Analysis

Data that is obtained from the field in raw state will be difficult to interpret and therefore such data will be analyzed to give meaning. Data collected was analyzed using the Statistical Packages for Social Sciences (SPSS v.23) and Analysis of a Moment Structure (Amos v.23) to run structural equation modeling (SEM) in other to answer the Research Hypotheses. Prior to conducting SEM, normality tests was performed to ensure the data meet the assumptions of normal distribution, as recommended by Kline and Tamer (2016). Normality was

Table 2. Exploratory factor analysis (EFA)

Rotated Component Matrix			
Measurement items	Component		
	1	2	3
SCMT3		.836	
SCMT4		.833	
SCMT5		.871	
SCMT8		.840	
SCMT9		.844	
MSE1			.884
MSE4			.875
MSE5			.873
MSE6			.870
SMA2	.921		
SMA4	.910		
SMA5	.799		
SMA9	.829		
SMA10	.909		
KMO and Bartlett's Test			
Total variance explained			78.237%
Kaiser-Meyer-Olkin measure of sampling adequacy			.875
Bartlett's test of sphericity		Approx. chi-square	2938.484
		df	91
		Sig.	.000
Determinant			9.243E-6

assessed using skewness and kurtosis values. All items were within acceptable thresholds, with skewness values falling within the range of ±2 and a critical ratio of less than 8.0, and kurtosis values within ±10 and a critical ratio of less than 3.0 (Cristea et al., 2020).

RESULTS

Exploratory Factor Analysis (EFA)

The Exploratory Factor Analysis (EFA) was conducted to identify the underlying factor structure of the variables related to Socio-Constructivist Mathematics Teaching (SCMT), Mathematics Self-Efficacy (MSE) and Students Mathematics Achievement (SMA). EFA is an essential statistical technique used to reduce a large number of variables into fewer dimensions by identifying the underlying relationships between the variables, ensuring that they represent distinct factors (see **Table 2**).

An Exploratory Factor Analysis (EFA) was conducted using principal component analysis with varimax rotation, and a minimum factor loading threshold of 0.50 was applied. The commonality of the scale, which reflects the variance explained by each dimension, was also evaluated to ensure an adequate level of explanation. The findings indicated that all commonalities exceeded 0.50. Items with factor loadings below 0.5 were removed, as per the criteria (Appiah et al., 2022). As a result, five, six, and five measurement items were eliminated from the SCMT, MSE, and SMA scales, respectively. The adequacy of the sample size for factor analysis was confirmed by the Kaiser-Meyer-Olkin (KMO) measure, which yielded a value of 0.875 which is far greater than the acceptable threshold of .6. According to Arthur et al. (2022a, 2022b) a KMO value above 0.8 is considered meritorious, indicating that the data were suitable for factor analysis. Moreover, Bartlett's Test of Sphericity produced a significant result with a chi square value of 2938.484, degrees of freedom of 91, and a p value 0.001, further validating the appropriateness of factor analysis for this dataset. The analysis also showed that the three identified components together explained 78.237% of the total variance, a high percentage that underscores the robustness of the factor structure. Additionally, the determinant of the correlation matrix was also 9.243E-6 (Hair et al., 2010).

Table 3. Reliability analysis

Variable	Number of items	Cronbach's alpha
SCMT	5	.915
MSE	4	.916
SMA	5	.936

Table 4. Confirmatory factor analysis

Model Fit indices: CMIN = 114.997; DF = 71; CMIN/DF = 1.620; TLI = .981; CFI = .985; GFI = .954; RMR = .020; RMSEA = .049; PClose = .525;		**Std. Factor Loadings**
SCMT	**Socio-Constructivist Mathematics Teaching (SCMT) CA = .915; CR=.915; AVE=.684**	
SCMT3	When we work in groups in maths class, I learn better	.821
SCMT4	There are exercises in my math lesson that have applications to everyday life	.815
SCMT5	In maths class, I feel at ease expressing my opinions	.862
SCMT8	When we utilize objects to comprehend maths, like blocks or models, I think it helps	.816
SCMT9	My maths instructor encourages us to consider several approaches to problem solving.	.820
MSE	**Mathematics Self-Efficacy (MSE); CA = .916; CR=.916; AVE=.733**	
MSE1	I feel confident enough to ask questions in my mathematics class.	.821
MSE4	I believe I am the kind of person who is good at mathematics	.860
MSE5	I believe I will be able to use math in my future career when needed.	.868
MSE6	I believe I can understand the content in a mathematics course.	.874
SMA	**Students Mathematics Achievement (SMA); CA = .936; CR=.934; AVE=.742**	
SMA2	In maths, I often receive good results.	.959
SMA4	I get the mathematical ideas that are covered in class	.916
SMA5	I do not need much assistance from the teacher to tackle maths issues.	.723
SMA9	I think I am ready for maths tests	.769
SMA10	My actual arithmetic ability is reflected in my grades.	.916

Reliability Analysis

Conducting a reliability analysis is crucial to ensure the consistency and dependability of the instruments used in the study. Cronbach's Alpha, a metric for internal consistency, assesses how well a set of items are interrelated. A Cronbach's Alpha value of 0.7 or higher is considered acceptable (Sürücü & Maslakçı, 2020).

Table 3 presents the findings, showing the number of items in each scale along with their respective Cronbach's alpha coefficients. These values offer insight into the reliability of each scale, confirming that the items consistently measure the intended construct. All three constructs had Cronbach's alpha values above 0.7, which is considered strong and acceptable (Sürücü & Maslakçı, 2020).

Confirmatory Factor Analysis

Confirmatory Factor Analysis (CFA) was conducted to verify the factor structure uncovered in the Exploratory Factor Analysis (EFA) and to evaluate how well the hypothesized measurement model fits the data. CFA is a statistical method used to determine if a set of observed variables aligns with a predetermined number of latent constructs, enabling researchers to validate the theoretical structure (Shi & Maydeu-Olivares, 2020).

The CFA was conducted to assess convergent validity by examining both composite reliability (CR) and average variance extracted (AVE). Fornell and Larcker (1981) outlined the criteria for these estimations, recommending that CR should be at least 0.7, and AVE should exceed 0.5, which ensures one-dimensionality and adequate convergent validity. The measurement model was tested using principal component estimation in Amos software (version 23). All fit indices were within the acceptable range: CMIN/df = 1.620 (≤ 3.000), TLI = 0.981, CFI = 0.985, GFI = 0.954, RMSEA = 0.049, RMR = 0.020, and PClose = 0.525, indicating strong reliability of the measurement items as expected (Hair et al., 2010). Both CR and Cronbach's alpha (CA) exceeded the minimum threshold of 0.7 (Dogbe et al., 2024). Additionally, all constructs had AVE values greater than the recommended cutoff of 0.5 (Fornell & Larcker, 1981), suggesting that the model fits the observed data well. **Table 4** and **Figure 2** display the model's fit indices.

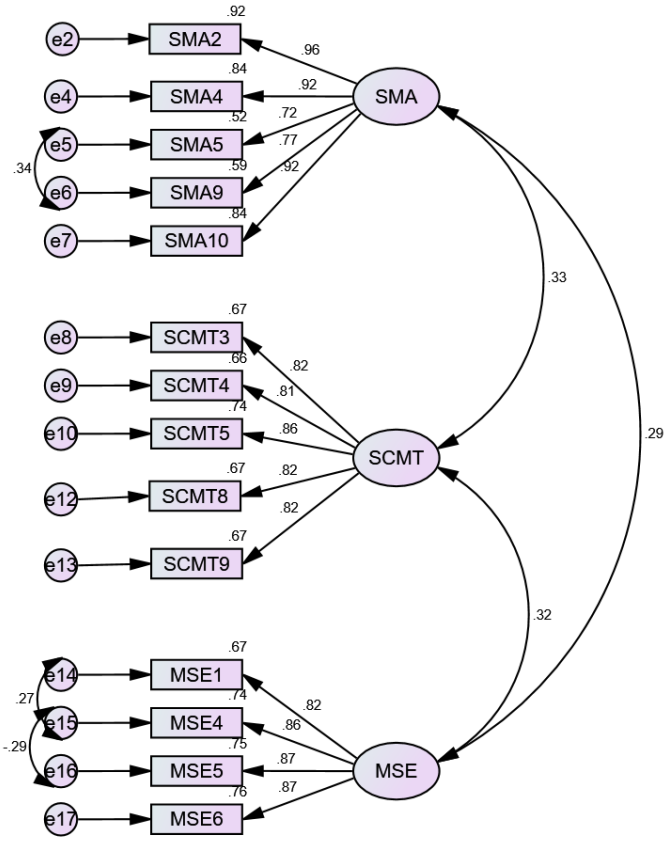

Figure 2. Confirmatory factor analysis

Table 5. Discriminant validity

Variable	CR	AVE	SMA	SCMT	MSE
SMA	0.934	0.742	**0.815**		
SCMT	0.915	0.684	0.335***	**0.827**	
MSE	0.916	0.733	0.291***	0.315***	**0.856**

Notes: * p < 0.050; ** p < 0.010; *** p < 0.001; $\sqrt{\text{AVE}}$ are bolded.

Discriminant Validity

Discriminant validity refers to the extent to which a construct is truly distinct from other constructs in a measurement model. It ensures that each factor in the model represents a unique concept and is not overly correlated with other factors. Establishing discriminant validity is crucial for confirming that the constructs measured in the study are distinct and not overlapping, which strengthens the credibility of the measurement model (Dogbe et al., 2024).

Composite reliability (CR) and Convergent validity measures how closely each observed item interacts with the other observed variables on the same construct (Dogbe et al., 2024). Expected values for the AVE and CR should be at least 0.7 and 0.5, respectively. In order to further examine the study and attain convergence validity, the AVE and CR were computed. The results demonstrate that the AVE and CR thresholds are met (Fornell & Larcker, 1981). To assess discriminant validity, the square roots of the AVE values for each construct were compared with the inter-construct correlations, as shown in **Table 5** (Fornell & Larcker, 1981). The analysis revealed that all the squared AVE values exceeded the corresponding inter-construct correlations. In other words, the smallest square root of AVE was still larger than the highest correlation coefficient, thus meeting the criteria for discriminant validity.

Table 6. Summary of path analysis

Direct Effect	Std. Estimates	S. E	C. R	P-Value
Gender → SMA	.011	.080	.1375	.856
Age → SMA	.022	.056	.3928	.710
Course → SMA	.091	.380	.239	.120
SCMT → SMA	.284	.077	3.688	***
SCMT → MSE	.315	.071	4.436	***
MSE → SMA	.207	.072	2.875	.002
Indirect Effect	**Std. Estimate**	**Lower Bound**	**Upper Bound**	**P-Value**
SCMT → MSE → SMA	.065	.021	.141	.002

Note: *** P = 0.1% significant value of p (0.001).

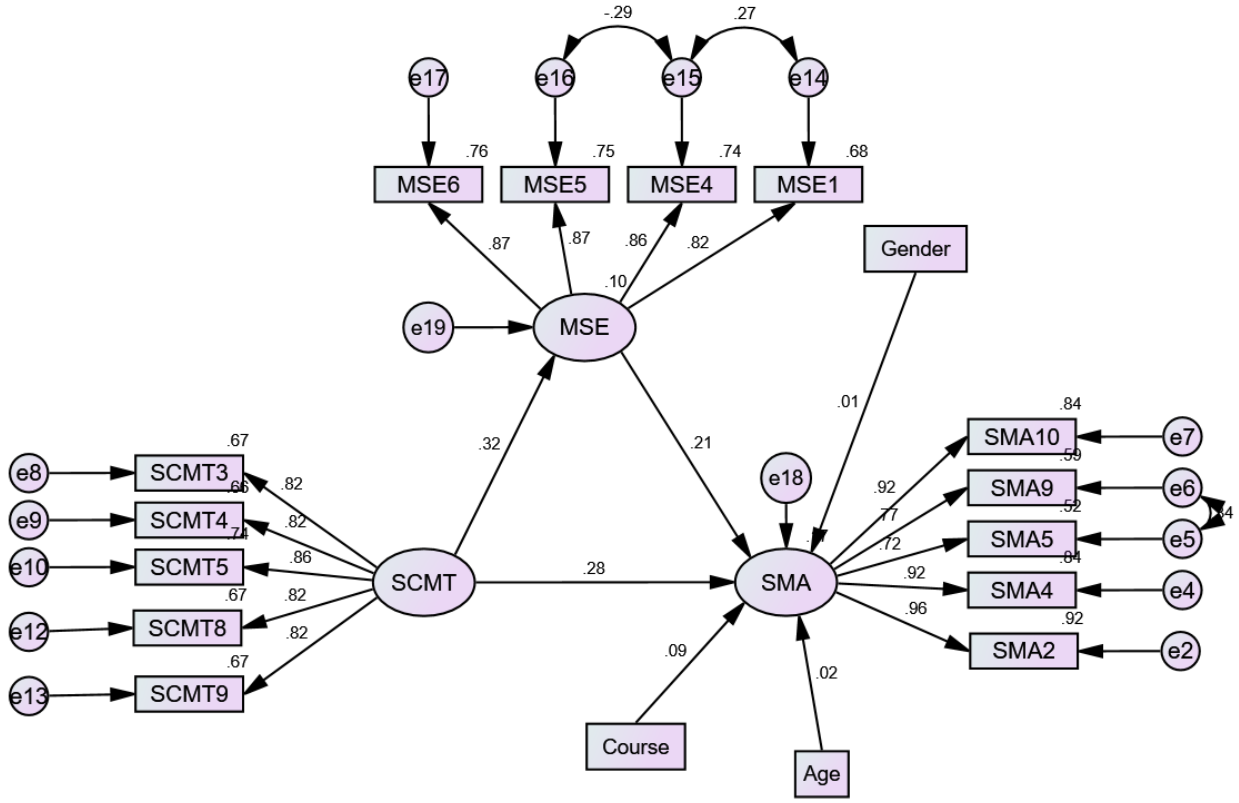

Figure 3. Path analysis

Path Analysis

Following the evaluation of the measurement model fit using Amos (v.23), additional analyses were conducted to explore the potential relationships between the endogenous and exogenous variables within the study's framework. Structural equation modeling (SEM) was used, and a mediation analysis was performed to assess both direct and indirect effects. This was done through bootstrap procedures with 5,000 samples and a 95% bias-corrected bootstrap confidence interval. The study specifically examined the mediating role of mathematics self-efficacy in the relationship between SCMT and SMA. Control variables were also incorporated into the analysis, with the results presented in **Table 6** and visually represented in **Figure 3**. Overall, the model demonstrated a good fit.

From **Table 6**, the result showed that Gender of the respondents had a positive effect on Students mathematics Achievement (SMA) but is statistically insignificant with 1.1% positive impact (β = 0.011; CR = .1375; p =.856). Age had a positive effect on Students Mathematics Achievement (SMA) but is statistically insignificant with 2.2% positive impact (β = 0.022; CR = .3928; p = .710). For the course of the respondent effect on Students mathematics Achievement (SMA) it is positive but statistically insignificant with 9.1% positive impact (β = .091; CR = .239; p = .120).

Hypothesis One

H1: Socio-Constructivist Mathematics Teaching has a direct positive effect on Students mathematics Achievement.

Results on the hypothesized paths, as shown in **Table 6**, demonstrated that Socio-Constructivist Mathematics Teaching had a positive effect on Students Mathematics Achievement and this impact was statistically significant, with a 28.4% positive impact on Students Mathematics Achievement (β = .284; CR = 3.688; p = .001). That is, a 28.4% increase in Students Mathematics Achievement can be attributed to the Socio-Constructivist Mathematics Teaching. Considering the study's findings, **H1:** which states that Socio-Constructivist Mathematics Teaching has a direct positive effect on Students mathematics Achievement was thus supported.

Hypothesis Two

H2: Socio-Constructivist Mathematics Teaching has a direct positive effect on Mathematics Self-Efficacy.

Results on the hypothesized paths, as shown in **Table 6**, demonstrated that Socio-Constructivist Mathematics Teaching had a positive effect on Mathematics Self-Efficacy and this impact was statistically significant, with a 31.5% positive impact on Mathematics Self-Efficacy (β = .315; CR = 4.436; p = .001). That is, 31.5% increase in students' Mathematics Self-Efficacy can be attributed to the Socio-Constructivist Mathematics Teaching. This suggests that students' Mathematics Self-Efficacy is positively impacted when the Socio-Constructivist Mathematics Teaching is incorporated into the teaching and learning process. Considering the study's findings, **H2:** Socio-Constructivist Mathematics Teaching has a direct positive effect on Mathematics Self-Efficacy was thus supported.

Hypothesis Three

H3: Mathematics Self-Efficacy has a direct positive effect on students' mathematics achievement.

Results on the hypothesized paths, as shown in **Table 6**, demonstrated Mathematics Self-Efficacy had a positive effect on students' mathematics achievement and this impact was statistically significant, with 20.7% positive impact on students' mathematics achievement (β = .207; CR = 2.875; p = .002). That is, 20.7% improvement in students' mathematics achievement can be attributed to Mathematics Self-Efficacy. Considering the study's findings, **H3:** Mathematics Self-Efficacy has a direct positive effect on students' mathematics achievement was thus supported.

Hypothesis Four

H4: Mathematics self-efficacy mediates the relationship between Socio-Constructivist Mathematics Teaching and students' mathematics achievement.

Using a 95% confidence level and a 5,000-bootstrap sample, the Bias-Corrected (BC) percentile method of bootstrapping was applied. The structural model shown in **Table 6** satisfied all of the different fit indices as recommended by Hair et al. (2010), just as the CFA did. Additionally, **Figure 3** displays the study's

diagrammatic representation of the structural model. The hypothesis four which states that; Mathematics self-efficacy mediates the relationship between Socio-Constructivist Mathematics Teaching and students' mathematics achievement was to determine whether Mathematics self-efficacy mediates the relationship between Socio-Constructivist Mathematics Teaching and students' mathematics achievement. As indicated in **Table 6**, results on the direct impact of Socio-Constructivist Mathematics Teaching and Students mathematics Achievement demonstrated a statistically significant effect with 28.4% positive impact on Students mathematics Achievement. ($\beta = .284$; CR = 3.688; $p = .001$). This implies that 28.4% improvement on Students mathematics Achievement is attributed to the Socio-Constructivist Mathematics Teaching. Similarly, the indirect effect of Socio-Constructivist Mathematics Teaching on students' mathematics achievement, mediated by Mathematics Self-Efficacy, was statistically significant ($\beta = .065$, 95% CI [0.021, 0.141], $p = .002$).

According to the study's findings, **H4:** Mathematics self-efficacy mediates the relationship between Socio-Constructivist Mathematics Teaching and students' mathematics achievement was thus supported. This implies that Mathematics Self-Efficacy explains or mediates the relationship between relationship between Socio-Constructivist Mathematics Teaching and students' mathematics achievement. Since the direct effect of Socio-Constructivist Mathematics Teaching is significant as well as the indirect effect, Mathematics self-efficacy serves as a partial mediator between the relationship of Socio-Constructivist Mathematics Teaching and students' mathematics achievement.

DISCUSSION

This study aimed to investigate the effects of Socio-Constructivist Mathematics Teaching on students' mathematics achievement and the mediating role of mathematics self-efficacy. The results supported all four hypotheses, indicating a complex interplay between teaching methodologies, self-efficacy, and academic performance in mathematics.

The first hypothesis posited that Socio-Constructivist Mathematics Teaching has a direct positive effect on students' mathematics achievement. The findings revealed a statistically significant positive effect, and this aligns with the socio-constructivist learning theory, which emphasizes that knowledge is constructed through social interactions and active engagement with the material (Ibanez & Pentang, 2021). This result supports previous studies, such as those by Eronen (2019), which found that collaborative learning environments enhance students' understanding and retention of mathematical concepts. The findings further confirm the studies of Majiwa et al. (2020) on influence of constructivism instructional approach on students' achievement in mathematics in secondary schools in Mandera central Sub County, Kenya. The findings indicated that learners educated via the constructivist pedagogical framework attained superior performance in Mathematics in comparison to their counterparts instructed through conventional methodologies. Furthermore, socio-constructivist approaches encourage students to articulate their thought processes, fostering deeper comprehension and improved performance.

Furthermore, the second hypothesis indicated that Socio-Constructivist Mathematics Teaching positively impacted mathematics self-efficacy, with a significant effect size. This finding is consistent with Bandura's (1997) self-efficacy theory, which posits that individuals are more likely to succeed in tasks they believe they can perform effectively. The incorporation of socio-constructivist strategies, such as group discussions and peer teaching, enhances students' confidence in their mathematical abilities by providing them with opportunities to engage actively in their learning (Hanifah et al., 2020). This finding is further in line with the work of Blazar and Kraft (2017) who found that collaborative learning settings boost students' self-perception of competence, leading to greater persistence and effort in mathematics.

Moreover, the third hypothesis confirmed that mathematics self-efficacy has a direct positive effect on students' mathematics achievement. This supports previous research that demonstrates a strong correlation

between self-efficacy beliefs and academic performance (Mozahem et al., 2021). Students who possess high self-efficacy are more likely to engage in challenging tasks, persevere through difficulties, and ultimately achieve better outcomes. A study by Özcan & Kültür (2021) further corroborates this relationship, emphasizing that self-efficacy is a critical determinant of academic success across various subjects, including mathematics.

Additionally, the fourth hypothesis, which posited that mathematics self-efficacy mediates the relationship between Socio-Constructivist Mathematics Teaching and students' mathematics achievement, was also supported. The results indicated a partial mediation effect, with mathematics self-efficacy explaining part of the influence of socio-constructivist teaching on achievement. This finding highlights the importance of fostering self-efficacy through effective teaching practices. As suggested by Bhati and Priyadarshini (2022) argue when students are engaged in socio-constructivist learning environments, they not only enhance their understanding of mathematical concepts but also develop a stronger belief in their capabilities, which in turn boosts their academic performance.

This study presents a novel examination of the combined effects of Socio-Constructivist Mathematics Teaching (SCMT) and mathematics self-efficacy on students' mathematics achievement, with a focus on the mediating role of self-efficacy. While previous research has explored these factors independently, this study integrates them to offer a more comprehensive understanding of their interaction. By introducing self-efficacy as a mediator between teaching strategies and academic performance, the study highlights how SCMT not only improves achievement but also enhances students' belief in their abilities, which in turn boosts performance. Conducted in the Ghanaian education context, the research provides fresh insights into the effectiveness of socio-constructivist approaches in non-Western settings. Additionally, it offers practical implications for educational policymakers, emphasizing the importance of fostering both cognitive and psychological development to improve student outcomes. This integrated approach contributes new perspectives to literature on interactive teaching and its impact on mathematics education.

CONCLUSION

This study has successfully demonstrated that Socio-Constructivist Mathematics Teaching significantly enhances students' mathematics achievement, with mathematics self-efficacy acting as a partial mediator in this relationship. The findings give way to new knowledge by pointing to the dual power of socio-constructivist approaches in bringing not only improvement in mathematical performance but also in nurturing students' self-efficacy, a vital factor which enhances confidence and resilience in learning. The current study adds to the literature by providing additional empirical evidence that such interactive and collaborative teaching practices create a supportive learning environment in which not only do students attain better academic outcomes, but also develop a stronger self-concept of their mathematical capabilities. These insights offer educators a clear path to improving both cognitive and affective aspects of learning mathematics and thereby enrich our understanding of how teaching practices can holistically influence student success.

Recommendations

Implement Socio-Constructivist Strategies: Teachers should adopt and integrate socio-constructivist teaching methods into their curricula to enhance student engagement and achievement. This includes using group work, discussions, and peer teaching to promote collaboration.

Focus on Building Self-Efficacy: Universities and Colleges training programs for teachers should emphasize the importance of fostering mathematics self-efficacy in students. Educators should be equipped with strategies to help students set realistic goals and celebrate their achievements to enhance their confidence.

Professional Development: Schools and educational institutions should invest in professional development programs that focus on the socio-constructivist approach and self-efficacy theory to ensure that teachers are well-prepared to implement these strategies effectively.

Parent and Community Involvement: Engaging parents and the community in supporting students' learning can further enhance self-efficacy and academic achievement. Schools could organize workshops or seminars to educate parents on how to encourage their children in mathematics.

Limitation

Sample Size and Generalizability: The study was conducted in a specific educational context in Ghana, which may limit the generalizability of the findings to other regions or educational systems. A larger and more diverse sample could provide more robust insights. Cross-Sectional Design: The research utilized a cross-sectional design, which limits the ability to infer causal relationships over time. Longitudinal studies could provide a clearer picture of how these variables interact over time.

Future Research Direction

Longitudinal Studies: Future research should explore the long-term effects of Socio-Constructivist Mathematics Teaching on students' self-efficacy and academic achievement through longitudinal studies.

Explore Additional Mediators: Researchers should investigate other potential mediators, such as motivation, classroom climate, and teacher-student relationships, that might further explain the relationship between teaching strategies and student achievement.

Diverse Contexts: Conducting similar studies in various cultural and educational contexts can help validate the findings and explore the generalizability of socio-constructivist methods and self-efficacy impacts on mathematics achievement.

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