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The Mediating Role of Student Attitude in Socratic Mathematics Instruction and Achievement: Evidence from 9493 Learners in Vietnam and Cambodia

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ABSTRACT

Large disparities in mathematics achievement persist across Southeast Asia, raising questions about how instructional practices interact with students' attitudes to shape learning outcomes in contrasting educational systems. Using data from 9493 fifteen-year-old students in Vietnam and Cambodia drawn from Programme for International Student Assessment (PISA) 2022, this study examines the relationships among Socratic mathematics instruction (SMI), student mathematics attitude (SMA), and student mathematics performance (SMP). Structural equation modeling was employed to compare a high-performing system (Vietnam) with a lower-performing one (Cambodia) and to assess the mediating role of student attitudes in translating instructional practices into achievement. Across both countries, SMI was positively associated with SMA (Vietnam: $\beta = 0.43$; Cambodia: $\beta = 0.39$; $p < 0.001$), and SMA was positively related to SMP, with a markedly stronger association in Cambodia ($\beta = 0.28$) than in Vietnam ($\beta = 0.07$; $p < 0.001$). The direct association between SMI and performance was positive in Vietnam ($\beta = 0.08$, $p < 0.001$) but small and negative in Cambodia ($\beta = -0.01$, $p = 0.004$). Mediation analysis revealed that the indirect effect of SMI on performance through SMA was substantially larger in Cambodia ($\beta = 0.11$) than in Vietnam ($\beta = 0.03$; $p < 0.001$), indicating that student attitudes play a compensatory role in contexts with limited instructional capacity. These findings highlight SMA as a key mechanism through which SMI affects achievement and show that instructional effectiveness is context dependent. By integrating pedagogical, affective,

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and contextual factors, the study extends Expectancy-Value Theory and emphasizes aligning instructional reforms with students' motivational and attitudinal profiles, especially in resource-constrained settings.

Keywords: Socratic Math Instruction; Student Math Attitude; PISA; Student Math Performance

1. Introduction

Student math attitude (SMA) is a multidimensional construct that entails enjoyment, interest, self-efficacy, and the perceived value of mathematics that is an incredibly important determinant of student performance in mathematics [1]. The positivity of SMA has always been associated with the amplification of engagement, the persistence in solving problems and adaptive learning strategies, but negative attitudes like math anxiety, have been connected with disengagement and reduced performance [2]. Although the affective factors are central to education, most changes in the instruction are based on the pedagogy aspect without paying enough attention to the emotional and motivational involvement of students, which constringes the possibilities of the effects of educational interventions [3]. The empirical studies, 5711 Vietnamese students are analyzed by PISA 2022 suggest that using inquiry-based pedagogic practices may improve SMP, and SMA is an important mediator of this correlation [4].

SMI has gained academic interest among the current instructional innovations due to its ability to provoke greater cognitive knowledge. This instructional strategy is based on the constructivist theory and its foregrounding, guided questioning, dialogic reasoning, and reflective engagement thus placing learners as active participants in the co-construction of knowledge [5]. SMI pedagogical rationale is based on the Zone of Proximal Development, developed by Vygotsky, which emphasizes the importance of using the social interaction and the scaffolding in cognitive development. Studies show that SMI does not only improve conceptual understanding, but it also develops classroom environments that value inquiry, discussion and critical reflection [6]. However, the effectiveness of SMI depends on students' attitude, as their motivation and engagement determine how they respond to SMI [7].

In this study, the conceptualization of the role of SMA is developed as a mediating variable in the context of Expectancy Value Theory (EVT). EVT states that expectancy of success and value of a particular task determine academic engagement of the students [8]. EVT thus offers a conceptual prism on which the study of the effects of instructional practice on cognitive and affective learning dimensions can be examined through SMI [9]. Students tend to exert greater effort and achieve higher outcomes in mathematics when they perceive themselves as competent and recognize the content as relevant and meaningful. Through reflection, autonomy, and conceptual response, SMI can improve both expectancy and value, thereby positively mediating between SMA and SMP [10].

The present study examines the mediating role of SMA in the relationship between SMI and SMP across the different educational contexts of Vietnam and Cambodia. Vietnam has engaged in large-scale reforms, which support dialogic and student-centered teaching and continuous teacher training, thus creating a good environment for the successful implementation of SMI [11]. On the other hand, Cambodian schools often face a challenge of limited resources and rote education which limits the possible effectiveness of Socratic approaches [12]. Comparative analyses across contrasting national education systems allow examination of how variation in institutional and pedagogical environments interacts with students' psychological and motivational profiles [13]. This interaction helps explain variations in learning outcomes across countries and highlights the role of student dispositions in shaping academic performance. Consequently, such analyses provide valuable insights into the potential of SMI to enhance learning in low- and middle-income countries [14].

The current study integrates EVT, empirical evidence regarding on SMI, and a cross-national comparison of Vietnam and Cambodia to clarify how SMA mediate between SMI and SMP. It further conceptualizes students' attitudes not as passive outcomes of instruction but as dynamic processes that actively shape both the reception and effectiveness of instructional practices [15]. This framework offers both theoretical and practical contributions by providing insights for designing contextually responsive mathematics instruction and informing policy interventions aimed at enhancing equity, student engagement, and learning outcomes across

diverse educational settings[16].

2. Theoretical Framework

To strengthen the study, an integrative approach is needed that combines both pedagogical practices, students' psychological dispositions, and broader contextual factors within a cohesive and dynamic framework[17]. Accordingly, SMA functions as a key mediator through which inquiry-based pedagogy, particularly SMI, affects measurable learning outcomes. Inspired by EVT[18], which aligns student perceptions of competence and task value with their effort and achievement, the present study theorizes that SMA is a mental mechanism that mediates the differences in mathematics performances in a variety of circumstances. Although the available research highlights the cognitive benefits that come with inquiry based pedagogy[19], not much focus has been placed on the affective and motivational aspects of inquiry based pedagogy particularly across various countries[20]. When comparing Vietnam and Cambodia, the study provided understandings of interdependency of pedagogy, student attitudes, and student performance in the two different educational systems[21]. Through this, it contributes to theory by applying EVT in mathematics education and makes a form of contribution to practice by showing how the idea of instructional strategies can be adopted in different educational contexts.

2.1. Socratic Math Instructions in Mathematics Education

The importance of mathematics education is generally understood as the pillar of cognitive development, critical thinking, and the ability to solve problems that form the basis of socioeconomic development as stipulated by the Organisation for Economic Co-operation and Development (OECD) in 2022. Thus, there has been a pedagogical transformation in the world aspect seen in lessening teacher-based modalities and adopting student-based modalities especially in low- and middle-income states[22]. SMI is one such prominent constructivist framework, which encourages the active involvement of students in the learning processes based on exploration, questioning and discussing and making discoveries. Instead of presenting mathematics as a predefined system of operations, SMI helps learners to form meaning and build strong conceptual knowledge in response to a real inquiry and problem-solving situations.

Within this paradigm, SMI uses the process of structured questioning to assist the learners in the process of expressing their reasoning and critically reflecting on mathematics concepts[23]. That strategy is consistent with the Piaget theory of cognitive development and the Zone of Proximal Development (ZPD) proposed by Vygotsky that focuses on the socially mediated and scaffolded learning[24]. Due to initiating dialogue, response, and peer interaction, SMI makes students more active knowledge builders and facilitates increased interaction with mathematical material[25].

2.2. Socratic Math Instruction and Attitudinal Outcomes

The cognitive benefits of SMI have been well-documented[26], however, its overall effectiveness is shaped by affective factors, particularly students' attitudes and emotional responses toward mathematics. According to the emerging studies, SMA, which is operationalized by interest, enjoyment, confidence, and self-efficacy is instrumental in maintaining motivation, persistence, and performance[27]. Students that have positive SMA are more resilient, actively engaged, and more likely to succeed in mathematical assignments compared to those that have negative attitudes, which show anxiety and low self-concept and are easily disengaged[28]. SMI is a proactive method of enhancing SMA through engagement, conversing, and in-depth content of mathematical concepts. Inquiry-based classrooms create instructional environments that promote feelings of respect and intellectual competence, thereby fostering the development of robust self-belief and positive attitudes toward mathematics[29]. In such environments, mathematics is only introduced as an array of formulae to memorize instead of being a dynamic, purposeful process of reasoning and thus enhancing confidence in students to learn and succeed[30].

Moreover, SMA is also determined by how the students perceive the character and worthiness of mathematics. Classroom environments that emphasize inquiry and Socratic questioning provide conditions in which growth mindsets are more likely to develop. In such settings, students come to view mathematical competence as malleable and improvable through effort, a perspective that is consistently associated with higher academic achievement[31]. From this perspec-

tive, SMA reflect the quality of instructional practices they experience. At the same time, SMA functions as a key process through which effective instruction is transformed into measurable gains in mathematics performance.

2.3. Expectancy-Value Theory: A Motivational Lens

This study explores the role of SMA as an intermediary between SMP and SMI through the prism of EVT. This theory suggests that students' academic participation and performance depend on their beliefs about succeeding and the importance they attribute to learning tasks. These two motivational components jointly influence students' effort, persistence, and achievement [32]. A close relationship between expectancy and value plays a significant role in shaping students' motivational orientation, the intensity of their effort, and their persistence in addressing academic challenges [33].

SMI aligns closely with by simultaneously addressing both expectancy and value components of student motivation. Through scaffolded questioning and meaningful dialogue, SMI enables students to experience success, receive immediate feedback, and reinforce their expectancy beliefs, including self-efficacy and confidence [34]. Students who see the practical relevance of mathematical concepts are more likely to find mathematics meaningful and valuable, which increases their interest in the subject [35]. Therefore, students who find mathematics useful, interesting, and possessing a connection with their personal aspirations, tend to be more interested and perform at high levels when they refer to mathematics [36]. The conceptual framework provides a comprehensive account of how instructional interventions, such as SMI, influence mathematics achievement. It considers not only content delivery but also students' beliefs, attitudes, and motivational orientations.

2.4. Cross-National Comparison: Vietnam and Cambodia

Vietnam and Cambodia, neighboring countries in Southeast Asia with a common colonial background yet different educational pathways, are the focus of this comparative study. The research investigates how instructional practices influence SMA and, in turn, affect SMP. The recent reforms in Vietnam have focused on improving teaching quality and improving student-centered learning practices [37]. These efforts encompass extensive teacher training, the adoption of participatory teaching methods, and the implementation of accountability measures aimed at enhancing educational outcomes [38]. This means that Vietnam has scored well in global tests like PISA with the OECD registering a 469 score in mathematics in the year 2022.

In contrast, Cambodia continues to rely heavily on rote learning, with classrooms marked by low student engagement and limited opportunities for critical thinking. The barriers to successful implementation of inquiry-based pedagogical strategies are structural constraints, such as the lack of teacher preparation, excessively large classrooms, and the lack of resources [39]. The low-confidence, mathematics-anxiety and disengagement often accompany the Cambodian students, which may negatively affect the effectiveness of even a well-designed instructional strategy [40]. In this way, Vietnam and Cambodia are a natural contrast to analyze the way inquiry-based teaching works in the different educational systems and the role SMA plays in this process and how performance is mediated. Despite the similarities in the desires of the two countries as regards the development of pedagogical reforms, attitudinal development and systemic support also vary and affect the degree in which the reforms direct academic success to the students [41].

2.5. Contribution to the Literature and Conceptual Advancement

The current study adds to the literature on mathematics education since it establishes SMA as a mid-level construct instead of a nominal outcome or secondary variable. The research was based on the EVT, where cognitive, emotional, and motivational aspects are combined to explain the importance of SMI in improving the performance in mathematics [42]. Even though SMA has been linked to academic success, relatively few studies conceptualize SMA as an active mediating mechanism through which pedagogy affects learning outcomes [43]. Through the application of the comparative approach between Vietnam and Cambodia this study shows that similar pedagogical approaches interact differently with students' attitudes across diverse structural and cultural contexts [44]. This approach strengthens the explanatory power of EVT in under researched Southeast Asian contexts while highlighting the importance of culturally respon-

sive instructional paradigms[45]. In conclusion, this study presents a holistic model that integrates pedagogical practices, students' psychological dispositions, and contextual factors. The findings offer practical insights for educators and policy makers seeking to design equitable and effective mathematics learning environments.

3. Hypothesis

Grounded in the theoretical framework and supported by existing empirical evidence, the hypotheses in this study are formulated to examine the relationship between SMA and mathematics performance in Vietnam and Cambodia as shown in **Figure 1**.

H1. *SMI has a statistically significant direct impact on the improvement of SMP in Vietnam and Cambodia.*

H2. *In both national settings, SMA is revealed to have a positive and significant relationship with student success in mathematics.*

H3. *SMI demonstrates a statistically significant positive association with SMA in both Vietnam and Cambodia.*

H4. *The effect of SMI on SMP is mediated by SMA and there may be differences in mediation strength between Vietnam and Cambodia.*

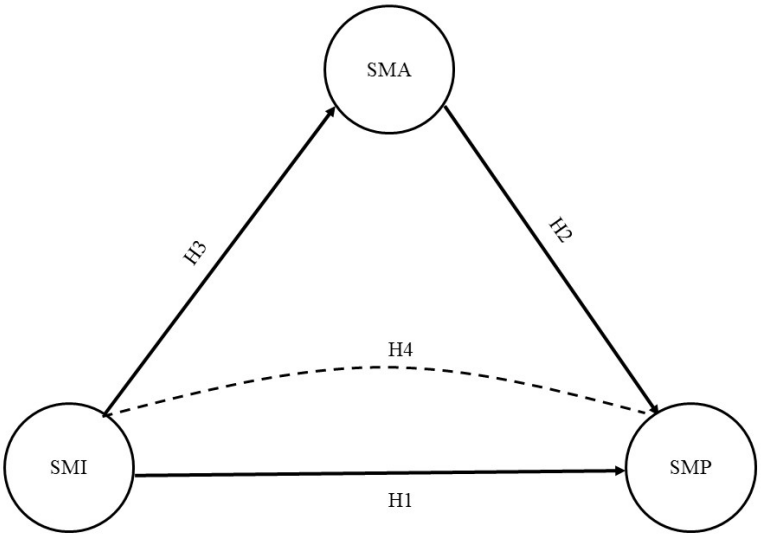


Figure 1. Visual framework outlining four key hypotheses that explore the interplay between Socratic instruction, student attitudes, and mathematics achievement.

4. Method

4.1. Participants

Using publicly available data from the Programme for International Student Assessment (PISA), this study examines the relationship between Socratic mathematics instruction and students' mathematics achievement. Specifically, it analyzes how SMA mediate the effect of SMI on SMP. This study uses publicly available secondary data from the OECD Programme for PISA 2022; therefore, sampling procedures were determined by the data provider and were not conducted by the authors. The analytic sample comprises 9493, fifteen-year-old students from Vietnam and Cambodia. All the demographic information is shown in **Table 1**. PISA cycle, conducted by the Organisation for Economic Co-operation and Development (OECD), provides internationally comparable measures of students' cognitive skills, mathematics performance, and learning attitudes across education systems. This study focuses on the 2022 PISA cycle because mathematics was a major assessment domain, allowing for a detailed examination of factors contributing to mathematics achievement. Notably, SMI is effective in Vietnam, whereas its impact is negligible in Cambodia. By examining this sample, the study offers context-specific insights into how pedagogy and students' attitudes interact to shape mathematics performance across these contrasting Southeast Asian educational settings.

Table 1. Demographic profile of study subjects (n = 9493).

Student Background Variables	Total		Vietnam		Cambodia	
	Mean	SD	Mean	SD	Mean	SD
Study subjects (%)	-	-	39.84	-	60.16	-
Age (years)	14.91	0.28	15	-	14.70	0.41
Female (%)	51.92	0.50	1.48	0.50	1.46	0.50
Socioeconomic status	−1.54	2.61	−1.21	3.18	−2.04	1.24
Math performance test scores	418.27	102.82	471.20	84.53	338.34	71.63

Mathematics is essential for equipping students to navigate future challenges and opportunities in STEM disciplines; consequently, this study emphasizes the critical role of mathematics education. PISA 2022 conducted by the OECD, provides a pertinent context for this study, with mathematics as a primary domain of assessment [46]. It also captures students' attitudes toward mathematics, their perceptions of instructional practices, and their performance on cognitive tasks. An initial pool of 11,347 students was screened, and 1,854 were omitted owing to missing data on SMI and SM. The remaining 9493 participants formed the basis of the study, each contributing complete records for variables as shown in **Figure 2**. The students taken in this study are from the two South Asian Pacific countries, Cambodia and Vietnam, through a student questionnaire developed by OECD.

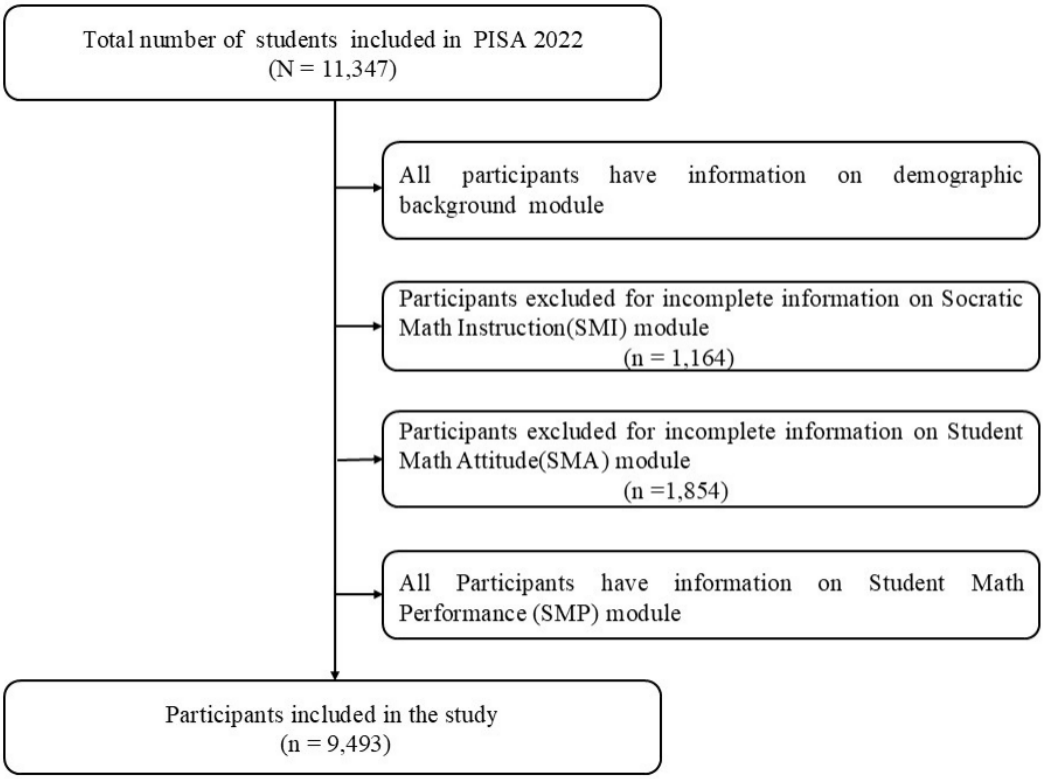


Figure 2. Flow chart of subject inclusion.

4.2. Instruments

4.2.1. Socratic Math Instruction (SMI)

SMI is treated as the independent variable in the current study. This latent construct is operationalized using a seven-item scale from the student questionnaire. The items are designed to measure the frequency with which students are exposed to elements of Socratic teaching in mathematics. Examples include teacher questioning that prompts students to explain their reasoning, discussions that explore multiple

solution approaches, focused engagement with mathematical concepts, and the facilitation of group problem-solving activities.

Students' experiences of SMI were measured using seven items on a five-point Likert scale, ranging from "Never or almost never" to "Every lesson or almost every lesson" (**Table 2**). demonstrates the reliability and validity indices. The Cronbach alpha is 0.81 and the ratio of Kaiser Meyer Olkin showed that the sampling was adequate (0.838). The means of four standardized factors loadings of the seven items ranged between 0.66 and 0.81, which lends even more strength to the validity of the latent construct.

Table 2. Latent measurement for Socratic Math Instruction.

Items	Mean	SD	Factor Loading
Socratic Math Instruction			
The teacher asked us to solve mathematics problems without computing anything.	1.81	1.17	0.89
The teacher asked us to explain how we solved a mathematics problem.	3.31	1.40	0.66
The teacher asked us to explain our reasoning when solving a mathematics problem.	3.10	1.41	0.67
The teacher asked us to defend our answer to a mathematics problem.	3.0	1.46	0.66
The teacher asked us to think about how new and old mathematics topics were related.	3.28	1.41	0.76
The teacher encouraged us to think about how to solve mathematics problems in different ways than demonstrated in class.	3.68	1.36	0.80
The teacher taught us to memorize rules and apply them to solve mathematics problems.	4.07	1.26	0.76

Note: Cronbach alpha is 0.8084, KMO measure of sampling adequacy is 0.838, Bartlett's test-of-sphericity statistic is 21875.248 (df = 21, $p = 0.001$).

4.2.2. Student Math Attitude (SMA)

Next, students' attitudes toward mathematics were treated as the mediating variable. To ensure the validity of this construct, mathematical attitude was conceptualized as a latent variable. For the empirical analysis, a five-item scale from the 2022 PISA student questionnaire was utilized. This scale was chosen to operationalize the latent construct of mathematics attitude, providing a reliable and standardized measure of students' perceptions and feelings toward the subject. The items prompted students to indicate the frequency with which these experiences occurred during their lessons: (1) "I paid attention when my mathematics teacher was speaking", (2) "I put effort into my assignments for mathematics class", (3) I made time to learn the material for mathematics class" etc.

Students' responses were recorded on a five-point Likert scale, from which they could select (1) "Never or almost never", (2) "Less than half of the lessons", (3) "About half of the lessons", (4) "More than half of the lessons", (5) "Every lesson or almost every lesson". **Table 3** presents the construct validity indices and standardized factor loadings for mathematics attitude. The four-item scale demonstrates a Cronbach's alpha of 0.67 and a KMO value of 0.748, indicating acceptable construct validity, while standardized factor loadings ranging from 0.77 to 0.86 further support the empirical robustness of the latent construct.

4.2.3. Students Math Performance (SMP)

In this study, SMP serves as the outcome variable. It is operationalized as a latent construct represented through ten plausible values generated from responses to an extensive battery of mathematics items included in the assessment. Each plausible value reflects a potential performance estimate for an individual student. The mean mathematics grades of the sample population were 418.27 with a corresponding standard deviation of 102.82 therefore being the measure of central tendency and distribution of the performance of the students respectively as shown in **Table 1**.

In addition to the three main constructs under study, the analysis included students' socioeconomic status (SES), gender, and grade level as covariates. Controlling for these background factors helps reduce potential confounding effects, providing a clearer estimate of the relationships among the key variables. Previous research has shown that SES is strongly associated with academic achievement. Research highlighting its significant impact on student performance [47]. Gender has also been found to influence differences in learning experiences and motivational orientations. Grade level was included as an indicator of students' academic progression and maturity, which may further affect performance outcomes.

Table 3. Latent Measurement for Student Math Attitude.

Items	Mean	SD	Factor Loading
Student Math Attitude			
I paid attention when my mathematics teacher was speaking.	4.12	1.12	0.79
I put effort into my assignments for mathematics class.	3.79	1.20	0.86
I gave up when I did not understand the mathematics material that was being taught.	2.10	1.24	0.84
I made time to learn the material for mathematics class.	3.32	1.30	0.77
I lost interest during mathematics lessons.	2.06	1.32	0.84
I started my work on mathematics assignments right away	3.58	1.30	0.80

Note: Cronbach alpha is 0.6662, Kaiser–Meyer–Olkin measure of sampling adequacy is 0.748, Bartlett's test-of-sphericity statistic is 16024.692 (df = 15, p = 0.001).

4.3. Statistical Analysis

Statistical analyses for this study were conducted using STATA (version 15.1; Stata Corp LLC, College Station, TX). To address the main research questions, a structural equation modeling (SEM) framework was employed to examine the relationships among SMI, SMA, and SMP (**Figure 3**). The analysis was based on data from 9493 Vietnamese and Cambodian students, and a mediation analysis was further conducted to assess the extent to which SMA explained the effect of instructional practices on performance outcomes. SEM offers several methodological advantages over traditional techniques such as ordinary least squares regression. It enables the simultaneous estimation of direct and indirect effects, allowing for high-precision testing of complex theoretical models[48]. This capability aligns closely with theory-driven research objectives and has contributed to the growing adoption of SEM in educational studies[49]. Additionally, SEM reduces the likelihood of Type I errors by estimating multiple interrelated pathways within a single analytical framework, thereby minimizing error variance and maximizing explanatory power.

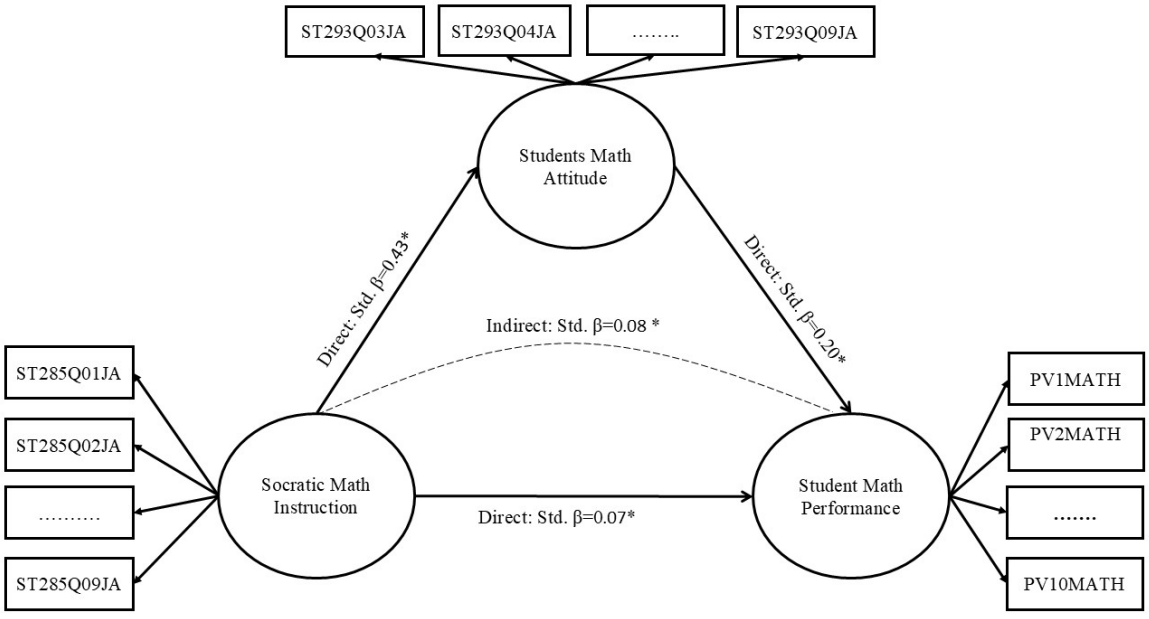


Figure 3. A graphical illustration presenting the standardized estimates and directional associations among Socratic Mathematics Instruction (SMI), Student Mathematics Attitude (SMA), and Student Mathematics Performance (SMP).

Note: Path coefficients marked with asterisks denote statistically significant effects (p < 0.05).

To ensure comparability across measures, all latent constructs were standardized to a mean of zero and a standard deviation of one. This normalization also mitigates potential multicollinearity, enhancing the stability and robustness of the estimations[50]. Collectively, these methodological strategies provide a rigorous and comprehensive approach

for testing the hypothesized relationships and evaluating the mediating role of students' mathematics attitudes in linking instructional practices to performance outcomes.

5. Results

5.1. Descriptive Statistics

In **Table 4**, the analysis was conducted on a pooled sample of 9493 students from Vietnam (60.16%) and Cambodia (39.84%), with a gender distribution of 51.3% male as shown in **Table 1**. Descriptive statistics indicated that students reported frequent exposure to SMI (M = 3.76, SD = 0.57), positive SMA (M = 3.67, SD = 0.67), and relatively high SMP scores (M = 86.17, SD = 6.21).

5.2. PLS-SEM Analysis

The SEM demonstrated acceptable fit to the data. Fit indices were χ^2 (296) = 7837.60, $p < 0.001$, CFI = 0.97, TLI = 0.87, RMSEA = 0.052, and SRMR = 0.070. Analysis was done on the direct and the indirect effects in the framework of mediation and the inferred path coefficients are given in **Table 4** and **Figure 3**. The TLI was slightly below the conventional threshold of 0.90, the combination of other indices indicates a reasonable alignment between the hypothesized model and the observed data, consistent with recommendations for large samples [51]. The model fit supports the direct and indirect effects observed, highlighting the strong mediating role of SMA in linking SMI to SMP across both Vietnam and Cambodia.

Table 4. Results derived from mediation pathways within the SEM framework.

Independent Variable	Dependent Variable	Pooled Sample		Vietnam		Cambodia	
		Std. Coefficient	*p*-Value	Std. Coefficient	*p*-Value	Std. Coefficient	*p*-Value
Direct Effect							
SMI	SMA	0.43	<0.001	0.43	<0.001	0.39	<0.001
SMA	SMP	0.20	<0.001	0.07	<0.001	0.28	<0.001
SMI	SMP	0.07	<0.001	0.08	<0.001	−0.01	<0.004
Indirect Effect							
SMI→ SMA → SMP		0.08	<0.001	0.03	<0.001	0.11	<0.001
Total Effect		0.15	-	0.11	-	0.10	-

Note: Model fit statistics were as follows: $\chi^2(296) = 7837.60$, $p < 0.001$; CFI = 0.97; TLI = 0.87; RMSEA = 0.052; and SRMR = 0.070. Abbreviations: SMI = Socratic Mathematics Instruction; SMA = Student Mathematics Attitude; SMP = Student Mathematics Performance.

5.3. Path Analysis

The standardized path coefficients revealed that SMI had a strong positive association with SMA in both Vietnam ($\beta = 0.43$, $p < 0.001$) and Cambodia ($\beta = 0.39$, $p < 0.001$), confirming that exposure to inquiry-based, Socratic teaching is strongly linked to positive attitudes toward mathematics. SMA, in turn, was positively associated with SMP (Vietnam: $\beta = 0.07$, $p < 0.001$; Cambodia: $\beta = 0.28$, $p < 0.001$), highlighting the central mediating role of student attitude in shaping academic outcomes.

The direct effect of SMI on performance varied across contexts: it was positive and significant in Vietnam ($\beta = 0.08$, $p < 0.001$) but negligible and non-significant in Cambodia ($\beta = -0.01$, $p = 0.004$). The indirect effect of SMI on performance through SMA was stronger in Cambodia ($\beta = 0.11$, $p < 0.001$) than in Vietnam ($\beta = 0.03$, $p < 0.001$), suggesting that in resource-constrained settings, student attitudes play a compensatory role in translating pedagogical efforts into measurable outcomes [52]. Latent variable correlations were all statistically significant and theoretically meaningful. Notably, the pooled sample of SMI and SMA were strongly correlated (r = 0.43), SMA and SMP were moderately correlated (r = 0.20), and SMI showed a smaller correlation with SMP (r = 0.07). These patterns reinforce the notion that the effectiveness of Socratic instructional methods is largely mediated by the attitudes and motivational orientations of learners.

Overall, the findings confirm that while SMI is effective in enhancing positive attitudes toward mathematics in both countries, its direct impact on performance is context dependent. In Cambodia, the limited direct effect underscores the importance of cultivating student attitudes prior to implementing sophisticated pedagogical approaches. In Vietnam, the combination of strong attitudes and direct pedagogical effects produces more consistent performance gains. These

results emphasize that SMA is a critical mediator and highlight the need for context-sensitive instructional strategies in diverse educational environments.

6. Discussion

This study investigates the complex interplay between SMI, SMA, and SMP in two Southeast Asian countries, Vietnam and Cambodia. The findings highlight that SMA plays a critical mediating role in converting Socratic instructional practices into tangible learning outcomes. This underscores the extended explanatory utility of EVT within mathematics education. In the pooled sample, SMI was positively associated with SMA, which, in turn, significantly influenced SMP. However, mediation analyses revealed notable contextual differences: in Vietnam, SMI exerted a strong direct effect on SMP, whereas in Cambodia, the direct effect was minimal, with SMA serving a compensatory function to enhance performance despite instructional challenges. These results highlight the critical importance of aligning instructional design with students' affective and motivational dispositions to optimize mathematics learning, particularly in culturally and structurally diverse educational environments [53].

The results of this study demonstrate that Socratic instructional strategies can shape both the cognitive and affective dimensions of student learning. In Vietnam, SMI showed a significant direct effect on SMP, reflecting the effectiveness of systematic instructional reforms, teacher development programs, and student-centered curricula. In contrast, the minimal direct impact of SMI on SMP in Cambodia highlights structural constraints, such as large class sizes, limited instructional resources, and the persistence of teacher-centered, rote-based methods, which restrict the immediate effects of new pedagogical approaches [54]. Nonetheless, SMI consistently and positively influenced SMA in both contexts, indicating that even in resource-limited settings, inquiry-based instruction can enhance student engagement, self-efficacy, and the perceived value of mathematics. These findings align with prior research emphasizing the importance of Socratic pedagogy and learner questioning in promoting both conceptual understanding and affective involvement [55].

The mediation analysis offers evidence on how instructional practices translate into student achievement through underlying psychological mechanisms. In Cambodia, the direct effect of Socratic Mathematics Instruction on student mathematical performance is limited, whereas student mathematics attitude exerts a substantial influence, indicating that the cultivation of positive attitudes can partially offset structural and instructional constraints. In Vietnam, SMI exhibits a stronger direct effect on student mathematical performance. Nevertheless, SMA continues to serve as a key mediator, suggesting that well-structured, student-centered classrooms not only deliver immediate instructional benefits but also enhance student motivation and engagement [56]. These results further support the explanatory power of EVT, highlighting achievement expectations and the perceived value of mathematics as crucial pathways through which instruction influences performance [57]. Viewing SMA as a mediator highlights the critical role of affective and motivational processes in shaping classroom performance. This perspective emphasizes how SMA influences the effectiveness of instructional practices.

The cross-national comparison in this study highlights how the same pedagogical interventions can yield different outcomes. These differences are shaped by systemic structures, cultural norms, and student attitudes. Unlike much prior research that focused on single-country studies, evidence shows that changes in instructional practices, student attitudes, and organizational structures are all equally important in promoting meaningful educational outcomes [58]. Systemic reforms in Vietnam, including expanded professional development programs and the implementation of a student-centered curriculum, have targeted mathematics instruction. Specifically, the adoption of SMI has been emphasized. These reforms have been reported to strengthen both the direct and mediating effects of mathematics instruction on student achievement [59].

Teacher-centric practices, limited resources and lack of professional development have created a situation in Cambodia where SMI has a minimal direct influence making SMA a necessity in learning outcomes. The Strengthening Teacher Education Programs in Cambodia (STEP-Cam) is a collaborative initiative between UNESCO and the Cambodian Ministry of Education, Youth and Sports (MoEYS). The program aims to enhance teaching and learning standards across Cambodia by improving teacher preparation, providing professional development, and strengthening the institutional capacity of the education system. The focus of these interventions involves the elimination of deficiencies

by use of joint teacher training and institutional development plans. The findings highlight the importance of contextual reforms that combine pedagogic innovation and reforms to promote positive attitudes in students.

In practice, the results have practical implications in the teaching practice and policy development. In educational settings with smaller scale or incremental reforms, instructional methods that cultivate positive mathematical attitudes, such as dialogue, reflection, and collaboration, can enhance student engagement. When effectively implemented, these approaches also contribute to improved learning outcomes. Teacher training should focus on implementing practices that enhance students' understanding, foster self-efficacy, and increase the perceived value of mathematics. Likewise, these findings can be utilized by curriculum designers to match learning goals to the instructional strategies that promote active inquiry and attitudinal development thus enhancing the chances of the long-term academic success [60]. This research highlights the central role of attitudinal factors in learning mathematics. It informs the design of interventions that improve student agency, resilience, and intrinsic motivation across diverse socioeconomic contexts.

Notably, this research contributes to the academic discussion of mathematics education related to the introduction of affective elements in the teaching plan. Unlike previous studies that often treat student attitudes as mere outcomes of instruction, the present findings highlight SMA as a key mechanism through which teaching strategies exert their effects. This underscores the reciprocal relationship between cognitive and affective processes in mathematics learning. The results are particularly relevant to the developing world, where the structural obstacles could to some extent mitigate the pedagogical influence and the attitude of students would be a prominent factor for determining level of success. The study provides a multifaceted view of the interaction of policy, pedagogy and the psychology of a learner when it is comparatively analyzed in Vietnam and Cambodia and thus, offer a practical idea of how SMI should be extended to other countries having similar context.

7. Limitations

This research has certain limitations. Specifically, the cross-sectional design of the PISA 2022 dataset restricts the ability to draw causal inferences regarding the relationships among Socratic Mathematics Instruction, student mathematics attitudes, and mathematics performance. Moreover, the focus on 15-year-old students from Vietnam and Cambodia limits the generalizability of the findings to other age groups, educational contexts, and national settings. Also, the study does not capture the long-term effects of SMI, nor does it account for potential changes in student SMA and performance over time, particularly within educational systems experiencing rapid reform. In addition, substantial within-country disparities exist, including variations in teacher quality, resource allocation, and curriculum implementation, which were not examined in the present analysis. These unobserved internal inequalities may have influenced instructional processes and learning outcomes beyond the scope of this study. Finally, the analysis did not incorporate other relevant psychological and contextual factors, such as mathematics anxiety, self-regulation, and classroom climate. The omission of these variables may limit a more comprehensive understanding of the mechanisms through which instruction influences mathematics outcomes, despite modeling SMA as a mediator. Addressing these issues will require longitudinal research designs and mixed-method approaches to capture changes over time. Such strategies would enable a deeper examination of the nuanced mechanisms linking pedagogy, student attitudes, and SMP.

8. Conclusions

The results indicate that SMA serves as a decisive mediator between (SMI) and subsequent SMP. This finding highlights how SMA translates instructional efforts into measurable achievement. It further demonstrates the combined influence of cognitive, motivational, and contextual factors on mathematics learning outcomes. Consistent with these findings, SMI positively influenced SMA in both Vietnam and Cambodia. However, the direct effect of SMI on SMP depended on contextual factors. In resource-constrained settings like Cambodia, changes in student attitude emerged as the critical determinant of performance gains. These findings challenge the traditional assumption that instructional reforms alone drive learning outcomes. Instead, they highlight that the effectiveness of such reforms depends critically on cultivating positive student attitudes toward mathematics.

Combining cross-national empirical evidence with SEM, the current study contributes to theoretical debates on pedagogy and motivation as well as provides the specifics of educational policy and practice recommendations. Specifically, the findings support reform initiatives that combine innovative teaching and learning practices with sustained efforts to strengthen positive student mathematics attitudes. Such integrated approaches are more likely to promote equitable and sustainable improvements in mathematics learning across diverse educational contexts.

Author Contributions

A.A. led the conceptualization, methodology design, formal analysis, visualization, and preparation of the original manuscript draft. Y.C. provided supervision and project administration. N.A. conducted the literature review and supported the interpretation of the findings. Y.C. and N.A. contributed to manuscript review and editing. A.H. assisted with data interpretation, contributed to methodological refinement, and provided critical revisions to strengthen the overall clarity and rigor of the study. All authors reviewed and approved the final manuscript.

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Institutional Review Board Statement

This study used anonymized, publicly accessible secondary data from PISA 2022. Ethical approval was not required.

Informed Consent Statement

Not applicable.

Data Availability Statement

With permission from the Organisation for Economic Co-operation and Development (OECD), the data used in this study are publicly available via the OECD data repository (https://www.oecd.org/pisa/data/2022database/).

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Conflicts of Interest

The authors declare no conflict of interest.

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