Research Article

EDUCATIONAL POINT
An International Peer-Reviewed Journal

https://www.educationalpoint.net
ISSN: 3062-1011 (Online)

Optimizing mathematics achievement through real-life contexts and historical insights: The moderating role of teaching and learning materials

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CITATION: Amo-Asante, K., Arthur, Y. D., & Bonyah, E. (2025). Optimizing mathematics achievement through real-life contexts and historical insights: The moderating role of teaching and learning materials. *Educational Point*, *2*(1), e121. https://doi.org/10.71176/edup/16552

ARTICLE INFO

Received: 05 Sep 2024
Accepted: 10 Jun 2025

OPEN ACCESS

ABSTRACT

The study examined how applying mathematical concepts to real-life situations and using mathematical history as teaching strategies affect students' performance in mathematics. It also investigated the impact of students' perceptions and teaching and learning materials on these relationships. This study is important because it offers insights into how context-based and historically grounded teaching methods can enhance mathematics achievement, informing more effective and culturally relevant instructional practices. Conducted with a cross-sectional survey design, the study used a structured questionnaire to collect data from 579 secondary school students across six schools in the Kwabre East district, Ashanti Region, Ghana. Data analysis was performed using structural equation modeling in Amos (v.23) software. Results indicated that applying mathematical concepts to real-life situations positively and significantly influenced students' performance. Incorporating the history of mathematics did not directly impact performance but was fully mediated by students' perceptions. Additionally, students' perceptions partially mediated the link between real-life application and performance. The use of teaching and learning materials moderated both the relationship between real-life application and students' perceptions and the relationship between history of mathematics and students' perceptions.

Keywords: history of mathematics, real-life application, students' perception, students' performance, teaching and learning materials

INTRODUCTION

National development depends on high-quality education because it creates the skilled labor force that propels economic growth (Bondar-Pidhurska et al., 2021). Critical thinking and problem-solving abilities are crucial for socioeconomic growth, and mathematics is a key component of these abilities (Anderson, 2024). Globally, mathematics is considered vital to human resource development in disciplines like science, technology, and the humanities (Ansah et al., 2020). Consequently, student performance in mathematics has garnered increasing attention due to its direct implications for national growth (Amo-Asante & Bonyah, 2023).

Despite its significance, a lot of students continue to struggle with mathematics, leading to widespread performance issues across diverse educational systems. Global large-scale assessments, such as the Trends in International Mathematics and Science Study (TIMSS) and the Programme for International Student Assessment (PISA), have consistently highlighted significant disparities in students' mathematical proficiency. For instance, TIMSS results indicate students from Southeast Asian countries such as Singapore and South Korea consistently outperform their peers from European and North American nations, indicating gaps in instructional effectiveness and curriculum relevance (TIMSS, 2019). Similarly, PISA findings reveal that even students in high-performing countries often lack the capability to apply basic mathematical concepts to real-world contexts, reflecting a deeper issue of conceptual understanding and transferability (OECD, 2019).

One promising yet underutilized strategy to address these challenges is the integration of the history of mathematics (HOM) into teaching. HOM provides a rich contextual background that not only humanizes mathematics but also enhances conceptual understanding and student engagement. By situating mathematical ideas within their historical evolution and cultural significance, HOM has the potential to bridge abstract concepts with meaningful, real-world applications—thus aligning with the competencies assessed by PISA and TIMSS.

A similar pattern of low mathematics achievement is observed in many developing countries, including Ghana, where students often face challenges in applying mathematical knowledge to practical and meaningful contexts. International assessments such as TIMSS and PISA have consistently highlighted a critical issue in mathematics education: students across various countries, including those in West Africa, struggle with applying mathematical concepts to real-life problems and demonstrating deep conceptual understanding. This global trend is mirrored in data from the West African Examinations Council (WAEC), which shows persistently low performance in mathematics on the West Africa Secondary School Certificate Examination (WASSCE) from 2015 to 2021. Notably, in 2021, the mathematics pass rate declined by 11%, with only 54.11% of students earning a passing grade (A1–C6) (WAEC Chief Examiner's Report, 2015–2021). These findings underscore the need for innovative instructional strategies like incorporating HOM, which can contextualize abstract concepts, improve engagement, and foster the kinds of critical thinking and application skills that international assessments aim to measure. Various factors contribute to these outcomes, including incomplete syllabi, insufficient instructional time, lack of qualified educators, and ineffective teaching methods (Abreh et al., 2018). To address these challenges, this study focuses on four key factors believed to significantly influence students' mathematics performance: the real-life application of mathematical concepts, integration of HOM in teaching, students' perceptions of mathematics, and the use of teaching and learning materials (TLMs). These factors were chosen based on their strong theoretical and empirical foundations in mathematics education research. Each addresses a specific dimension of learning—contextual relevance, historical-cultural engagement, learner attitudes, and instructional support—that aligns with the competencies emphasized in global assessments such as TIMSS and PISA. Together, they offer a comprehensive framework for improving both conceptual understanding and performance in mathematics. A key issue affecting students' performance is their capaability to relate mathematical concepts to real-life situations, which can enhance understanding and engagement (Jawad, 2022). The ability to relate mathematical concepts to real-life situations is crucial in fostering both understanding and engagement among students. Research, including studies by Boaler (2016) and Freudenthal (1991), highlights that when students can connect mathematical ideas to their daily lives, they develop a deeper conceptual understanding and are more motivated to learn.

A major challenge in mathematics education is students' persistent difficulty in connecting abstract concepts to real-world applications, which often results in low engagement and achievement (Retnawati et al., 2020).

One key factor in addressing this issue is the real-life application of mathematics, which helps students relate mathematical ideas to their everyday experiences and enhances their conceptual understanding. Another promising approach is using HOM, which situates mathematical concepts within their historical and cultural contexts, thereby fostering interest and motivation (Bütüner, 2015). Additionally, students' own perceptions of mathematics—shaped by prior experiences, confidence levels, and perceived relevance—significantly influence their learning outcomes (Anastasiadis & Zirinoglou, 2022). Equally important is the availability and quality of TLMs, which play a vital role in enriching students' mathematical understanding through visual, tactile, and interactive supports (Haleem et al., 2022; Rezat, 2024). This study investigates how these four student-centered factors—real-life application, historical context, perception, and learning resources—interact to influence mathematics performance, with particular attention to how learning materials may moderate these relationships.

LITERATURE REVIEW

Real-Life Application and Students' Performance in Mathematics

One primary goal of mathematics curricula is to enable students to connect the concepts they learn with real-world applications. Educational theories in mathematics strongly advocate for the integration of real-life challenges into the learning process, as this approach is believed to improve comprehension and retention (Arthur et al., 2018). However, despite these theoretical underpinnings, research shows that many students struggle to apply mathematical concepts in practical, everyday contexts (Arthur et al., 2018). Son (2022) emphasizes the importance of this connection, highlighting that students' ability to apply mathematical knowledge in real-life situations is essential for meaningful learning. Rafiepour and Faramarzpour (2023) argue that teachers who adopt problem-based approaches that are grounded in students' daily experiences can foster a more cohesive understanding of mathematics. This approach not only helps students build a solid foundation of interconnected knowledge but also enhances their practical skills. Moreover, effectively linking real-life scenarios with mathematical concepts is a critical pedagogical strategy for deepening students' comprehension (Son, 2022). Nonetheless, Kaya and Kesan (2023) highlighted that many mathematics educators often overlook the critical importance of connecting mathematical content to technological innovation and professional practice. While their study points to a general lack of awareness among teachers, it falls short of exploring how this disconnect specifically affects students' understanding and engagement. What remains underexplored in the literature is how this instructional gap translates into missed opportunities for students to develop applied problem-solving skills and see the relevance of mathematics in real-world contexts. Moreover, previous studies have not sufficiently examined how alternative pedagogical strategies—such as the use of real-life applications and the HOM—could address this gap by making abstract mathematical ideas more meaningful and engaging for learners. Based on this, we hypothesize that:

> *H1: Real-life application of mathematical concepts has a significant positive effect on students' performance in mathematics.*

History of Mathematics Concepts and Students' Performance in Mathematics

Incorporating HOM into teaching is not a recent teaching method, as it has been used since the 1960s and 1970s (Chorlay et al., 2022). Numerous studies have highlighted the importance of HOM in enhancing mathematics education (e.g., Fauvel & van Maanen, 1997; Jahnke et al., 2022; Lim & Chapman, 2015). Clark (2019) noted the establishment of the Institute for the History of Mathematics and its use in teaching (IHMT) to promote the inclusion of historical modules in math lessons. Research has offered various reasons for integrating HOM, with Fried (2014) grouping these into three key themes, the broadest being its ability to make lessons more engaging and reduce students' fear of mathematics, ultimately improving performance. Fried (2014) outlines two main strategies for incorporating HOM into the curriculum: the "*strategy of addition*," which broadens the curriculum by introducing historical figures and their contributions, and the "*strategy of accommodation*," which uses historical developments to explain concepts and enhance teaching. Studies by Arthur and Asare (2022) and Bütüner and Baki (2020) demonstrated that incorporating HOM into classroom instruction led to notable improvements in students' academic performance and attitudes toward mathematics. These studies primarily explored the motivational and cognitive benefits of HOM as a teaching tool within specific instructional contexts. However, they did not examine how HOM interacts with other influential factors such as students' perceptions of mathematics, the application of mathematical concepts to real-life situations, or the availability of TLMs. Additionally, there is limited research on how these elements collectively influence students' overall mathematics achievement, particularly within broader educational settings. This study aims to fill that gap by investigating how HOM, alongside other student-centered factors, contributes to improved performance in mathematics. Based on this, we hypothesize that:

H2: The incorporation of HOM in teaching and learning of the subject has a significant positive effect on students' performance in mathematics.

Role of Students' Perception in Mathematics

Mathematics is often perceived as a difficult subject, with students showing little enthusiasm, which hinders their ability to grasp mathematical concepts and apply them to real-life situations (Hagan et al., 2020). Affective factors like beliefs, attitudes, and emotions are critical in mathematics education (Aguilar, 2021). Students' beliefs about mathematics significantly influence their performance (Shone et al., 2024), and their attitudes and perceptions play a key role in the learning process (Hwang & Son, 2021; Özdemir et al., 2021). Research (e.g., Appiah et al., 2022; Capuno et al., 2019) consistently shows a strong relationship between students' attitudes toward mathematics and their achievement. Studies in Ghana by Arthur et al. (2017a) and Asiedu-Addo et al. (2017) found students with positive perceptions of mathematics were more motivated and achieved better results, while those with negative perceptions struggled. Connecting mathematics to real-world problems can boost students' interest and positively influence their perceptions (Arthur et al., 2018). Research also suggests that incorporating HOM can foster greater enthusiasm and confidence among students. For instance, Kapofu and Kapofu's (2020) study on grade eleven girls' perceptions of the Pythagorean theorem found that HOM positively influenced students' attitudes toward mathematics. However, the study was limited in scope, focusing narrowly on a single concept and a specific demographic. It did not explore the broader impact of HOM on overall mathematics performance or examine how HOM interacts with other factors such as students' perceptions, real-life application of mathematics, or the availability of TLMs. These gaps underscore the need for a more comprehensive investigation into the role of HOM within a multifactorial framework that addresses diverse learning contexts and outcomes. We therefore hypothesize that:

H3: Students' perception towards mathematics mediates the relationship between real-life application of mathematics concepts and students' performance in mathematics.

H4: Students' perception of mathematics mediates the relationship between HOM and students' performance in mathematics.

Moderating Role of Teaching Learning Materials

TLMs are essential to creating an effective educational environment, contributing significantly to student achievement (Tanridiler, 2024). Both human and non-human resources, when utilized effectively, help institutions meet their goals (Mahapatro, 2022). In science and mathematics education, practical activities are key, and TLMs such as textbooks, teaching aids, and laboratory tools help make abstract concepts tangible

(Yara & Otieno, 2010). Mathematics laboratories, for example, enable students to explore concepts and verify theories, linking theory to practice (Nath & Binny, 2018). This hands-on approach improves students' perception of how mathematics applies to real life (Oguntuase et al., 2013). Using models can further enhance understanding. Agyei et al. (2022) note that manipulating physical objects leaves a stronger impression than merely observing them.

TLMs are vital resources in bridging the gap between abstract mathematical concepts and students' real-world understanding. For example, Yara and Otieno (2010) showed that improvised instructional tools, such as handmade globes, helped students better grasp the concepts of longitude and latitude by enabling them to visualize and apply these ideas practically. Similarly, Mukhni et al. (2020) found that media tools—particularly ICT-based resources—enhanced students' engagement and conceptual clarity by making mathematical content more accessible and relatable. Despite these promising findings, few studies have examined the combined impact of TLMs alongside other critical variables, such as the real-life application of mathematics, students' perceptions, and the integration of HOM. This study includes TLMs as a key variable to explore their potential moderating role in strengthening the relationship between these pedagogical strategies and students' overall mathematics performance. We therefore hypothesize that:

H5: TLMs positively moderate the positive relationship between real-life application of mathematics concepts and students' perception towards mathematics.

Mathematics is often perceived as difficult due to its abstract nature, making it challenging for students to grasp. Alshatri et al. (2019) found that using teaching aids helps students overcome these difficulties by making the subject more engaging, which in turn fosters a positive perception of mathematics. When incorporating HOM into lessons, visual aids such as portraits of renowned mathematicians and stories behind their discoveries can spark students' interest and reduce the perception of mathematics as abstract. Teaching strategies that include the use of teaching aids stimulate learners' minds, allowing them to construct their own mathematical knowledge (Rahmayanti, 2021), aligning with Piaget's constructivist theory of learning. According to Piaget, learners build their knowledge through their experiences in their environment (Alanazi, 2016), and teaching aids provide such experiences, making mathematical concepts more tangible. This approach not only helps students understand the subject but also fosters a more positive attitude toward it. Recent studies highlight the importance of visual and contextual learning aids in shaping students' attitudes toward mathematics. For example, integrating portraits of influential mathematicians alongside stories of their contributions has been shown to humanize the subject and stimulate students' interest and motivation (Barbin et al., 2020). Such approaches help demystify mathematics by linking abstract concepts to real people and historical contexts, thereby enhancing student engagement and performance. We therefore hypothesize that:

H6: TLMs positively moderates the positive relationship between HOM and students' perception towards mathematics.

The integration of HOM into instruction has been shown to positively influence students' perceptions of the subject by making mathematical concepts more meaningful, relatable, and human-centered. HOM provides students with a narrative context that highlights the cultural, historical, and practical significance of mathematics, which can reduce anxiety and foster a deeper appreciation for the discipline (Barbin et al., 2020; Bütüner & Baki, 2020). By learning about the struggles, breakthroughs, and contributions of mathematicians over time, students are more likely to view mathematics as an intriguing and accessible discipline other than a set of abstract rules. This shift in perception can enhance motivation, curiosity, and self-belief in learning mathematics. Therefore, this study hypothesizes that HOM positively shapes students' perceptions of mathematics, and that the availability and use of TLMs further strengthen this relationship by making historical content more tangible and engaging. **Figure 1** shows the conceptual framework of the study which depicts the relationship between the variables under study.

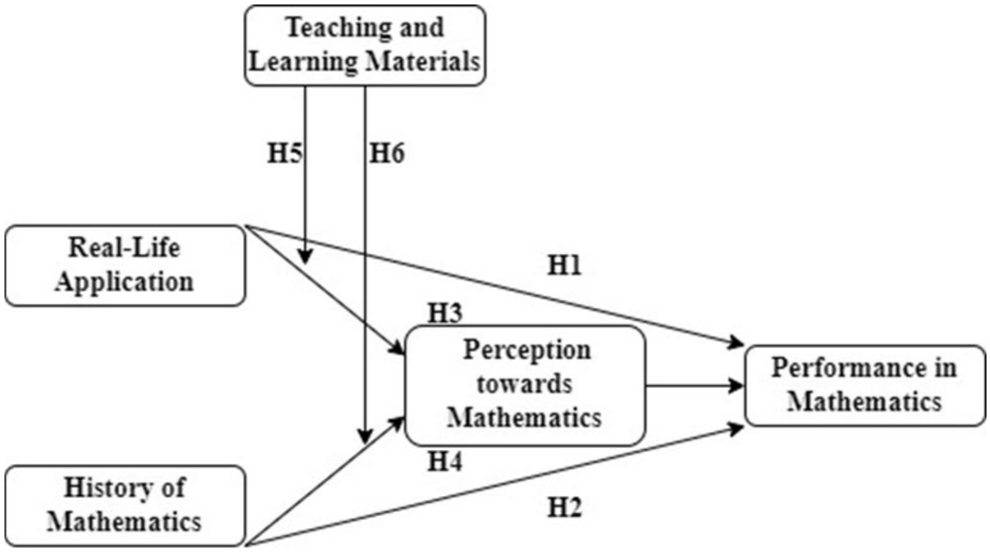

Figure 1. Conceptual framework (Authors' construct, 2024)

METHODOLOGY

Research Paradigm, Design, Sample and Data Collection

This study adopted a positivist approach, emphasizing objectivity and the use of empirical evidence to analyze phenomena through quantitative methods (Aliyu et al., 2014; Creswell, 2015). A cross-sectional survey design was employed, collecting data from a sample population at a single point in time to allow for descriptive and inferential analysis (Burns & Grove, 2010; Creswell, 2014).

The target population comprised secondary school students from six public schools in Kwabre East district, Ashanti Region, Ghana. A total of 600 questionnaires were distributed, with 579 returned, yielding a 96.5% response rate. Structured, self-administered questionnaires were used, and participants were selected using convenience sampling. Permissions were obtained from school authorities through introductory and cover letters.

The demographic data indicated in **Table 1** showed a slight majority of female students (51.2%). The largest group by specialization was General Science (19.8%), followed by Home Economics (16.3%) and Technical (15.1%). Most students were under 18 years old (73.6%) and primarily in their second year (39%).

Questionnaire and Measures

The study focused on five key variables: the real-life application of mathematical concepts, the use of HOM in pedagogy, students' perceptions of mathematics, the adoption of appropriate TLMs, and students' mathematics performance. Students' perceptions of mathematics were measured using a structured questionnaire adapted from validated instruments in previous studies (e.g., Anastasiadis & Zirinoglou, 2022). The perception scale consisted of multiple Likert-type items designed to capture cognitive, affective, and behavioral components of students' attitudes toward mathematics. The instrument demonstrated good internal consistency, with a Cronbach's alpha value above 0.80, indicating high reliability. Content and construct validity were also confirmed through expert review and exploratory factor analysis. Each variable was measured on a Likert scale from 1 (strongly disagree) to 5 (strongly agree). The measurement items for real-life

Table 1. Demographics characteristics (Source: Survey data, 2024)

Demographics	Frequencies (N)	Percentages (%)
Gender	**579**	**100.0**
Male	283	48.8
Female	296	51.2
Course of Study	**579**	**100.0**
General Science	114	19.8
Home Economics	94	16.3
Technical	88	15.1
Business	85	14.7
Visual Arts	76	13.2
General Arts	67	11.6
Agric Science	54	9.3
Age	**579**	**100.0**
Below 18 years	426	73.6
18 years and above	153	26.4
Form	**579**	**100.0**
Year 1	168	29.0
Year 2	226	39.0
Year 3	185	32.0

application of mathematics concepts were adapted from Arthur et al. (2018) and Baki et al. (2009). The instruments used in this study comprised four items for each construct. The HOM scale included four items adapted from Panasuk and Horton (2012) and Yıldız et al. (2011). Students' perceptions of mathematics were measured using four items adapted from the works of Aboagye and Yawson (2020), Aldous (2004), and Madani and Forawi (2019). The TLMs construct was also assessed with four items based on Alshatri et al. (2019). Finally, students' mathematics performance was evaluated using four items adapted from Arthur et al. (2021, 2022). Each item was measured on a five-point Likert scale, and the instruments were reviewed for content validity and demonstrated acceptable reliability levels.

Control variables included Gender (0 = Male, 1 = Female), Course (0 = Others, 1 = General Science), Age (0 = Less than 18 years, 1 = 18 years and above), and Form (1 = Year 1, 2 = Year 2, 3 = Year 3).

Validity and Reliability Analysis

Before conducting the path analysis, confirmatory factor analysis (CFA) was performed using Amos (v.23) to assess model fit. Measurement items with factor loadings below 0.5 were removed, following previous recommendations (Amoako et al., 2020). Internal consistency was tested using Cronbach's alpha (CA) in SPSS (v.23), with a score of 0.7 or higher indicating reliable constructs (Pomegbe et al., 2020). After developing the test items, the researcher hired a specialist to guarantee the validity of the instrument. The questionnaire's internal consistency was assessed using Cronbach's alpha reliability testing after a pilot test drawn from 50 students to guarantee reliability. The pre-test evaluated students' initial familiarity with real-life applications of mathematics and historical mathematical contexts. To further contextualize HOM and its application to real-life scenarios, Group Discussions and Collaborative Learning sessions were designed to enhance students' understanding of how historical mathematical developments relate to modern mathematical concepts and their practical applications in everyday life. Feedback from the pilot was used to refine and clarify the language of the questionnaire items to ensure comprehensibility. The secondary school students' responses showed that the reliability coefficient of the questionnaire ranged from .775 to .875 at a high level. The lowest CA score was 0.775 (for HOM), confirming the reliability of all constructs. Convergent validity was assessed through average variance extracted (AVE) and composite reliability (CR), where AVE values of 0.5 or higher and CR values above 0.7 indicate validity (Fornell & Larcker, 1981). The lowest AVE was 0.501 (for HOM), and the lowest CR was 0.796 (for students' perception of mathematics), confirming convergent validity for all constructs. Model fit was evaluated using the thresholds recommended by Hair et al. (2010): CMIN/DF < 3, TLI and

Table 2. Confirmatory factor analysis

Model Fit Indices: CMIN=887.566; DF=366; CMIN/DF=2.425; CFI=0.912; TLI=0.938; RMR=0.065; RMSEA=0.052	**Std. Factor Loading**
Real-life Application: CA=0.875; CR=0.879; AVE=0.596	
There are sufficient Mathematical Connections to real-life problems during Mathematics lessons (RLA1)	0.815
My Mathematics teachers link mathematics to other subject areas during lessons (RLA2)	0.692
I am able to connect mathematics topics to real-life problems (RLA3)	0.890
I am able to apply mathematical concepts to solve real-life problems (RLA4)	0.783
My Mathematics teachers provide real-life examples and case studies during lessons (RLA5)	0.656
History of Mathematics: CA=0.775; CR=0.799; AVE=0.501	
My mathematics teachers incorporate history of mathematics concepts in mathematics lessons (HMC1)	0.625
My mathematics teachers use history of mathematical concepts during lessons to assist students in learning mathematical concepts (HMC2)	0.801
My mathematics teachers incorporate history of mathematics in lessons to make the topics interesting and attractive (HMC3)	0.714
My mathematics teachers incorporate history of mathematics in lessons to show where and how mathematical concepts originated (HMC4)	0.679
Perception Towards Mathematics: CA=0.789; CR=0.796; AVE=0.502	
I get a great deal of satisfaction out of solving a mathematical problem (SPM1)	0.503
I am sure that I can learn and understand mathematics (SPM2)	0.738
I plan to take as much mathematics as I can during education (SPM3)	0.865
It's fun learning mathematics (SPM4)	0.679
Teaching and Learning Material: CA=0.868; CR=0.876; AVE=0.642	
My mathematics teachers use TLMs to develop the level of students' thinking during teaching (TLM1)	0.724
My mathematics teachers use TLMs such as models to facilitate mathematics lessons (TLM2)	0.898
My mathematics teachers use TLMs such as audio-visuals to connect abstract concepts to real situations during lessons (TLM3)	0.689
My mathematics teachers use TLMs to make mathematical concepts become real (TLM4)	0.873
Mathematics Performance: CA=0.789; CR=0.802; AVE=0.504	
Mathematics as a subject is one of my strengths (PIM1)	0.725
I am good at working out difficult mathematics problems (PIM2)	0.739
I score high marks in mathematics examination (PIM3)	0.621
I am confident in my understanding of mathematics as a subject (PIM4)	0.747

CFI: Comparative Fit Index, CMIN/DF: Chi-Square/Degree of Freedom, TLI: Tukey-Lewis Index, RMR: Root Mean Square Residual, RMSEA: Root Mean Square Error of Approximation

CFI > 0.9, and RMSEA and RMR < 0.08. The results in **Table 2** indicate that the model adequately fits the data. The graphical representation of the Confirmatory Factor Analysis is shown in **Figure 2**.

In this research, "real-life problems" refer to mathematical situations or tasks that students encounter in their everyday lives, which require the application of mathematical concepts and skills to solve. These problems are designed to bridge the gap between abstract mathematical theories and practical applications, allowing students to see the relevance of mathematics in their daily activities. Whiles, the term "history of mathematics" in this study encompasses the significant developments and contributions of various cultures and individuals to the field of mathematics. This includes the exploration of mathematical concepts and techniques that have evolved over time, illustrating the rich tapestry of mathematical knowledge and its application throughout history.

The descriptive and discriminant validity scores are presented in **Table 3**. Results showed that the mean scores for all variables were above 3, with the application of mathematics to real-life scenarios scoring the highest mean of 3.740. Since the measurement items were measured on a 5-point Likert scale (1 = strongly disagree, to 5 = strongly agree), the highest possible mean score was 5. The higher mean score therefore, the more the respondents were in agreement with the measurement items.

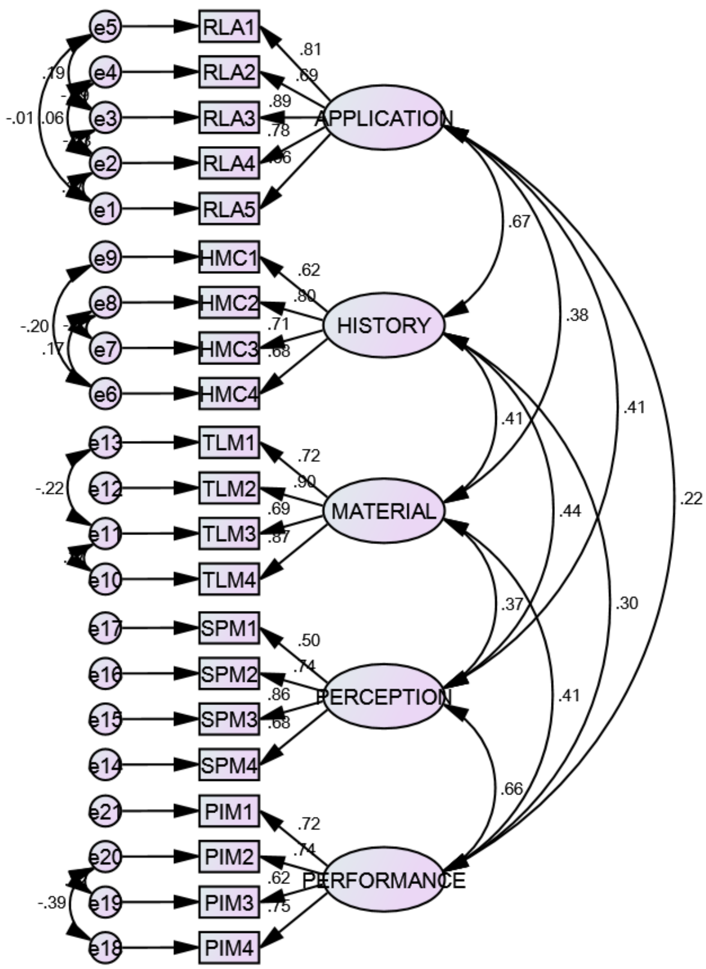

Figure 2. Confirmatory factor analysis

Table 3. Descriptive and discriminant validity analysis

Variables	Mean	Std. Dev.	1	2	3	4	5	6	7	8	9
Gender (1)	-	-	-								
Course (2)	-	-	0.002	-							
Age (3)	-	-	–0.134**	0.118**	-						
Form (4)	-	-	–0.006	0.018	0.047	-					
Application (5)	3.740	1.058	–0.027	–0.167**	–0.178**	–0.057	**0.772**				
History (6)	4.215	0.755	0.211**	–0.225**	–0.220**	–0.060	0.667**	**0.708**			
Perception (7)	3.609	1.001	0.130**	–0.057	–0.026	–0.055	0.414**	0.435**	**0.709**		
Material (8)	3.611	1.152	–0.031	0.002	–0.087*	–0.025	0.382**	0.407**	0.368**	**0.801**	
Performance (9)	3.246	1.023	0.051	–0.061	–0.227**	–0.075	0.216**	0.300**	0.411**	0.657**	**0.710**

√AVEs are bold; *~ P-value significant at 5% (0.05); **~P-value significant at 1% (0.01)

The discriminant validity was assessed by measuring the square-root of the AVEs (√AVEs) against the corresponding correlation coefficients. Discriminant validity is achieved when the √AVE is larger than the corresponding correlation scores (Sarsah et al., 2020), and this was achieved for all constructs in the model. Multicollinearity in a dataset could also cause confounding effects, and as such, it needs to be checked. Correlations scores higher than 0.7 is an indication of potential multicollinearity (Dogbe et al., 2021), but the highest correlation score in this study was 0.667 (**Table 3**).

Table 4. Path estimates

Direct Paths	UnStd. Estimate	Std. Error	C.R.
Application → Perception	0.261	0.045	5.807**
History → Perception	0.201	0.052	3.865**
Material → Perception	0.178	0.029	6.185**
RLA_TLM → Perception	0.139	0.023	6.076**
HMC_TLM → Perception	0.286	0.027	10.77**
Application → Performance	0.216	0.057	3.817**
History → Performance	0.067	0.053	1.268
Perception → Performance	0.850	0.082	10.376**
Course → Performance	0.005	0.018	0.251
Age → Performance	–0.521	0.093	–5.605**
Gender → Performance	–0.112	0.079	–1.415
Form → Performance	–0.082	0.054	–1.516
Indirect Paths	**UnStd. Estimate**	**Lower BC**	**Upper BC**
Application → Perception → Performance	0.223	0.065	0.349
History → Perception → Performance	0.171	0.076	0.250

Bias-Corrected (BC) Percentile Method; 5000 Bootstrap sample; 95% Confidence level.
** ~ P-value significant at 1% (0.01)

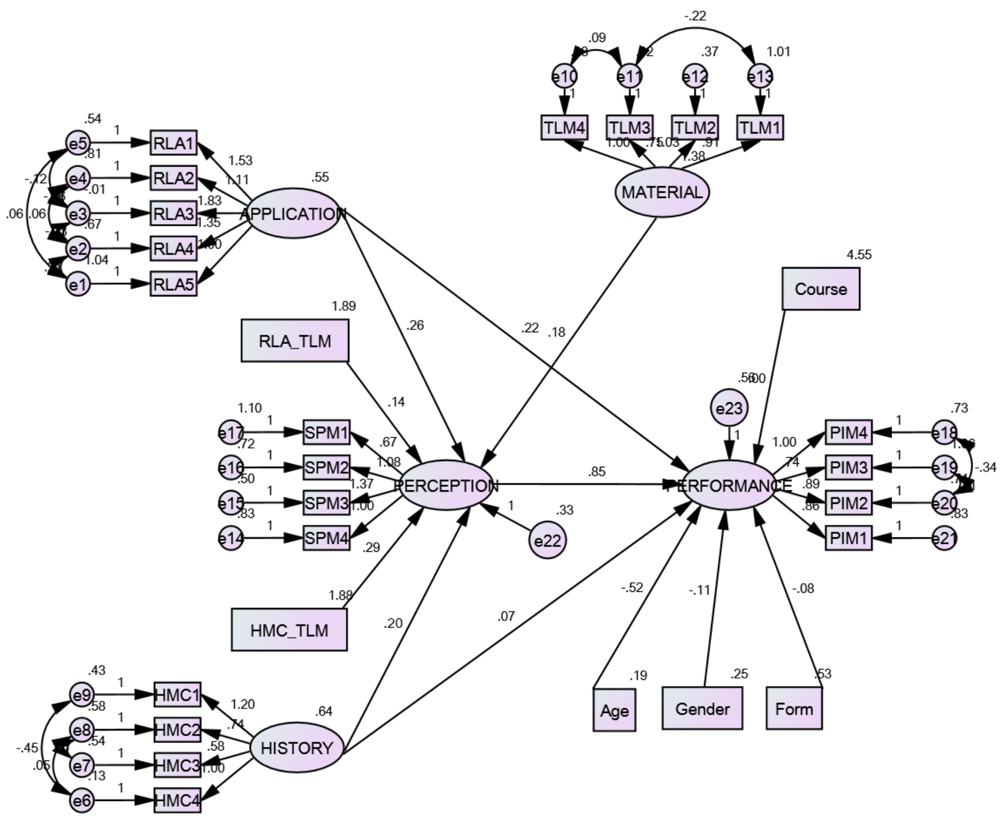

Figure 3. Structural paths

RESULTS

The path analysis for this study was conducted using covariance-based structural equation modeling (SEM) with Amos (v.23) software. The Bias-Corrected (BC) percentile bootstrapping method was employed with 5000 bootstrap samples and a 95% confidence level. The results are detailed in Table 4 and Figure 3.

The analysis revealed that the course offered by students had a statistically insignificant negative effect on their performance in mathematics ($p > 0.05$). Similarly, gender and the student's form or level had negative but statistically insignificant effects on performance ($p > 0.05$). In contrast, the age of students had a significant negative effect on their performance ($\beta = -0.521$; $p < 0.01$), indicating that students older than 18 years performed worse in mathematics compared to those younger than 18. This may be attributed to older students often being in secondary school due to poor academic performance, which reflects their lower performance in mathematics.

Regarding the primary paths, the real-life application of mathematical concepts was found to have a significant positive effect on students' mathematics performance ($\beta = 0.216$; $p < 0.01$). This suggests that linking mathematics to real-life situations enhanced students' performance by approximately 26.1%. Therefore, Hypothesis H1: "Real-life application of mathematical concepts has a significant positive effect on students' performance in mathematics," was supported. Conversely, the incorporation of HOM in lessons did not significantly impact students' performance in mathematics ($\beta = 0.067$; $p > 0.05$), leading to the rejection of Hypothesis H2: "The incorporation of HOM in the teaching and learning of the subject has a significant positive effect on students' performance in mathematics."

To evaluate the mediating role of students' perceptions, the effect of real-life application on students' perceptions of mathematics was assessed first. The results showed that real-life application positively influenced students' perceptions ($\beta = 0.261$; $p < 0.01$), enhancing their perception by about 26.1%. Additionally, students' perceptions significantly impacted their mathematics performance ($\beta = 0.850$; $p < 0.01$), with favorable perceptions improving performance by about 85%. The indirect effect coefficient was 0.223, which was statistically significant, indicating that students' perceptions partially mediated the relationship between real-life application and performance. Thus, Hypothesis H3: "Students' perception towards mathematics mediates the relationship between real-life application of mathematical concepts and students' performance in mathematics," was supported.

For the indirect effect of HOM on students' performance through their perceptions, it was first necessary to estimate the effect of HOM on students' perceptions. The results indicated that HOM positively affected students' perceptions ($\beta = 0.201$; $p < 0.01$), improving their perception by about 20.1%. The coefficient of the indirect effect was 0.171, statistically significant, showing that students' perceptions fully mediated the relationship between HOM and their performance. Specifically, the findings suggest that while incorporating HOM does not have a direct, measurable effect on students' mathematics performance, it influences their perceptions of mathematics in a way that subsequently impacts their performance. In other words, HOM enhances students' interest, motivation, and attitudes toward mathematics, and it is these changes in perception that lead to improved performance, rather than HOM itself having an immediate effect on performance outcomes. Consequently, Hypothesis H4: "Students' perception of mathematics mediates the relationship between HOM and students' performance in mathematics," was accepted.

Results showed a direct positive effect of the use of TLMs on students' perception towards mathematics ($\beta = 0.178; p < 0.01$). This suggests that the use of appropriate TLMs during mathematics lessons enhanced students' perception towards the subject by about 17.8%, and vice versa. In assessing the moderating effect, an interaction term was calculated using mean centering approach. Results from **Table 4** pointed out that the interaction between real-life application and teaching and learning materials (RLA_TLM) had a significant positive effect on students' perception towards mathematics ($\beta = 0.139; p < 0.01$). This was supported by **Figure 4**. From **Figure 4**, it was identified that the highest score of students' perception towards mathematics was achieved when the scores of both real-life application and TLMs were all high (orange line). This suggests that the use of appropriate TLMs enhanced the effect of real-life application on students' perception towards mathematics. Hypothesis H5: "TLMs positively moderates the positive relationship between real-life

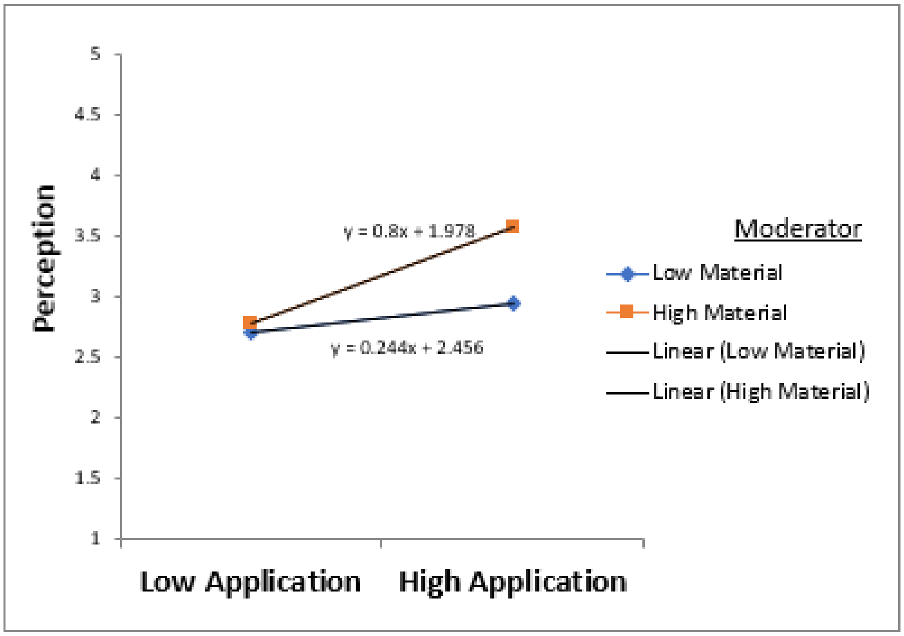

Figure 4. Interaction plot (Real-life application and TLM)

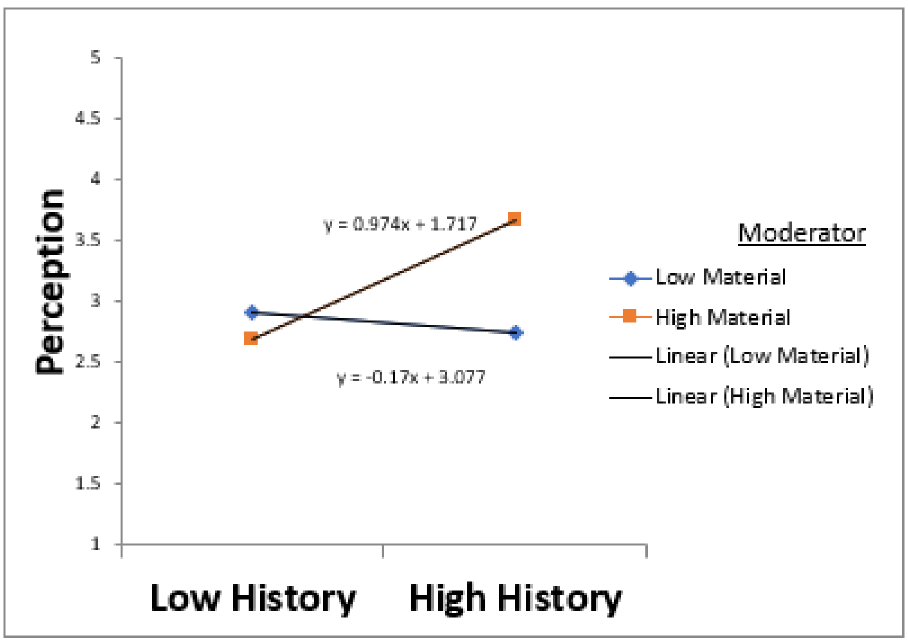

Figure 5. Interaction plot (HOM and TLM)

application of mathematics concepts and students' perception towards mathematics", was therefore accepted by this study.

HMC_TLM had a significant positive effect on students' perception towards mathematics ($\beta = 0.286$; $p < 0.01$). This was supported by **Figure 5**. From **Figure 5**, it was identified that the highest score of students' perception towards mathematics was achieved when the scores of both HOM and TLMs were all high (orange line). This suggests that the use of appropriate TLMs enhanced the effect of HOM on students' perception towards mathematics. Hypothesis H6: "TLMs positively moderates the positive relationship between HOM and students' perception towards mathematics", was therefore accepted by this study.

DISCUSSION OF RESULTS AND THEORETICAL CONTRIBUTIONS

The findings indicated a positive association between the application of mathematical concepts to real-life situations and students' performance in mathematics. It aligns with studies by Arthur et al. (2017b, 2018) and Özgeldi and Osmanoğlu (2017), which highlight that when teachers connect classroom mathematics to everyday challenges, students' achievement in the subject improves significantly. Making mathematics practical through real-world applications helps demystify its abstract nature, contributing to the constructivist learning theory, which emphasizes that students construct their knowledge through real-life experiences (Pritchard, 2017). By connecting classroom concepts with their daily lives, students gain a deeper understanding and show improved academic performance. However, the study found no significant effect of using HOM on students' performance, contrasting with the findings of Arthur and Asare (2022) and Kaygin et al. (2011), who reported positive impacts on performance when HOM was integrated into mathematics teaching.

Additionally, the research revealed a positive relationship between applying mathematical concepts to real-life situations and students' perceptions of mathematics. This is consistent with the National Council of Teachers of Mathematics (NCTM) standards (1989), which advocate linking mathematics to everyday life to improve students' perceptions. Students who could see the practical relevance of mathematical concepts developed a more positive view of the subject. Asiedu-Addo et al. (2017) similarly found that students with positive perceptions of mathematics were more interested in the subject, which ultimately enhanced their performance. The study also showed that incorporating HOM in lessons positively influenced students' perceptions of mathematics. This finding is in line with McBride and Rollins (1977), who observed improved attitudes among college algebra students when HOM was used as a teaching tool. Similarly, Baah-Duodu et al. (2022) found that pre-service teachers' perceptions of mathematics improved after HOM was integrated into lessons. Learning about famous mathematicians and their contributions to mathematics fosters a belief among students that they, too, can excel in the subject, positively impacting their attitudes and performance. Furthermore, students' perceptions fully mediated the relationship between the use of HOM as a pedagogical tool and their performance. Full mediation by students' perceptions indicates that HOM's influence operates through these psychological and attitudinal changes.

The study also found that the use of TLMs enhanced students' perceptions of mathematics. TLMs contribute to conceptual understanding, which positively influences how students view the subject (Ismail & Groccia, 2018). Concrete models and manipulatives allow students to engage with mathematical concepts hands-on, helping them overcome the perception that mathematics is difficult. The findings indicated that applying mathematical concepts to real-life situations, along with the use of TLMs, significantly improved students' perceptions of the subject. Larbi and Mavis (2016) support this by noting that manipulatives provide students the opportunity to interact with and apply mathematical concepts, thus enhancing their perception of the subject. Moreover, the study showed that regularly incorporating HOM and TLMs in lessons significantly shaped students' perceptions and attitudes toward mathematics. The combined use of these tools had a greater impact on improving students' views of mathematics than either strategy used in isolation. This suggests that TLMs reinforce the positive effect of HOM on students' perceptions of mathematics.

CONCLUSION

This research explored the impact of applying mathematical concepts to real-life situations and using HOM as a teaching strategy on students' mathematics performance. It also investigated the roles of students' perceptions of the subject and the use of TLMs in shaping these relationships. The study focused on secondary school students' mathematics performance, drawing on a sample of 579 students from six secondary schools in the Ashanti Region of Ghana. The findings revealed that the real-life application of mathematical concepts had a significant positive effect on students' performance in mathematics. This contributes new knowledge to the literature by providing empirical evidence from a Sub-Saharan African context, where such studies are limited. While prior research has primarily focused on real-life applications in Western or Asian educational settings, this study addresses a notable gap by examining its impact within the Ghanaian secondary school system. The findings highlight how contextually relevant, real-life examples can enhance conceptual understanding and academic achievement, thereby offering practical insights for curriculum developers and mathematics educators seeking culturally responsive strategies to improve student outcomes.

While the incorporation of HOM in lessons did not directly influence performance, the relationship was fully mediated by students' perceptions of mathematics. Additionally, students' perceptions partially mediated the relationship between the real-life application of mathematical concepts and their performance. Finally, TLMs were found to moderate both the relationship between the real-life application of mathematical concepts and students' perceptions of the subject, as well as the relationship between the use of HOM and students' perceptions.

PRACTICAL IMPLICATIONS

The findings of this study carry significant implications for both the senior high school mathematics curriculum and teaching methodologies. To improve students' problem-solving, analytical, and innovative thinking skills, mathematics instruction should prioritize context-based teaching strategies that actively engage learners in meaningful, real-world problem situations. To strengthen students' career readiness and interdisciplinary competencies, mathematics education should be integrated with practical applications from science, technology, and everyday life, enabling learners to see its relevance across various professional fields. Varying instructional approaches can also cater to individual student needs. Enhancing the use of both virtual and concrete TLMs in mathematics lessons is essential, as these tools positively influence students' attitudes toward the subject. Based on the study's findings, curriculum developers globally should consider integrating historically grounded content into secondary mathematics curricula to improve students' perceptions and engagement. Specifically, mathematics lessons should incorporate narratives of mathematical discoveries, the biographies of mathematicians, and culturally relevant historical contexts to humanize mathematics and stimulate interest. Additionally, practical, activity-based approaches—such as mathematical modeling using real-life scenarios and interactive learning through manipulatives—should be embedded into classroom instruction. Establishing dedicated mathematics learning spaces, such as math labs or innovation hubs, equipped with TLMs, can support experiential learning. These recommendations are particularly relevant for education systems undertaking STEM reforms, such as Ghana's STEM academy initiative, and can serve as a model for other nations seeking to improve mathematics outcomes through pedagogical innovation and historical contextualization.

LIMITATIONS AND SUGGESTIONS FOR FUTURE RESEARCH

The study explored the impact of applying mathematical concepts to real-life situations and incorporating HOM on students' mathematics performance, along with the influence of students' perceptions and the use of TLMs in secondary schools. While the findings contribute to the existing body of knowledge on factors influencing students' achievement in mathematics, some limitations remain. Specifically, the study did not investigate the specific methods and teaching strategies that mathematics teachers could adopt to integrate HOM into their lessons or apply mathematical concepts to real-life scenarios. Additionally, the focus was limited to secondary school students. Future studies should consider broadening the scope to include tertiary-level students who study mathematics and explore effective teaching strategies for incorporating HOM and applying mathematical concepts to real-world contexts.

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