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Cultural Values and Mathematical Problem-Solving in Ghana: The Interplay of Motivation and Prior Knowledge

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Abstract: The extent to which students' cultural values influence mathematical problem-solving skills was investigated, with emphasis placed on the moderating effect of prior mathematical knowledge and the mediating role of student motivation. A mixed-methods design was employed to ensure both quantitative and qualitative dimensions of the inquiry were addressed, enabling a comprehensive understanding of the underlying relationships. A purposive sample of 370 students from culturally diverse regions of Ghana was selected to ensure contextual validity and sociocultural relevance. It was found that students' cultural values significantly shaped their problem-solving performance, particularly in relation to cognitive processing strategies and the selection of problem-solving heuristics. The relationship between cultural values and problem-solving skills was moderated by students' prior knowledge, with students possessing a stronger foundational understanding of mathematics deriving greater benefit from cultural alignment. Contrary to expectations, the mediating effect of student motivation on this relationship was not supported, suggesting that while motivation is influenced by cultural values, it does not serve as a direct conduit for enhanced problem-solving capability. These findings underscore the necessity of incorporating culturally responsive pedagogical strategies that recognize and harness cultural value systems as cognitive assets. Furthermore, implications for curriculum development and teacher training were discussed, with a recommendation that future research explore context-specific interventions that operationalize cultural capital to improve mathematical learning trajectories.

Keywords: Cultural values; Mathematical problem-solving skills; Prior knowledge; Motivation; Moderation; Mediation

1. Introduction

The connection between cultural values and mathematics education has captured the interest of both researchers and educators in this rapidly globalizing world (Hill et al., 2021). Cultural values profoundly influence how students approach learning, particularly in subjects like mathematics that require advanced problem-solving skills (Hunter, 2021). Different cultural perspectives on education, learning styles, and problem-solving methods shape students' mathematical abilities. Understanding these factors is crucial in designing curricula that cater to a diverse student population, ultimately aiming to enhance mathematical problem-solving skills globally (Thompson, 2024). By examining these cultural influences, educators can develop more inclusive and effective teaching methods, fostering a generation of students who are not only proficient in mathematics but also capable of critical and creative thinking in a multicultural setting.

The interplay between cultural values and mathematics education within the African context presents unique opportunities and challenges (Hunter, 2021). African societies, characterized by their rich traditions, languages, and communal lifestyles, offer a distinctive perspective on education and problem-solving. In many African cultures, oral traditions and collaborative problem-solving are vital components of education (Walshaw, 2017). These cultural practices can significantly influence how students tackle mathematical problems, often favoring teamwork over individual approaches. Recognizing and incorporating these cultural values into educational frameworks can enhance student engagement and mathematical performance. Additionally, aligning instructional methods with students' life experiences and cultural backgrounds can help address educational disparities across the continent by ensuring that teaching practices resonate with students' lived experiences.

Ghana serves as an intriguing case study on the influence of cultural values on mathematical problem-solving abilities, reflecting the broader African cultural milieu. Ghanaian students often bring to the classroom a set of cultural norms and values that shape their learning behaviors (Mensah & Baidoo-Anu, 2022). For instance, respect for authority and elders, a strong sense of community, and the emphasis on oral communication are deeply ingrained in Ghanaian society. These principles can affect how students interact with their teachers and peers, their approach to problem-solving, and their persistence when faced with challenging arithmetic problems. By adapting instructional methods to better reflect these cultural values, Ghanaian educators can create a supportive and inspiring learning environment for their students. This type of culturally sensitive education not only improves students' mathematical proficiency but also nurtures a sense of identity and belonging.

Mathematics education, by its very nature, greatly benefits from an understanding of cultural values (Tang et al., 2021). The broader cultural context in which mathematics is taught and learned often shapes educational practices. Traditional educational systems may emphasize individual achievement and rote memorization, while other cultural contexts might prioritize understanding and collaborative learning (Kirkham & Chapman, 2022). By integrating cultural awareness into mathematics instruction, teachers can make the subject more relevant and accessible to students from various backgrounds (Di Martino et al., 2023). This approach can lead to more effective teaching methods that utilize and respect students' cultural knowledge, thereby improving their problem-solving skills and overall mathematical competence. Additionally, culturally responsive mathematics education fosters equity and inclusivity, equipping students to thrive in a multicultural and globalized world (Ramírez et al., 2023).

Understanding the impact of cultural values on mathematics education and problem-solving is not only an important academic pursuit but also a key aspect of personal development (Sancar-Tokmak, 2015). Students, particularly those from diverse cultural backgrounds, can achieve better academic outcomes and enhanced self-esteem by recognizing and leveraging their cultural strengths. Although mathematics is often seen as a universal language, it can become a powerful tool for personal growth when taught in a culturally relevant manner (Rosyidi et al., 2024). Encouraging students to integrate their cultural experiences and perspectives deepens their connection to the subject matter. This approach not only boosts cognitive skills but also fosters resilience, creativity, and critical thinking (Hariyanto et al., 2023). However, limited research has specifically examined the impact of cultural values on students' mathematical problem-solving skills, as well as the mediation and moderation effects within this relationship. Understanding how factors such as student motivation mediate and prior knowledge moderates this impact is crucial for developing culturally responsive instructional strategies. Addressing these gaps can provide deeper insights into how cultural dimensions shape mathematical learning and problem-solving processes.

1.1 Theoretical Framework

To clarify potential research conclusions, the theoretical framework for studying how cultural values influence students' mathematical problem-solving abilities incorporates several key perspectives. Social cognitive theory (Bandura, 2009) posits that children learn through observation, imitation, and modeling, and it suggests that cultural values affect students' problem-solving skills by shaping their perceptions of and success with mathematical problems. Furthermore, socio-cultural theory (Shabani, 2016) provides a lens to understand how cultural values influence students' interactions with mathematical concepts within their social and cultural contexts. These theories together offer a comprehensive approach to examining the impact of cultural values on students' mathematical problem-solving abilities.

By integrating various theoretical perspectives, the framework elucidates how cultural values impact students' mathematical problem-solving abilities (Kaur et al., 2022). It posits that cultural values shape students' problem-solving methods and strategies, highlighting the dynamic interplay between cultural contexts, motivational factors, and prior knowledge (Rocha et al., 2024). For instance, cultural values that emphasize group achievement may encourage students to adopt collaborative problem-solving techniques, thereby enhancing their ability to generate and evaluate solutions collectively.

1.2 Conceptual Framework

As shown in Figure 1, the components of this conceptual framework—students' cultural values, prior knowledge, motivation, and problem-solving skills—are crucial for enhancing student learning and performance. Students' cultural values influence their attitudes and engagement with educational content, making it essential for creating culturally responsive instruction. Students' prior knowledge moderates how new information is integrated, allowing educators to provide targeted support based on their existing knowledge. Students' motivation drives their participation and effort, impacting their ability to apply problem-solving strategies effectively. Finally, students' problem-solving skills reflect their ability to analyze and resolve challenges, which is vital for academic and career success. Understanding these components helps educators tailor instruction, foster engagement, and support skill development, leading to improved learning outcomes.

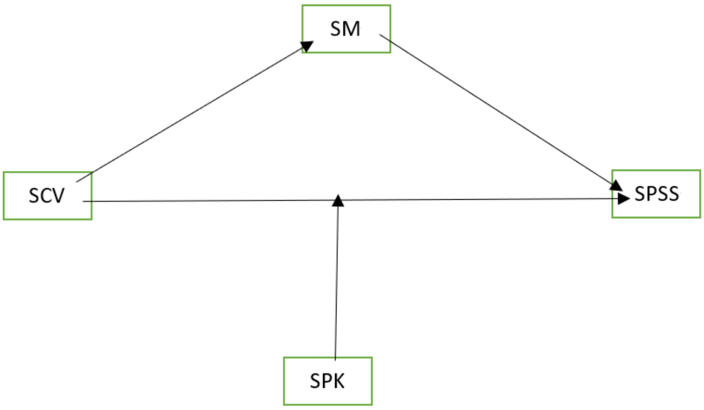

Figure 1. Conceptual framework
Note: SCV indicates students' cultural values, SPK indicates students' prior knowledge, SM indicates student motivation, and SPSS indicates students' problem-solving skills.

2. Literature Review

2.1 Cultural Values in Mathematics Education

Cultural values play a crucial role in mathematics education by shaping how students perceive and engage with the subject (Otieno & Povey, 2023). These values influence learning approaches, problem-solving strategies, and overall attitudes toward education (Kirkham & Chapman, 2022). By understanding and incorporating cultural values into mathematics instruction, educators can enhance student motivation and engagement, making the subject more accessible and relevant. When students see their cultural backgrounds represented in the curriculum, they are more likely to develop a positive attitude towards mathematics, boosting their confidence and encouraging them to tackle challenging problems (Kurniawan et al., 2024). This relevance helps students connect abstract concepts to their cultural contexts and experiences, leading to a deeper understanding and appreciation of mathematical ideas.

Integrating cultural values into mathematics instruction also promotes equality and inclusivity in the learning environment (Kurniawan et al., 2024). By recognizing and respecting students' diverse cultural backgrounds, educators can create a more supportive and comprehensive educational experience. Valuing cultural diversity allows teachers to design a more inclusive curriculum that addresses the varied learning needs of students (Di Martino et al., 2023). This approach helps close the achievement gap and prepares students for success in a multicultural world. Culturally responsive teaching practices enable students to appreciate different perspectives and methods, enhancing their teamwork, critical thinking, and problem-solving skills (Xenofontos & Andrews, 2012). In the end, incorporating cultural values into mathematics instruction enhances the educational experience for all students, fostering a more diverse, equitable, and effective learning system.

2.2 Students' Mathematical Problem-Solving Skills

Mathematical problem-solving abilities are crucial for both academic success and practical applications, requiring not only computational skills but also creativity, perseverance, and critical thinking (Rosyidi et al., 2024). Cultural factors significantly influence the development and use of these skills by students (Tang et al., 2021). Different cultures value various cognitive and educational processes, leading to diverse problem-solving approaches. For example, some cultures emphasize individual achievement and independent thinking, while others prioritize group problem-solving and collaborative learning, fostering cooperation and communication skills. These cultural orientations impact how students perceive mathematical problems, generate solutions, and persist in solving them, ultimately affecting their overall problem-solving proficiency (Sancar-Tokmak, 2015).

Cultural values significantly shape students' perceptions of mathematics and their confidence in problem-solving skills (Clements & Sarama, 2015). Beliefs about the importance of education, mathematics, and societal expectations can either motivate students or induce anxiety and aversion (Sancar-Tokmak, 2015). For instance, cultures that foster a growth mindset encourage perseverance and resilience in students facing challenges, enhancing their problem-solving skills. Conversely, cultures that view mathematical ability as an innate trait may discourage struggling students, hindering their problem-solving development (Clark et al., 2014).

Additionally, cultural norms influencing family and community support play a crucial role in providing students with resources, motivation, and role models (Xenofontos & Andrews, 2012). This support can bolster students' confidence and skills in problem-solving (Rubel et al., 2022). By understanding these cultural influences, educators can create more culturally responsive and effective teaching strategies, ultimately enhancing each student's mathematical problem-solving abilities.

2.3 Prior Mathematical Knowledge

Students' mathematical problem-solving abilities are heavily influenced by their foundational prior knowledge of mathematics (Lee et al., 2022). Those with a strong grasp of basic mathematical principles are better equipped to handle complex problems with confidence and efficiency (Florentino et al., 2023). This foundational knowledge allows students to identify patterns, apply appropriate methods, and make connections between different mathematical concepts, enhancing their problem-solving capabilities. Conversely, students with weak prior knowledge may struggle to understand problem statements, choose suitable approaches, or perform necessary calculations, leading to increased frustration and a decline in confidence in their mathematical skills (Florentino et al., 2023).

Furthermore, a solid understanding of mathematics enhances cognitive flexibility, enabling students to adapt and apply different problem-solving approaches in various situations. When students encounter new and more challenging problems, their ability to use previously learned concepts and skills becomes vital to their success (Özpınar & Arslan, 2023). This cumulative knowledge promotes higher-order thinking and analytical abilities, leading to a deeper understanding of complex topics. Teachers who recognize the importance of prior mathematical knowledge can tailor their lessons to reinforce and build upon these foundational ideas, providing students with the tools they need to tackle difficult problems (Florentino et al., 2023). By emphasizing the continuity of learning and the interconnectedness of mathematical concepts, teachers can help students develop a robust problem-solving toolkit that can benefit them in both their academic and professional lives.

2.4 Student Motivation

Motivation is a crucial factor that significantly affects students' ability to solve mathematical problems (Tabuena & Pentang, 2021). Motivated students often exhibit higher levels of engagement, persistence, and effort when tackling mathematical challenges (Daher, 2022). Those with intrinsic motivation have a genuine interest in learning and solving problems, which helps them understand and retain mathematical concepts more deeply (Taurina, 2018). Their inherent drive encourages them to confront difficulties directly, explore various problem-solving strategies, and persist through challenges. Conversely, students lacking motivation may quickly give up on difficult problems, leading to reduced effort and a decline in performance.

Moreover, students' motivation significantly influences their willingness to practice self-control and critical thinking, both essential for effective problem solving (Otoo et al., 2018). Motivated students are more likely to set goals, monitor their progress, and seek help when needed, all of which contribute to their success in problem solving (In'am & Sutrisno, 2020). They are also more inclined to engage in metacognitive activities, such as reviewing and refining their problem-solving strategies (Saadati & Celis, 2023). Teachers can enhance students' intrinsic motivation by fostering a positive and supportive learning environment, encouraging them to take ownership of their education and develop the resilience (Rodionov & Dedovets, 2018) and perseverance needed for successful mathematical problem solving (In'am & Sutrisno, 2020). Cultivating motivation not only aids in solving problems more effectively but also fosters lifelong learning habits that benefit students beyond the classroom (Hill et al., 2021).

2.5 Problem Statement

Students' mathematical problem-solving abilities are profoundly affected by cultural values, yet there has been limited research into what is behind this influence. Although numerous studies have examined educational outcomes in relation to cultural contexts, few have delved into the intricate effects of cultural values on these outcomes. For instance, Aybala & Emine (2023) emphasized the potential benefits of culturally responsive teaching in mathematics and highlighted the necessity for a more detailed understanding of how cultural values shape educational practices and student performance (Suparatulatorn et al., 2023). Similarly, Kurniawan et al. (2024) underscored the importance of incorporating cultural perspectives into shaping students' problem-solving approaches, noting that cultural values significantly impact cognitive functions and learning methods. However, there remains a critical gap in the literature regarding how cultural values directly influence students' mathematical problem-solving skills, particularly in terms of the underlying cognitive and motivational mechanisms driving this effect. While previous studies acknowledge the role of culture in education, they fall short of providing empirical evidence on how cultural values interact with key learning variables such as motivation and prior knowledge. Furthermore, the mediation effect of student motivation and the moderation effect of prior mathematical knowledge in this relationship remain largely unexplored. Addressing these gaps is crucial, as understanding the precise ways in which cultural values shape mathematical learning experiences can inform the development of culturally responsive pedagogies. This research, therefore, aims to provide empirical insights that can support inclusive educational practices and policies, ensuring that diverse student populations can receive equitable opportunities for academic success.

2.6 Research Objectives

a) The direct effect of cultural values on students' mathematical problem-solving skills.

b) The moderation effect of prior mathematical knowledge between cultural values and students' mathematical problem-solving skills.

c) The mediation effect of motivation between cultural values and students' mathematical problem-solving skills.

d) Students' perception of the impact of cultural values on their mathematical problem-solving skills.

2.7 Research Questions

a) What is the direct effect of cultural values on students' mathematical problem-solving skills?

b) What is the moderation effect of prior mathematical knowledge between cultural values and students' mathematical problem-solving skills?

c) What is the mediation effect of motivation between cultural values and student' mathematical problem-solving skills?

d) How do students perceive the impact of cultural values on their mathematical problem-solving skills?

3. Methodology

This study employs pragmatism as its research paradigm and utilizes a sequential explanatory research design to comprehensively explore how cultural values influence students' mathematical problem-solving skills. This study focuses specifically on students, which may limit the generalizability of the findings to other student populations, such as high school or university students in non-education programs. However, this focus is intentional, as students represent future educators whose cultural values and problem-solving strategies will directly influence the teaching and learning of mathematics in Ghanaian classrooms. Understanding their perspectives is therefore critical to shaping effective, culturally responsive pedagogical approaches.

A purposive sampling method was used to select participants representing a range of cultural backgrounds and different colleges, such as the McCoy College of Education and NJA College of Education. The sample size of 370 participants is justified based on established guidelines for power analysis, ensuring sufficient statistical power for detecting meaningful effects in both the qualitative and quantitative components of the study. A power analysis was conducted prior to data collection, determining that this sample size would provide a power of 0.80 at an alpha level of 0.05, allowing for reliable conclusions regarding the relationships between cultural values, motivation, prior knowledge, and mathematical problem-solving skills. This analysis ensures that the study can detect small to medium effect sizes, supporting the validity of the findings.

Purposive sampling was employed to ensure the inclusion of students with diverse cultural backgrounds, reflecting the varied educational contexts within Ghana. This approach was specifically designed to target individuals who could provide in-depth insights into the research topic. By focusing on students from different regions, schools, and communities, the study ensured that the sample captured the rich diversity of cultural values that influence mathematical problem-solving. This strategy aligns with the study's goals of understanding how cultural factors shape students' learning experiences in mathematics and allows for a nuanced exploration of the intersection between culture, motivation, prior knowledge, and academic performance.

To further substantiate the adequacy of the sample size and the representativeness of the purposive sampling technique, precedents from similar educational research in Ghana were cited, where comparable sample sizes were found to be effective in producing reliable results. For example, previous studies on cultural influences in education within sub-Saharan Africa have utilized sample sizes of similar magnitude, achieving meaningful and generalizable insights into the learning experiences of students from diverse backgrounds. By referencing these studies, the study can strengthen its argument for the adequacy of both the sample size and the sampling method employed in this research.

Data was collected through self-administered instruments known as the Cultural Impact in Mathematics Education Questionnaire (CIMEQ), which includes both closed- and open-ended questions. The closed-ended questions generate quantitative data, allowing for statistical analysis of trends and correlations related to cultural effects on problem-solving in mathematics. The instrument was also pilot-tested with 30 pre-service teachers, and revisions were made based on item clarity, cultural appropriateness, and feedback from content experts, thereby supporting content validity. The coefficients for PK, PSS, CV, and SM were 0.756, 0.712, 0.812, and 0.759, respectively, all exceeding the 0.7 threshold recommended by Jackson et al. (2009). Meanwhile, seven students were sampled, and the open-ended questions provide qualitative data, offering a deeper understanding of the participants' individual experiences and perspectives. This mixed-methods approach offers a robust framework for understanding how cultural values influence mathematical modeling by integrating both quantitative and qualitative data. The sequential explanatory design ensures a thorough examination of the research topics, allowing quantitative findings to be elaborated upon and contextualized through qualitative insights. This approach not only facilitates a detailed analysis of statistical trends and correlations but also enriches the understanding of individual experiences and perspectives. By employing this methodology, the study effectively bridges the gap between numerical data and personal narratives, providing a comprehensive and nuanced view of how cultural factors shape mathematical modeling.

3.1 Data Analysis

The study aims to investigate the effect of problem-based learning on students' mathematical modeling abilities and prior knowledge as a moderator. A sequential mixed-methods analysis was utilized to gain a deeper understanding of the quantitative and qualitative data collected. The reliability of the open-ended questionnaires was assessed using test-retest reliability, ensuring the consistency of the items. For the quantitative data, Cronbach's alpha was reported at 0.771, indicating a satisfactory level of reliability for analysis. To ensure the validity of the closed-ended questionnaires, factor analysis was employed as a statistical method to accurately extract the observed variables that measured the latent variable. Inductive coding was applied to the open-ended questionnaires using the Braun & Clarke (2006) thematic analysis to enhance validity by ensuring that identified themes accurately represented participants' perspectives and the research questions. The approach of Braun & Clarke (2006) to thematic analysis is a method for identifying, analyzing, and reporting patterns (themes) within qualitative data. They proposed a six-step process for conducting a rigorous thematic analysis, which is outlined as follows:

a) Familiarization with the data

Before the analysis, familiarization with the data's depth and breadth involved reading and re-reading the data several times and noting down initial ideas.

b) Generating initial codes

Interesting features of the data across the entire dataset were systematically coded. The codes were labeled to identify important aspects of the data that might be relevant to the research questions.

c) Searching for themes

In this phase, coded data were examined and grouped to form themes. A theme might capture significant ideas about the data with the research questions.

d) Reviewing themes

This involved checking whether the themes work in relation to the coded data and the entire dataset, since it is an iterative process, where some themes may be refined, combined, or discarded by the researcher.

e) Defining and naming themes

Before the themes were finalized, each theme was defined clearly, determining what aspect of the data it captured and giving it a descriptive name. This process captured the essence of each theme.

f) Producing the report

The analysis was written up in a coherent and logical manner, presenting the themes in relation to the research questions. The goal was to provide a compelling narrative that answers the research questions using the themes derived from the data.

The statistical tools employed for the quantitative data analysis included both the Analysis of Moment Structures (AMOS) and the Statistical Package for the Social Sciences (SPSS). SPSS was primarily used to conduct Exploratory Factor Analysis (EFA), which involves identifying the underlying structure of the data by exploring potential factor structures without imposing a preconceived model. This initial step helps in understanding the data's dimensionality and identifying any patterns or groupings of variables.

Following the exploratory phase, AMOS was utilized for Confirmatory Factor Analysis (CFA) and path analysis. CFA is a more structured approach that tests the hypothesis about the factor structure identified during the exploratory phase. It allows researchers to confirm whether the data fits a specific factor model. Path analysis, also conducted using AMOS, involves examining the direct and indirect relationships between variables, helping to understand the causal pathways and the strength of associations among them.

4. Results

4.1 Introduction

This chapter presents an analysis of data. It starts with descriptive statistics to summarize participant demographics, followed by Structural Equation Modeling (SEM) to evaluate the proposed hypotheses. A thematic analysis was conducted on the collected qualitative data and presented accordingly. The chapter concludes with a discussion of the findings and implications of key insights.

4.2 Demographic Characteristics of the Respondents

Demographic information plays a crucial role in research data analysis and should not be overlooked. It examines both the static and dynamic characteristics of the studied population (Bryman et al., 2008). In this study, the empirical survey included questions on respondents' gender, age, program of study, and school affiliation. These aspects provided key insights into participant characteristics and ensured the validity of their inclusion in the research.

Table 1. Gender of respondents

Gender	Frequency (f)	Percentage (%)
Male	192	51.9
Female	178	48.1
Total	370	100.0

As shown in Table 1, the study's gender distribution reveals a fairly balanced representation, with 192 male participants (51.9%) and 178 female participants (48.1%) out of a total of 370 respondents. While there is a slight majority of males, the difference is minimal, indicating that both genders are nearly equally represented in the study.

Table 2. Age of respondents

Age	Frequency (f)	Percentage (%)
18-23 years	81	21.9
24-30 years	197	53.2
31-35 years	64	17.3
≥36	28	7.6
Total	370	100

Table 2 displays the age distribution of respondents, showing that the largest proportion, 21.9% (81 out of 370), falls within the 18-23 age range. This is followed by the 24-30 category, which comprises 53.2% (197 out of 370). A smaller segment, 17.3% (64 out of 370), falls between 31 and 35 years, while only 7.6% (28 out of 370) are aged 36 and above. These findings suggest that the majority of respondents are mature and possess experiences that can contribute valuable insights to address the research questions.

4.3 Exploratory Factor Analysis (EFA)

Table 3 shows the results of EFA. The Kaiser-Meyer-Olkin (KMO) measure of sample adequacy was 0.853, indicating good adequacy as it exceeds the recommended threshold of 0.5. Bartlett's test of sphericity was significant at the 0.05 level, confirming the suitability of the factor analysis. According to the rotated component matrix, items related to problem-solving skills were grouped under Component 1, cultural values items under Component 2, prior knowledge items under Component 3, and student motivation items under Component 4. These components collectively explained 67.12% of the total variance.

4.4 Confirmatory Factor Analysis (CFA)

Figure 2 and Table 4 displays the results of CFA. The model fit indices were assessed to determine how well the conceptual model aligned with the respondent data. The indices were as follows: Chi-Square Minimum Discrepancy (CMIN) = 274.121, degrees of freedom (DF) = 126, resulting in a CMIN/DF ratio of 2.176, which meets the acceptable criterion of being close to 1, with a maximum threshold of 3. The Comparative Fit Index (CFI) and Tucker-Lewis Index (TLI) were 0.951 and 0.965, respectively, both surpassing the acceptable threshold of 0.95. The Root Mean Square Residual (RMR) and Root Mean Square Error of Approximation (RMSEA) were 0.071 and 0.056, respectively, both meeting the criterion of 0.08 or less. The PClose value of 0.119, which is above 0.05, suggests that RMSEA is not significantly different from zero, indicating a good model fit (Li, 2016). Overall, these indicators suggest that the conceptual model is well-suited for the study.

Cronbach's alpha coefficient (CA) was calculated for each construct to assess internal consistency. The coefficients for PK, PSS, CV, and SM were 0.756, 0.712, 0.812, and 0.759, respectively, all exceeding the 0.7 threshold recommended by Jackson et al. (2009). Average variance extracted (AVE) and construct reliability (CR) were calculated for each construct, with minimum thresholds of 0.5 for AVE and 0.6 for CR (Fornell & Larcker, 1981). PK had an AVE of 0.54 and a CR of 0.82, PSS had an AVE of 0.502 and a CR of 0.82, SM had an AVE of 0.64 and a CR of 0.88, and CV had an AVE of 0.51 and a CR of 0.78. According to Li (2016), the quality of a measure is reflected in the average variance recovered and CR, which were achieved in this study.

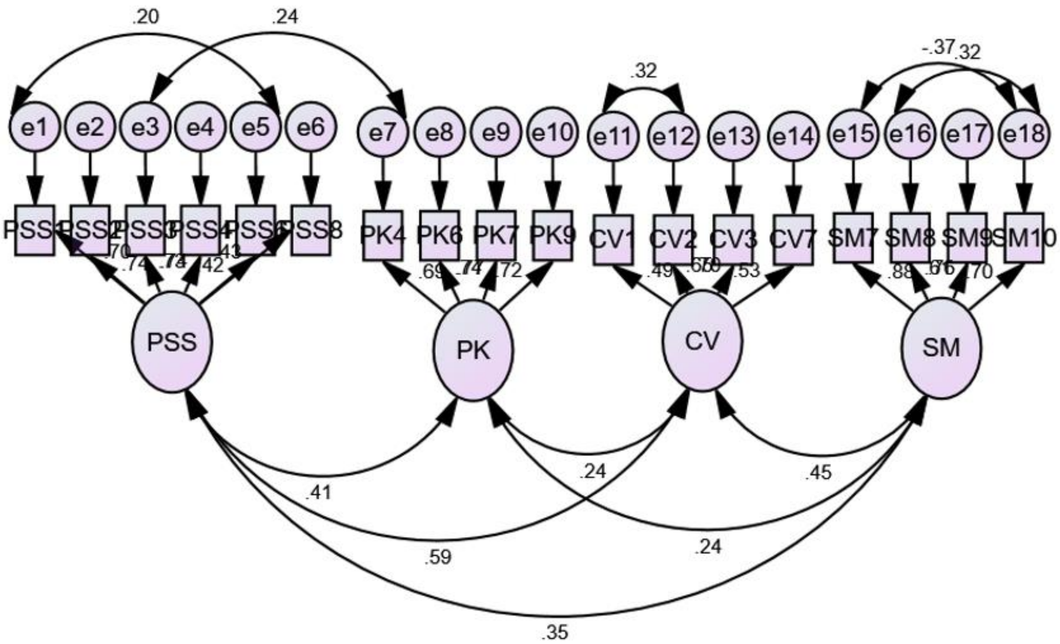

Figure 2. Diagram of Confirmatory Factor Analysis (CFA)

Table 3. The data of EFA

Components		**1**	**2**	**3**	**4**
PSS1		.662			
PSS4		.626			
PSS2		.624			
PSS6		.591			
PSS3		.575			
PSS8		.521			
CV1			.595		
CV2			.582		
CV3			.569		
CV7			.520		
PK6				.753	
PK7				.739	
PK9				.735	
PK4				.679	
SM9					.777
SM10					.776
SM8					.755
SM7					.750
Total variance explained					67.12%
KMO measure of sampling adequacy					.863
Bartlett's test of sphericity	Approx. chi-square				4654.544
	df				780
	Sig.				0.000

Note: Principal axis factoring was used as the extraction method; varimax with Kaiser was used as the rotation method; and the rotation converged in five iterations.

Standardized factor loadings represent the cumulative impact of each indicator on the constructs. Table 4 indicates that PSS1 had the highest impact on PSS, followed by PSS4, PSS2, PSS6, PSS3, and PSS8. PK6 had the greatest influence on PK, followed by PK7, PK9, and PK4. SM9 had the most significant impact on SM, followed by SM10, SM8, and SM7. CV1 had the strongest influence on CV, followed by CV2, CV3, and CV7.

Table 4. CFA

Model fit indices: CMIN=274.121, CMIN/DF=2.176, DF=126, TLI=0.951, CFI=0.965, RMR=0.071 RMSEA=0.056, PClose= 0.119					
PSS	Problem-solving skills	CA=0.712	CR=.0.82	AVE=0.502	**Std loading**
PSS1					.662
PSS4					.626
PSS2					.624
PSS6					.591
PSS3					.575
PSS8					.521
CV	Cultural values	CA=0.812	CR=0.78	AVE=0.51	
CV1					.595
CV2					.582
CV3					.569
CV7					.520
PK	Prior knowledge	CA=0.756	CR=0.82	AVE=0.54	
PK6					.753
PK7					.739
PK9					.735
PK4					.679
SM	Student motivation	CA=0.759	CR=0.88	AVE=0.64	
SM9					.777
SM10					.776
SM8					.755
SM7					.750

4.5 Discriminant Validity

The correlation between each of the components was performed to verify discriminant validity. As shown in Table 5, PSS was 0.47, 0.55, 0.3197 and 0.6076, respectively, with PK, CV, and SM. Furthermore, the connection among PK, CV and SM was 0.1681, 0.0576 and 0.3481, respectively. The correlation coefficient among PK, CV and SM was 0.0576 and 0.1225. The correlation coefficient between CV and SM was 0.2025, which was significant at the 0.05 level. This explains that the items or indicators associated with a construct are not capturing other constructs, ensuring the validity of the measurement model. Discriminant validity is actually crucial for ensuring that each construct in a model is measuring a unique aspect of the concept being studied, thereby enhancing the overall validity and reliability of the research findings.

Table 5. Discriminant validity

Variables	PSS	PK	CV	SM
PSS	**0.47**	0.1681	0.0576	0.3481
PK	0.1681	**0.55**	0.0576	0.1225
CV	0.0576	0.0576	**0.3197**	0.2025
SM	0.3481	0.1225	0.2025	**0.6076**

4.6 Path estimates

4.6.1 Direct effect and moderation

SEM illustrates the relationships among several latent constructs (PSS, CV, SM, and PK_CV) and their observed indicators. PSS is measured by indicators PSS1 to PSS6, with factor loadings ranging from 0.44 to 0.78, while CV is measured by indicators CV1 to CV4, with factor loadings ranging from 0.60 to 0.94. SM is measured by indicators SM7 to SM10, with factor loadings ranging from 0.61 to 0.87. PK_CV is linked to CV but has no direct indicators shown. The path coefficients indicate significant relationships, with CV strongly influencing PSS (0.55) and SM (0.42), while the direct influence of PSS on SM is weaker (0.13). The model also shows correlations between error terms, such as e1 and e2 (0.18) and e18 and e17 (-0.32). The factor loadings and path coefficients highlight the strength of these relationships, underscoring the importance of construct validity in predicting problem-solving skills and students' motivation.

The model fit indices, such as CMIN/DF in the model, have a CMIN of 195.931 with 82 degrees of freedom, resulting in a CMIN/DF ratio of 2.389. A CMIN/DF ratio less than 3 is considered an acceptable fit and the p-value of 0.000 indicates that the model fit is statistically significant. However, in large samples, the chi-square test can be overly sensitive, leading to significant p-values even for well-fitting models (Jackson et al., 2009). The RMR reported at 0.048 suggests a good fit as it is below the recommended threshold of 0.08 (Jac kson et al., 2009) and the Goodness-of-Fit Index (GFI) also reported a value of 0.964, which is above the threshold of 0.95, indicating a good fit (Li, 2016). TLI has a value of 0.971, which is close to the recommended value of 0.95, suggesting an acceptable fit (Jackson et al., 2009) and CFI has a value of 0.951, which exceeds the threshold of 0.95, indicating an excellent fit (Li, 2016). RMSEA has a value of 0.069, which is below 0.08, indicating a reasonable fit. The PClose value of 0.045 suggests that RMSEA is statistically significantly different from zero, providing further evidence of acceptable fit (Li, 2016).

Therefore, as shown in Table 6, the model fit indices, including CMIN=195.931, DF=82, p-VALUE=0.000, CMIN/DF=2.389, RMR=0.048, GFI=0.964, TLI=0.971, CFI=0.951, RMSEA=0.069, and PClose=0.055, indicate a reasonable fit. These indices suggest that the model has acceptable goodness-of-fit, with CFI and GFI values above 0.95 indicating good fit. In addition, TLI is close to 0.95, RMSEA is below 0.08, and RMR is below 0.05, further supporting the validity and reliability of the model. The strong positive effects of K-V on both PSS and CV, along with the weak positive impact of CV on PSS, highlight the nuanced relationships among these constructs.

Table 6. Direct effect of the path analysis

Paths	STD. Estimate	S. E	C. R	Sig.
SM<- - -CV	.618	.115	5.386	***
PSS<- - - CV	.059	.069	.846	.397
PSS<- - - SM	.085	.045	1.905	.057
PSS<- - - K_V	.104	.011	9.740	***
Model fit indices: *CMIN = 195.931; DF = 82; CMIN/DF = 2.389; CFI = 0.951; TLI = 0.971; RMR = .048; RMSEA = .069; PClose = 0.055; GFI=.964.*				

Note: *** indicates that the P-value is less than 0.05.

Figure 3 shows the model used for testing the direct relationships between the constructs in AMOS.

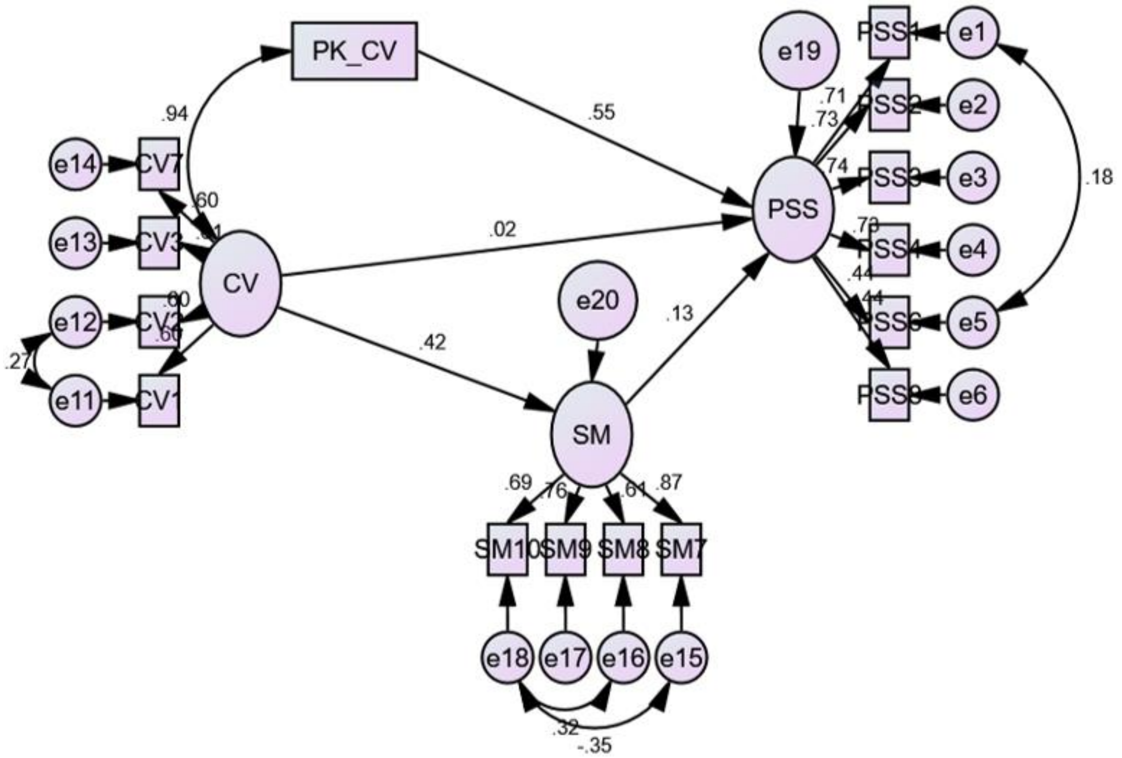

Figure 3. Model used for testing the direct relationships between the constructs in AMOS

4.6.2 Mediating effects

The Sobel's test was used to investigate the indirect effects of student motivation success via both cultural norms and mathematical problem-solving skills (Table 7). The findings demonstrated that both impacts were negligible. This result was reached by comparing Sobel's test z-score to the critical value from a 95% confidence interval. If Z < 1.96, the mediation effects are not considerable; therefore, the mediation effects are not significant because it has z scores of 1.7807, which is less than 1.96.

Table 7. Indirect effect

Paths	a		b		a*b	SE_{ab}	$z = a * b/SE_{ab}$
	Est	SE	Est	SE			
PSS<- - -SM<- - -CV	0.618	0.115	0.085	0.045	0.05253	0.0295	1.7807

Note: $SE_{ab} = \sqrt{(SE_a)^2 \times b^2 + (SE_b)^2 \times a^2}$

Research on the qualitative results emphasizes several key themes related to the intersection of cultural values and mathematical problem-solving skills. Firstly, it explores the integral role that cultural values play in shaping students' mathematical abilities, highlighting how these values influence learning outcomes. Secondly, it examines the positive impact of cultural contexts on education, demonstrating how cultural environments can enhance students' engagement and performance in mathematics. Thirdly, the research investigates the influence of cultural attitudes and parental involvement, revealing how family and community perspectives affect students' mathematical learning experiences. Fourthly, it provides unique cultural insights into how diverse cultural backgrounds shape problem-solving approaches. Finally, the study contrasts practical versus theoretical approaches, analyzing how practical experiences and theoretical knowledge interplay in the context of cultural values. This comprehensive analysis is visually represented in Figure 4.

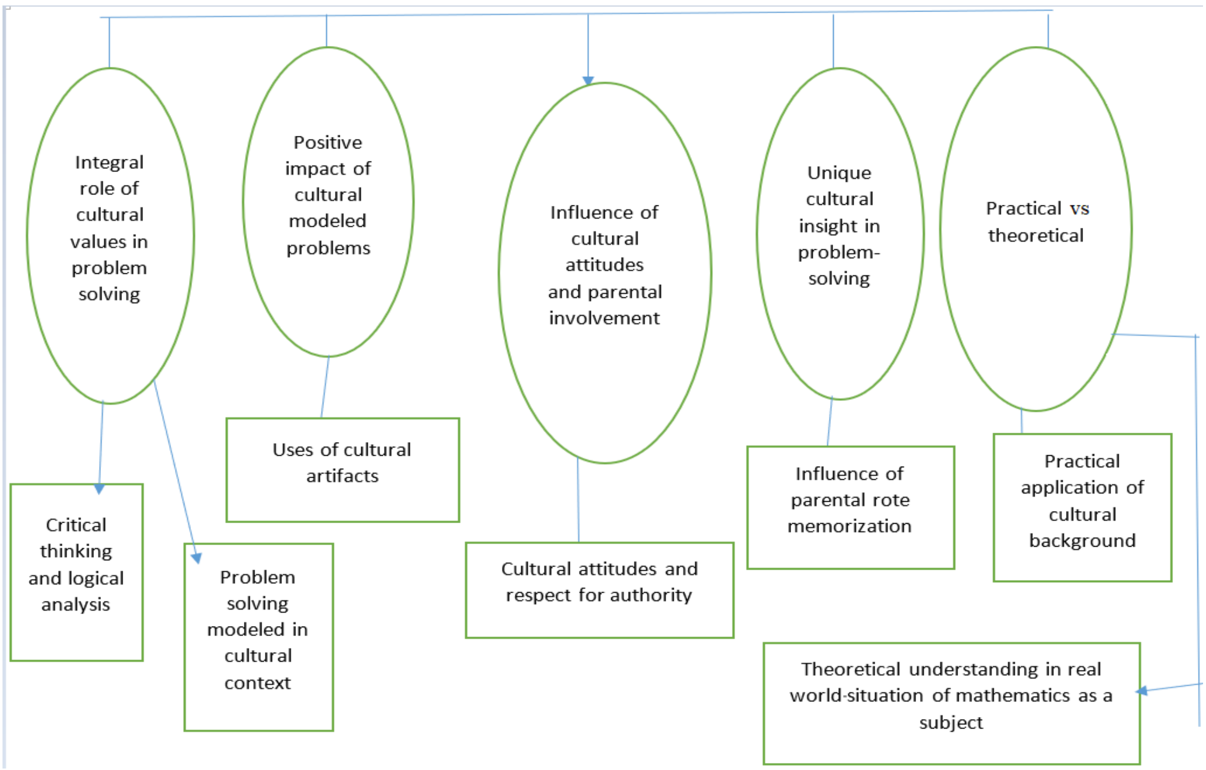

Figure 4. Students' perceptions of the impact of mathematical problem-solving skills
Source: Adapted from the study by Braun & Clarke (2006)

4.7 Transcribed Data

Respondent 1: Cultural values have become the integral part of any country. The cherishing of its cultural values, which have been inculcated into the domain of mathematical elites in a given society, brings out the best of the learners through critical thinking and logical analysis of the daily concomitances of life. It enhances learners' problem-solving skills.

Respondent 2: Cultural values have a positive impact on students' mathematics problem-solving skills, especially when the mathematical problem solving is carefully modeled to depict learners' culture. This makes the mathematical problem more real and practical. Cultural artefacts mostly have materials that are used in everyday mathematics. If learners are carefully guided on these cultural values, they will help to improve students' mathematical problem-solving skills.

Respondent 3: Cultural attitudes towards education, such as respect for authority or embracing rote memorization, sometimes influence how students handle mathematical tasks. Cultural norms regarding parental involvement and expectations can shape students' attitudes towards mathematics. Students may sometimes believe that their cultural background provides unique insight to problem-solving.

Respondent 4: Mathematics as a tool vs. mathematics as a subject. Students from some cultures view mathematics as a practical tool. For example, Chinese culture may focus on applying problem-solving skills to real-world situations and those from those cultures view mathematics as a subject. Greek culture may emphasize theoretical understanding.

Respondent 5: Cultural values influence how I approach math problems by shaping the way I think and solve logically, especially through the emphasis my community places on practical, real-life problem-solving. For example, using familiar examples from farming or trading helps me understand abstract math concepts better.

Respondent 6: My cultural background emphasizes respect for authority, so I tend to rely heavily on teacher-approved methods and avoid exploring unfamiliar strategies when solving math problems.

Respondent 7: Growing up in a community that values collaboration, I naturally prefer discussing math problems with peers, which helps me see different perspectives and better understand complex tasks.

a) Integral role of cultural values

Theme 1 revealed that cultural beliefs play a significant role in shaping the development of logical analysis and critical thinking in mathematical education. Different cultural methods and approaches to problem-solving influence how students cultivate and apply their analytical skills. For instance, cultures that emphasize collective well-being may prioritize collaborative problem-solving, enhancing students' teamwork abilities and encouraging them to tackle complex challenges from multiple viewpoints. Conversely, cultures that value individual achievement might foster self-reliance and independent critical thinking. By integrating various cultural values into mathematics education, teachers can provide students with a more nuanced and enriched approach to developing their reasoning skills, leading to a more rewarding educational experience.

b) Positive impact of cultural contexts

Theme 2 indicated that incorporating cultural contexts and artifacts into mathematics instruction significantly enhances relevance and engagement. When mathematical problems are rooted in students' cultural backgrounds, they become more accessible and meaningful, bridging the gap between abstract concepts and real-world applications. For instance, integrating local cultural items and traditions into problem-solving activities can make learning more concrete and engaging. This approach not only increases students' enthusiasm and motivation but also improves their ability to apply mathematical concepts to everyday situations. By embedding mathematical problems within cultural contexts, teachers can help students gain a deeper understanding and retention of mathematical ideas.

c) Influence of cultural attitudes and parental involvement

Theme 3 also revealed that parental engagement and cultural attitudes are crucial in shaping students' mathematical educational outcomes. The expectations and attitudes of parents toward education significantly affect students' motivation, self-efficacy, and academic performance. In societies that highly value education, supportive environments are often created that contribute to students' academic success. Conversely, in cultures where academic achievement is less emphasized, fostering a strong desire to learn can be challenging. Active parental involvement and positive educational attitudes provide additional support and resources that enhance students' learning experiences and outcomes in mathematics. Therefore, understanding and leveraging these cultural factors can profoundly influence students' success in mathematics instruction.

d) Unique cultural insights

Theme 4 revealed that incorporating diverse cultural perspectives into mathematics instruction can offer valuable insights that enhance both learning and problem-solving. Each cultural background brings unique viewpoints and solutions to mathematical problems, enriching the educational experience. Exposure to various cultural perspectives can introduce innovative approaches and techniques that might not be evident within a single cultural context. By embracing these diverse viewpoints, teachers can create a more dynamic and inclusive learning environment that promotes critical thinking and creative problem-solving. This cross-cultural integration not only broadens students' understanding of mathematics but also prepares them to approach problems from multiple perspectives.

e) Practical vs. theoretical approaches

Theme 5 suggested that in mathematics education, balancing theoretical and practical approaches to problem-solving—both influenced by cultural perspectives—is essential. Cultures that emphasize practical, experience-based learning often focus on hands-on activities, making abstract mathematical concepts more accessible and relevant. In contrast, cultures that prioritize theoretical knowledge might emphasize conceptual thinking and abstract reasoning. Integrating both theoretical and practical methods fosters a well-rounded mathematics education by accommodating diverse learning styles and enhancing overall comprehension. By recognizing and incorporating various cultural viewpoints, teachers can create a more comprehensive and effective mathematics curriculum that addresses a broad spectrum of thinking and problem-solving skills.

5. Discussion and Conclusion

Well-established mediation and moderation mechanisms were employed in this study to explore how cultural values affect mathematical problem-solving. Specifically, motivation was examined as a mediating factor — meaning it explains how or why cultural values influence problem-solving outcomes. Prior knowledge functions as a moderator, determining when or under what conditions cultural values have a stronger or weaker impact on students' performance.

What distinguishes this research is its unique application of these models within the Ghanaian educational and cultural context. In Ghana, cultural values such as communal learning, respect for authority, and traditional beliefs shape students' attitudes and behaviors in academic settings (Kirkham & Chapman, 2022). These values may enhance or inhibit motivation, thus influencing the degree to which cultural orientation drives engagement in mathematical problem-solving (Kurniawan et al., 2024). At the same time, prior knowledge interacts with cultural influences by either reinforcing or buffering their effect (Daher, 2022). For example, students with stronger foundational skills may rely less on cultural heuristics and more on formal strategies. This culturally responsive lens provides a nuanced understanding of how cognitive and cultural factors coalesce in mathematics learning, contributing novel theoretical insight to existing literature.

The study was designed to explore the impact of cultural values on students' mathematical problem-solving skills, in which both quantitative and qualitative data were collected and analyzed. The findings from the study were discussed below. It was found that cultural values have a direct effect on students' motivation to learn mathematics which aligns with existing research, highlighting the influence of societal norms and beliefs on mathematics outcomes. The findings of several studies (Kaur et al., 2022; Kirkham & Chapman, 2022; Kurniawan et al., 2024; Suparatulatorn et al., 2023) indicated that cultural dimensions, such as power distance and individualism-collectivism, illustrate how hierarchical respect in high power distance cultures and the drive for personal success in individualistic cultures enhance student motivation to study mathematics. In societies that highly value education, such as those studied by Kurniawan et al. (2024), students are generally more motivated to excel academically, driven by cultural expectations and societal pressure. This is particularly evident in mathematics, where cultural norms significantly shape students' attitudes and efforts, as noted by Daher (2022). The practical implications of this finding suggest that mathematics educators can boost student motivation by creating culturally responsive learning environments that align with these values, demonstrating the importance of mathematics and its relevance to students' futures. By recognizing and integrating cultural values into mathematics practices, mathematics educators can foster greater student engagement and academic success.

The lack of a clear correlation between cultural values and students' problem-solving abilities implies that while cultural values influence motivation, they do not directly enhance problem-solving skills. Problem-solving abilities are more closely related to cognitive processes and specific instructional methods rather than cultural norms (Zengin et al., 2022; Aybala & Emine, 2023; Hariyanto et al., 2023). Rosyidi et al. (2024) supported this, indicating that students' problem-solving skills are significantly impacted by cognitive development, practice, and the quality of instructional strategies, alongside cultural influences. This suggests that educators should focus on cognitive and instructional approaches to improve problem-solving skills, rather than relying solely on cultural values to drive these abilities. By emphasizing effective teaching methods and providing ample practice opportunities, educators can better develop students' problem-solving skills, independent of their cultural background.

It's interesting to note that students' motivation has no direct impact on their problem-solving abilities. While motivation is generally believed to enhance learning outcomes, problem-solving skills may not immediately benefit from motivation alone, as they require specific cognitive abilities and strategies. The tools or methods used to measure motivation may not have adequately captured its impact on problem-solving, particularly if they were not well-aligned with the specific cultural context of Ghana. Additionally, motivation in Ghana might be shaped by communal values and respect for authority, which could have a greater influence than individual motivation, potentially explaining why motivation did not mediate the relationship between cultural values and problem-solving skills as initially expected.

The findings suggest that motivation may not play a universal role in mathematical problem-solving across different cultural contexts. In Ghana's educational environment, cultural values could have a more significant influence, highlighting that factors beyond motivation may be more critical in shaping students' problem-solving abilities.

Unlike studies, such as the study by Daher (2022) which found a strong mediation effect of motivation, this study shows no such effect, possibly because motivation operates differently in Ghana or due to the cultural values influencing problem-solving strategies, highlighting the need for more culturally responsive models of motivation.

Tabuena & Pentang (2021) and Daher (2022) posited that although motivation is crucial for effort and engagement, the development of problem-solving skills relies more heavily on practice opportunities and high-quality instruction than on motivation alone. This highlights the importance of focusing on cognitive and instructional approaches to enhance problem-solving abilities, suggesting that educators should provide ample practice and effective teaching methods to improve these skills, rather than relying solely on fostering motivation.

The relationship between cultural values and problem-solving abilities is moderated by students' prior knowledge, highlighting the importance of foundational information in effectively applying cultural values in problem-solving contexts. Prior knowledge serves as a critical resource that enables students to incorporate cultural values into their learning effectively (Lee et al., 2022; Florentino et al., 2023). This is supported by Vygotsky's (Shabani, 2016) theory of the Zone of Proximal Development, which emphasizes the role of prior knowledge in the learning process. Students with a solid knowledge base are better equipped to utilize their cultural beliefs to enhance their problem-solving skills, demonstrating that foundational knowledge is essential for leveraging cultural values in academic achievement.

The lack of a mediation effect of students' motivation between cultural values and problem-solving abilities implies that motivation alone is insufficient to bridge the gap between cultural influences and the cognitive skills required for problem-solving. This finding suggests that other factors, such as the quality of education, cognitive abilities, and specific problem-solving strategies, play a more critical role in this context (Otoo et al., 2018; Aryani & Suarjana 2021; Mensah & Baidoo-Anu, 2022). This aligns with the research by Saadati & Celis (2023), which highlights the complex interplay between cognitive and motivational factors in academic achievement. Therefore, enhancing problem-solving skills requires a focus on improving educational quality and developing cognitive strategies rather than relying solely on increasing motivation.

The qualitative data reveal the integral role of cultural values in shaping students' problem-solving skills, as they influence how students' approach and resolve problems. Cultural values, encompassing societal norms, beliefs, and practices, impart specific attitudes and behaviors essential for effective problem-solving. McCloskey (2014), Sancar-Tokmak (2015), Hill et al. (2021), and Thompson (2024) supported this by highlighting that cultural contexts significantly affect cognitive processes, such as problem perception and resolution strategies. For example, collectivist cultures often emphasize collaborative problem-solving, while individualist cultures may foster independent problem-solving approaches. This underscores the importance for educators to recognize and integrate cultural values into their teaching practices, as doing so can significantly enhance students' problem-solving capabilities by aligning instructional methods with students' cultural backgrounds. The beneficial effects of the positive impact of culturally modeled problems on students' problem-solving abilities highlight the importance of contextualizing problems within familiar cultural frameworks. When problems are presented in culturally relevant contexts, students are more likely to engage and apply their cultural knowledge to find solutions. Hill et al. (2021), Hunter (2021), Clark et al. (2014), and Tang et al. (2021) supported this approach, emphasizing that using culturally relevant materials and examples, along with culturally responsive teaching, significantly enhances student engagement and learning outcomes. By designing learning experiences that resonate with students' cultural backgrounds, educators can create more relatable and meaningful challenges, thereby improving students' problem-solving skills.

A key finding is the significant impact of parental involvement and cultural attitudes on students' problem-solving abilities. Cultural attitudes towards mathematics education, including family expectations and support, greatly influence students' academic behaviors and outcomes. Ramírez et al. (2023), Kurniawan et al. (2024), and Otieno & Povey (2023) highlighted the crucial role of family participation in fostering academic success. In many cultures, active parental involvement and encouragement enhance students' confidence and motivation, which subsequently improves their problem-solving skills. This research suggests that to effectively develop students' problem-solving abilities, schools should build strong partnerships with parents and the community, leveraging family support to bolster students' academic growth.

Students' unique cultural insights into problem-solving underscore the importance of incorporating diverse perspectives in education. Pupils from different cultural backgrounds may approach problems in various ways, offering innovative solutions and enriching the learning environment. Suparatulatorn et al. (2023), Kaur et al. (2022), and Hill et al. (2021) highlighted the significance of multicultural education in promoting equity and inclusion, advising educators to leverage students' cultural insights to enhance collective problem-solving abilities. By valuing and integrating these diverse viewpoints, teachers can create more inclusive and effective learning environments that foster creative problem-solving and improve overall educational outcomes.

Another important discovery is the differentiation between theoretical and practical problems in problem-solving. Students frequently struggle to translate their academic understanding into real-world scenarios, which might impair their ability to solve problems. Kirkham & Chapman (2022), Hoyles (2018), and Hill et al. (2021) talked about the idea of reflective practice, using reflection and actual learning to close the gap between theory and practice. Teachers ought to concentrate on giving pupils the chances to apply abstract ideas in practical situations, which can improve their ability to solve problems in the real world. This method can enhance students' comprehension of the material and help them become more adept at handling challenging issues.

6. Recommendations

Educators should design culturally relevant problem-solving tasks that resonate with students' everyday experiences and cultural contexts. For instance, integrating mathematical problems that relate to local community practices, such as calculating costs in market trading or agricultural yield, could enhance engagement and problem-solving skills.

To bridge theory and practice, educators can adopt culturally responsive pedagogy by incorporating students' cultural values into learning, emphasizing communal problem-solving and group discussions. Task design should focus on connecting mathematical concepts to students' cultural narratives and real-world scenarios, ensuring relevance. Additionally, using local examples, such as incorporating local currency for financial problems or traditional counting methods, can make abstract mathematical concepts more relatable, enhancing students' ability to apply these principles effectively.

Teachers should reflect on their cultural biases and how these might impact their approach to teaching mathematics. Workshops or professional development sessions focused on culturally responsive teaching could provide teachers with strategies for adapting lessons to meet the cultural needs of students.

Data Availability

The data used to support the research findings are available from the corresponding author upon request.

Conflicts of Interest

The authors declare no conflict of interest.

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