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Research Article

Exploring the effect of students' willingness on mathematics cognitive achievement: A mediation model of problem-solving skills

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This study aimed to determine the effect of students' willingness on their mathematics cognitive development as mediated by student's problem solving skills in mathematics among senior high schools in Ghana. Simple random sampling technique was adopted to sample 212 respondents from a high school. Introductory letter was sent to seek for permission from the headmaster before the data was collected. A structured questionnaire was employed as a tool to gather information from the respondents since quantitative method was adopted for the study. Using Amos and SPSS software, the questionnaires were analyzed and evaluated the various correlations among the variables utilizing the model of structural equations. Findings of this study indicated that, student's willingness towards mathematics and student's mathematics problem solving, all have favorable impact on their cognitive accomplishments of Ghanaian senior high school students and this effect was statistically significant. Therefore, all the three hypotheses were supported by the study.

Keywords: Cognitive achievement, Mathematics, Problem solving, Willingness

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1. Introduction

Mathematics is the foundation for the development of modern technology and has the power to enhance human thought, it is significant in many sciences and should be learned from an early age. In student-centered learning processes, the instructor serves as a facilitator or guide, and it is the main point of contemporary educational systems. In student-centered learning processes, on the other hand, students are only passive information receivers. Humans encounter multifaceted challenges in their daily lives, which they attempt to address in a certain way based on their prior experiences and knowledge. In this sense, it is crucial for students to confront real-world issues in classroom settings and devise suitable solutions, as problem-based learning has been shown to enhance students' problem-solving skills, engagement, and preparation for future challenges (Lu et al., 2025; Ostby, 2022). A longitudinal study demonstrates that early cognitive skills in mathematics strongly predict later academic achievement (Ten Braaket al., 2022). These findings suggest that early cognitive development, especially in executive function and self-regulation, serves as a foundational predictor of long-term performance in geometry and algebra.

Many people believe that mathematics is a fundamental component of education since it helps develop analytical, critical thinking, and problem-solving abilities. Around the world, advances in disciplines like science, technology, engineering, and mathematics [STEM] are based on mathematics. Mathematics plays a

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crucial role in Ghana's Senior High School [SHS] curriculum, impacting students' academic paths and future employment opportunities (Davis et al., 2021). Strategic initiatives to equip students with the competencies required for the digital age are reflected in the curriculum's integration. Students who demonstrate greater willingness to engage in mathematics are more likely to adopt deep learning strategies and persist through challenging problems (Papageorgiou et al., 2025). Study found out that, in order to tackle mathematical issues, a student must think critically and make decisions using the right approach (Effandi & Normah, 2009).

The most crucial cognitive activity and a component of mathematics is problem solving (Jonassen, 2000). Stated differently, problem solving ability is the mental process of resolving a specific issue. It is not sufficient to merely model the methods of problem solving that pupils are familiar with. Throughout primary school, children's mathematics knowledge, skills, and cognitive abilities significantly advance. Study discovered that learning mathematics enhances general cognitive abilities and showed that, at least between the ages of 7 and 9, there is a reciprocal association between general cognitive abilities and mathematics learning. The phrase "non-routine problem" is frequently used in scientific literature in place of the word "problem" to highlight the fact that one cannot solve a problem solely by using immediate knowledge (Cowan et al., 2018). Non-routine problems are problems that are very likely to be unfamiliar to students. Even when the knowledge and abilities necessary to solve everyday problems have been acquired, they nonetheless impose cognitive demands that are higher than those necessary for solving them (Mullis et al., 2009). It is preferable to assess logical reasoning abilities, which are critical for a good mathematical learning experience, rather than domain-specific knowledge and techniques when measuring the cognitive processes necessary for problem solving (OECD, 2013).

Complementing these insights, international studies have demonstrated a significant positive relationship between students' behavioral and affective engagement—indicators of active willingness—and mathematics achievement. Ryan et al. (2022) reported that even as academic performance dipped in the transition to secondary school, students maintained high levels of engagement, motivation, and self-belief (e.g., self-efficacy, interest), underscoring that willingness can buffer academic challenges. Similarly, Hui and Mahmud's (2023) systematic review of game-based learning in mathematics—drawing upon Scopus and Web of Science—confirmed that interventions which target both cognitive skills and emotional investment produced gains across knowledge, skills, motivation, and engagement domains. These findings suggest that when students are behaviorally and emotionally invested—demonstrating readiness, perseverance, and belief in capability—their problem-solving efficacy in mathematics improves measurably. It is also stated that a student's willingness to learn is a critical component in helping them become better problem solvers. Does a student's cognitive achievement in mathematics really matter? Therefore, student's cognitive achievement in mathematics is significantly influenced by their willingness to solve problems. As a result, this study aims to advance theoretical and practical understanding of education by examining the connection between pupils' ability to solve problems and their desire to approach mathematical problems logically. Traditional approaches that focus on lectures, rote memorization, and repetitive exercises often fail to engage students in meaningful learning and do not foster a deep understanding of mathematical concepts or the development of critical thinking and problem-solving skills (Boaler, 2016).

1.1. Purpose of the Study

This study aimed to determine the mediating role that students' problem-solving abilities have in the connection between learners' cognitive achievement towards mathematics and their willingness to solve problems. The following research questions have been created based on this aim:

RQ 1) What is the effect of student's willingness on their cognitive accomplishment?

RQ 2) What extend do student's problem solving skills have impact on their cognitive development?

RQ 3) What extend does Students' problem-solving abilities mediate the relationship between their willingness and cognitive achievement?

2. Background

2.1. Conceptual Framework

Gestalt method and Cognitive Development learning theory both lend support to this study. Cognitive development is the term used to describe long-term changes in these processes. The act of thinking and remembering is called cognition. To him, he thinks that Learning is impacted by assimilation, which is the fitting of new experiences into preexisting conceptions, and accommodation, which is the fitting of preexisting concepts into new experiences (Piaget, 1977). There is oscillation between these two processes, leading to long-term developmental change as well as short-term learning. Gestalt theory emphasizes the value of meaning, experience, and the growth of insights. The key to insightful learning is the understanding that students solve problems by going through a sequence of approaches, applying logical concepts, and drawing on prior knowledge before coming up with a solution. One definition of mathematical problem solving is the process of applying previously acquired knowledge to a novel circumstance.

Students' views toward arithmetic and their general self-control when it comes to problem solving are highly connected (Effandi & Normah, 2009). Therefore, through the mediating role of problem-solving skills, this review intended to investigate the relationship between students' mathematical cognitive achievement and their desire to solve problems in mathematics. Students that are willing to solve problems are more likely to face obstacles with confidence and grow in the setting of problem-solving. These are two ideas of cognitive learning theory which are well-developed area of educational theory. Positive attitudes toward mathematics are associated with increased scholastic achievement, motivation, and problem-solving abilities. Research shows that pupils are far more inclined to persevere through difficulties and achieve higher results if they believe mathematics is relevant and doable (Peixoto et al., 2022). Thus, the aim of the study is to assess the effect of students' willingness to tackle mathematical problems affects their cognitive achievement in the subject: The role of problem-solving abilities as a mediator.

2.1.1. Social Cognitive Theory

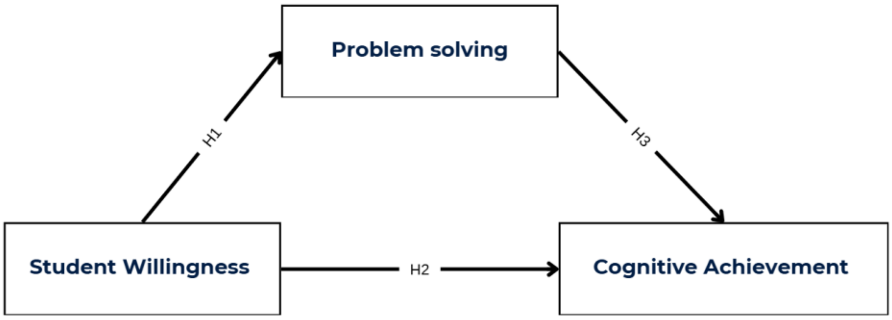
According to this viewpoint, Learning occurs in a communal environment and is intrinsically social. Vygotsky (1978) declared that thinking, speaking, and interacting are essential to comprehending the nature of human awareness in learning. Successful learning simply results from learners' reciprocal social interactions in a social context where understanding one another is facilitated by a diversity of discourse, cultures, and contexts (Kim, 2001). He also emphasized how, in a true sense, social constructivism theory aids in our comprehension of how individuals acquire and create knowledge in social situations to address issues; as a result, they build new concepts by reflecting on their own thought processes and benefit from one another's insights by reflecting on their own ideas.

2.1.2. Behavioral Cognitive Theory

This vantage point of view holds that an individual's beliefs eventually impact their actions, feelings, and, ultimately, their ability to learn and enjoy life. For example, individuals who believe they "don't like calculation subject" will find arithmetic more challenging, whereas those who think they're "good at drawing" will put in more effort and have a greater interest in the arts. These are two well-integrated and inclusive notions. While behavioral cognitive theory solely examines the effects of internal factors on learning, social cognitive theory considers both external and internal impacts.

It is necessary to combine the ideas of students' willingness and their aptitude for solving mathematical problems into a coherent theory that supports and guides students' cognitive accomplishment in mathematics. The three ideas that make up this study's conceptual framework are as follows: Students' Willingness towards Mathematics, Students' Problem Solving Skills that conceptualized as a mediating variable between willingness and their Cognitive Achievement as illustrated in Figure 1. This debating shows how each of these contexts have an impact on the daily life of individual learner's cognitive development; students' willingness in both the solution of mathematical puzzles and the clarification of the connections between ideas.

Figure 1
Conceptual Framework



2.2. Student's Willingness to Solve Problem and their Cognitive Achievement

The term "problem solving" describes the application of specific cognitive abilities to address a given situation. Additionally, it is thought of as a non-routine problem that requires additional comprehension and cognitive abilities in order to examine and solve. When it comes to solving mathematical word problems, learners encounter several hurdles, including knowing which approach to employ when and how to create new ones (Zawojewski et al., 2013). The study by (Schoenfeld, 2013) Suggests that problem solving, modeling metacognitive skills, and contemplation on learning to direct one's awareness and establish best practices for oneself are among the highly sought-after 21st century skills.

2.3. Student's Willingness on their Mathematics Cognitive Achievement

A student's willingness to engage deeply in mathematics is strongly linked to enhanced cognitive achievement. Longitudinal evidence shows that while prior achievement predicts later intrinsic motivation, students who express sustained interest and persistence also tend to demonstrate stronger performance over time (Garon-Carrier et al., 2016). Complementing this, another study found a significant positive relationship between behavioral and affective engagement—indicative of active willingness—and mathematics achievement, suggesting that when students are motivated to participate and emotionally invested, their problem-solving efficacy improves (Asare et al., 2024).

2.4. The Relationship between Students' Willingness and their Cognitive Achievement the Mediating Role of Problem Solving Skills

In order to apply metacognition, students must be able to attain higher degrees of reflection by using their own thought processes as examples of metacognition to support their use of the technique when addressing problems (Bormotova, 2010). Students that develop metacognitive techniques and skills are better able to organize their thoughts and hone their problem-solving abilities in mathematics, both of which are critical for the long-term growth of academic cognitive accomplishment (Knox, 2017). Students' thinking is influenced by the things they learn, and acquiring mathematics is meant to foster reasoning and problem-solving skills (Smith, 2022).

3. Method

3.1. Research Design

This study employed a quantitative research design to examine the effect of students' willingness on their cognitive development in mathematics, with a focus on the mediating role of students' problem-solving skills. This design enabled the objective measurement of relationships among variables and the statistical testing of proposed hypotheses through advanced modeling techniques.

3.2. Participants

For the research project, a random sample of 212 students from Ejuraman Anglican Senior High School were selected. The researchers anticipated collecting 215 datasets from the participants. After a brief period of data collection, 212 questionnaires were deemed valid for analysis, while three were excluded due to incomplete data or duplicate responses to survey items. Table 1 presents the demographic characteristics of the participants.

3.3. Data Collection

This study employed a structured questionnaire as the primary data collection instrument to measure three key constructs: students' willingness toward mathematics (four items), their problem-solving skills (three items), and cognitive achievement in mathematics (four items). The questionnaire items were adapted and validated based on expert review to ensure clarity, relevance, and appropriateness for the senior high school context. All questions were rated on a 5-point likert scale, ranging from 'strongly disagree' (1) to 'strongly agree' (5).

To assess the reliability of the instrument, Cronbach's alpha [CA] was calculated for each scale using SPSS (Version 23). The results demonstrated high internal consistency across all constructs: Student Willingness (CA = .865), Problem Solving (CA = .854), and Cognitive Achievement (CA = .891). All alpha values exceeded the acceptable threshold of .70, confirming the reliability of the items used.

Table 1
Demographic Information

Demographic	*Frequency*	*Percentage*
Gender		
Male	119	56.13
Female	93	43.87
Age		
15-19 years	160	75.47
20-24 years	49	23.11
25 years and above	3	1.42
Religion		
Christianity	115	54.25
Muslim	94	44.34
Traditional	2	0.94
Others	1	0.47
Course of study		
General Arts	60	28.30
General Science	52	24.53
Agric	35	16.51
Home Economics	35	16.51
Visual Arts	30	14.15

3.4. Data Analysis

The data collected through the structured questionnaire were coded and entered into Statistical Package for the Social Sciences [SPSS] for preliminary analysis. Descriptive statistics (e.g., means, standard deviations, frequencies) were computed to summarize the demographic characteristics of the participants and to assess the distribution of responses for each construct. The study also controlled for variables such as age, gender, religion, and the course students were enrolled in.

To examine the hypothesized relationships among the variables, including direct and indirect effects, Structural Equation Modeling [SEM] was conducted using AMOS software. Path analysis, a specific technique within SEM, was utilized to test the proposed mediation model. This method allowed for simultaneous estimation of multiple regression equations to assess the strength, direction, and significance of the relationships among students' willingness toward mathematics, their problem-solving skills, and their cognitive achievement in mathematics.

3. Findings

3.1. Findings Regarding the Measures

3.1.1. Reliability analysis

The internal consistency of the measurement items was evaluated using Cronbach's alpha [CA] analysis in SPSS (version 23). As shown in Table 2, the results revealed high internal consistency for the variables: Student Willingness with a CA of 0.865, Student Problem Solving [PS] with a CA of 0.854, and Student Cognitive Achievement with a CA of 0.891. Since all CA values exceeded the minimum threshold of 0.7, the observed variables demonstrated reliable internal consistency.

3.1.2. Exploratory factor

An Exploratory Factor Analysis [EFA] was conducted to examine the relationships between the observable variables and their corresponding latent variables. The results, presented in Table 2, show how each observable variable loaded onto the relevant latent variable. The analysis was deemed suitable with a Kaiser-Meyer-Olkin Measure of Sampling Adequacy [KMO] value of 0.886 and a determinant coefficient of 0.008. The KMO indicated that the observable variables accurately loaded onto the latent variables in 78% of cases. Additionally, Bartlett's Test of Sphericity yielded a Chi-square value of 1013.200 (df=52, $p < .001$), supporting the factorability of the data.

Table 2
Exploratory factor analysis

Rotated Component matrix			
	Component		
	1	*2*	*3*
Student's Willingness (SW)			
SW4	.746		
SW6	.831		
SW7	.721		
SW8	.725		
Problem Solving (PS)			
PS3		.990	
PS4		.649	
PS5		.754	
Cognitive Achievement (CA)			
CA5			.778
CA6			.724
CA8			.821
CA9			.804
Total Variance Explained			78%
Kaiser-Meyer-Olkin Measure of Sampling Adequacy			.863
Bartlett's Test of Sphericity	Approx. Chi-Square		1013.200
	df		52
	p		< .001
Determinant			0.008

3.1.3. Confirmatory factor analysis of the measures

CFA was executed to confirm the findings presented in the Exploratory Factor Analysis and confirm the measurements employed during EFA. Amos (version 23) was utilized to perform CFA on a sample of 212 participants. Several modifications were made to improve the model, including removing and combining errors that resulted in a poor model fit.

Table 3
Confirmation Factor Analysis (Source: Field Survey, 2024)

Variable	*Factor Loadings*
Student's Willingness (SW): CA=.865; CR=.843 ; AVE=.573	
SW4: I often feel happy to learning mathematics even though it is very challenging.	.746
SW6: I always feel like contributing more than my colleagues during mathematics lesson.	.831
SW7: I always put in much effort to understand mathematics.	.721
SW8: Mathematics is the most engaged and interesting subject I have ever seen.	.725
Problem Solving (PS): CA=.854 ; CR=.777 ; AVE=.538	
PS3: When challenging task is given to me, I start by breaking them down into smaller components.	.990
PS4: I often use open-ended questions to analyze mathematics problems.	.649
PS5: I personally feel satisfied when I am able to solve mathematics questions.	.754
Cognitive Achievement (CA): CA=.891 ; CR=.863 ; AVE=.612	
CA5: I often love discussing mathematics with my colleagues.	.778
CA6: I often feel a sense of achievement after completing a challenging task in mathematics.	.724
CA8: I always perform well in mathematics as a subject.	.821
CA9: I always contribute in class during mathematics lesson.	.804

Note. Modification indices: CMIN=72.223; Df =40; CMIN/df =1.806; TLI=.957; CFI=.969; RMR=.047; RMSEA=.062; P-close=.188; GFI=.939

3.1.4. Discriminant validity analysis of the measures

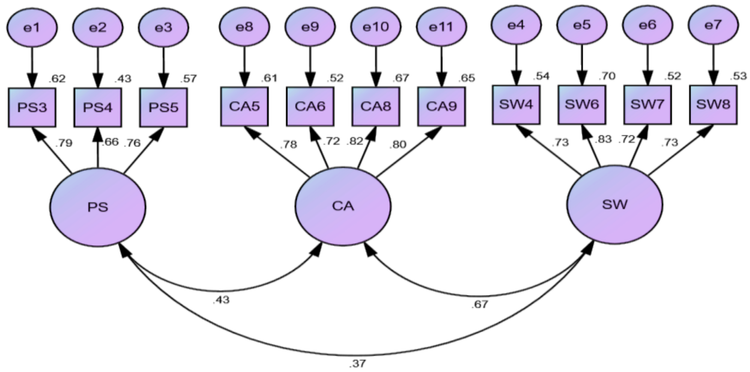
To evaluate discriminant validity, a comparison was made between the correlation coefficient and the square root of the Average Variance Extracted [AVE]. Discriminant validity is established when the highest inter-correlation score is lower than the least score of square root of AVE. The results of the discriminant validity analysis are presented in Table 3. As shown in Table 3, the maximum inter-correlation coefficient was 0.676, while the minimum value of square root of AVE value was 0.733. Since the least √AVE is greater than the largest correlation coefficient, this indicates that the study has achieved statistically significant discriminant validity, suggesting that the constructs are distinct and empirically separated.

Table 4
Discriminant Validity

Variable	*CR*	*AVE*	*MSV*	*MaxR(H)*	*SW*	*PS*	*CA*
SW	.777	.538	.195	.788	***.733***		
PS	.843	.573	.456	.850	.392	***.757***	
CA	.863	.612	.456	.867	.441	.676	***.782***

Note. **Bold** and **italic** is (√AVE); p−value significant at 5% (0.05); and p−value significant at 1% (0.01).

Figure 2
Confirmatory factor analysis



3.2. Findings regarding the Relationships among the Variables

This study explored the mediating role of problem-solving skills in the relationship between students' willingness to solve mathematics problems and their mathematics cognitive achievement. The result of the data analysis using SPSS (version 23) and Amos (version 23) is presented in this section. Table 4 shows the direct effect results of the structural path diagram. According to the path diagram, students' willingness had a positive and statistically significant effect on student's problem-solving skills (estimate = 0.397; CR = 4.504), aligning hypothesis **H1**. Additionally, students' willingness had a positive and statistically significant direct effect on their mathematics cognitive achievement (p < .001; estimate = 0.603; CR = 6.799), which support hypothesis **H2**. Furthermore, students' problem-solving skills had a positive and statistically significant effect on student mathematics cognitive achievement (p < .05; estimate = 0.198; CR = 2.754), which agree with the hypothesis **H3**. Therefore, the study confirms that students' willingness to solve problems, and mathematics cognitive achievement are positively related.

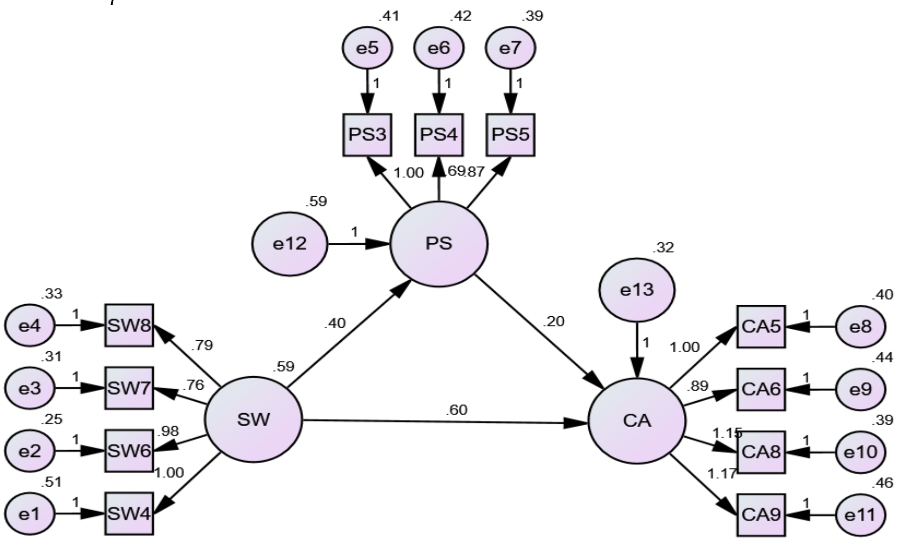
Table 5
Path Analysis

Direct effect	*S. Estimate*	*S.E.*	*C.R.*	*P-Value*
SW → PS	.397	.092	4.315	***
SW → CA	.603	.083	7.265	***
PS → CA	.198	.072	2.754	***
Indirect effect	*Estimates*	*L.BC*	*U.BC*	*P- value*
SW→ PS→ CA	.220	.120	.154	<.001

3.3. Mediating Effect

Table 4, was generated using Amos (version 23), and the results revealed the indirect relationship between students' cognitive achievement in mathematics and their desire to solve problems. The results indicated that students' willingness has a positive and significant effect on both their cognitive achievement and problem-solving abilities. Moreover, the relationship between students' willingness to solve problems and their mathematical cognitive achievement is mediated by their problem-solving abilities, as shown in Figure 3. Since the confidence intervals do not contain zero, this mediation effect is statistically significant. Therefore, the study's hypothesis is confirmed, which suggests that problem-solving abilities play a mediating role in the relationship between students' willingness to solve problems and their mathematical cognitive achievement among Senior High School students.

Figure 3
Structure path



4. Discussion

The study explored the mediating role of problem-solving abilities in the relationship between students' willingness to solve math problems and their cognitive achievement in math. The research involved 212 participants and tested three hypotheses.

The first hypothesis investigated the relationship between students' willingness to learn mathematics and their ability to achieve cognitively. The analysis revealed a statistically significant positive correlation between the two, indicating that students who are more willing to learn mathematics tend to perform better in problem-solving. This finding addresses a gap in previous research, which primarily focused on the impact of problem-solving as a mediating role among high school students in the relationship between willingness to learn and cognitive achievement. This study contributes to the existing literature. The findings suggest that students who recognize the importance of being willing to learn mathematics tend to have greater confidence in solving mathematical problems. Recent evidence supports this pathway: a large-scale study of Grade 5 students in Estonia found that motivation mediates the relationship between domain knowledge and word problem-solving ability, indicating that students' willingness and confidence influence their problem-solving performance (Sigus & Mädamürk, 2025). Additionally, longitudinal research demonstrates that cognitive activation—a proxy for students' willingness—boosts mathematics performance indirectly through increased interest and perseverance (Zhang et al., 2021). Additionally, research by Wardat et al. (2023) highlighted the importance of problem-solving in developing mathematical aptitude, providing students with the cognitive building blocks of mathematics.

Second research hypothesis found a positive correlation between students' willingness and their cognitive growth in mathematics, which aligns with previous research. Garon-Carrier et al. (2016) demonstrated that intrinsic motivation is a reliable predictor of mathematics achievement over time, reinforcing the foundational role of willingness. Furthermore, Zimmerman and Kitsantas (2014) observed that students with greater self-motivation and interest in mathematics consistently achieved higher academic success. Wong and Wong (2019) discovered that students with a greater interest in mathematics perform exceptionally well, while Gomes et al. (2020) identified disinterest as a primary factor in low math performance. These findings underscore enthusiasm for learning mathematics as a critical catalyst for cognitive development and analytical thinking. In essence, students' willingness to engage with mathematics directly influences their ability to think critically and understand the subject.

The third research hypothesis explored the mediating role of problem-solving abilities in the relationship between students' willingness to learn and their cognitive achievement. The results showed a positive and statistically significant mediation effect, indicating that students' ability to solve mathematical problems plays a crucial role in enhancing their cognitive growth when they are willing to learn. This finding aligns with previous research indicating that enthusiasm and interest in mathematics significantly predict problem-solving abilities and cognitive development (Garon-Carrier et al., 2016). Additionally, the study by Kalpana and Malathi (2019) found a positive relationship between students' willingness, mental achievement, and problem-solving skills, highlighting the importance of fostering a desire to learn mathematics and developing math skills to overcome challenges and achieve fulfillment.

In summary, the study's findings emphasize the importance of encouraging students to solve mathematical problems with enthusiasm, as it positively impacts their cognitive growth and development. By fostering a willingness to learn and developing problem-solving skills, students can achieve greater success in mathematics and enhance their overall cognitive abilities.

5. Conclusions

In conclusion, the study found that students' willingness has a significant and positive effect on their problem-solving skills and mathematics cognitive achievement. Moreover, the study revealed that students' problem-solving skills in mathematics play a mediating role in the relationship between their willingness to solve mathematics problems and their mathematics cognitive achievement. This means that students' willingness to solve mathematics problems influences their problem-solving skills, which in turn affects their mathematics cognitive achievement. These findings highlight the importance of encouraging student to develop interest in solving mathematics problems, as it can have a positive impact on their problem-solving skills and ultimately, their mathematics cognitive achievement.

6. Recommendations

The report recommends the teachers to always develop and incorporate problem-solving tasks that are relevant to students' interest and real-world scenarios. This can increase their willingness to participate and see the value in problem-solving among Ejuraman Anglican SHS students. Recommendations arising from the study advocate that there should be designed of problem-solving activities that specifically aim to enhance cognitive skills such as critical thinking, logical reasoning, and analytical abilities.

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Ethical statement: The researchers stated that the study was endorsed by the Department of Mathematics Education Research Ethics Committee of Akenten Appiah-Menka University of Skills Training and Entrepreneurial Development (AAMUSTED).

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