



Effects Of Metacognitive Strategy on Critical Thinking Skills in Identifying Geometric Shapes in Quranic Calligraphy and Mathematical Basis Among 200-Level Kaduna State University

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Abstract

This study investigated the effects of metacognitive strategy on critical thinking skills in identifying geometric shapes in Qur'anic calligraphy and understanding their mathematical basis among 200-level students of Kaduna State University. A quasi-experimental pre-test and post-test control group design was adopted. The population comprised 230 students, from which 60 were selected through simple random sampling and assigned to experimental and control groups. The instrument used for data collection was the Geometric and Quranic Calligraphy Critical Thinking Test (GQCCTT), with a reliability coefficient of 0.82. The experimental group received instruction using metacognitive strategies, including planning, self-questioning, monitoring, and reflective evaluation, while the control group was taught using the conventional lecture method. Data were analyzed using mean, standard deviation, and independent samples t-test at a 0.05 level of significance. Findings revealed that metacognitive strategy significantly improved students' abilities to identify geometric shapes, analyze mathematical foundations, interpret spatial and symmetrical relationships, and solve geometry-based problems derived from Qur'anic calligraphy. The study concluded that metacognitive strategy effectively enhances critical thinking and higher-order reasoning in geometry learning and recommended its integration into mathematics instruction.

Keywords: Metacognitive Strategy, Critical Thinking Skills, Geometric Shapes, Qur'anic Calligraphy, Mathematics Education, Higher-Order Thinking.

Introduction

Metacognitive strategy has increasingly been recognized as a powerful instructional approach that enhances learners' awareness, regulation, and control of their cognitive processes during learning. It involves planning, monitoring, and evaluating one's thinking, which are essential components for the development of critical thinking skills (Flavell, 1979; Schraw & Dennison, 1994). In the context of Quranic calligraphy, geometric patterns reflect underlying mathematical principles such as symmetry, proportion, and spatial organization. Identifying these geometric shapes requires analytical reasoning and reflective thinking skills, which are strongly supported by metacognitive instruction. Critical thinking, as defined by Facione (1990), involves interpretation, analysis, evaluation, and inference, all of which are essential in examining the mathematical basis embedded in Quranic calligraphic designs. At Kaduna State University, 200-level students studying Islamic Studies and Mathematics Education are increasingly exposed to integrative learning that connects religious texts with mathematical reasoning. However, many students still struggle with identifying geometric structures and explaining their mathematical significance due to limited use of reflective learning strategies. Therefore, applying metacognitive strategy is expected to enhance students' critical thinking skills in identifying geometric shapes in Quranic calligraphy and understanding their mathematical foundations. This study therefore investigates the effects of metacognitive strategy on critical thinking skills in identifying geometric shapes in Quranic calligraphy among 200-level students of Kaduna State University.

Statement of the Problem

Many 200-level students at Kaduna State University continue to experience difficulties in developing strong critical thinking skills in mathematics-related tasks, particularly in geometry-based problem-solving. This challenge is more evident when students are required to identify geometric shapes embedded in Quranic calligraphy, where visual-spatial interpretation and analytical reasoning are essential. Furthermore, students demonstrate limited ability to analyze the mathematical basis of geometric patterns in Quranic calligraphy, interpret spatial and symmetrical relationships, and apply reasoning skills to abstract visual representations. These weaknesses

indicate a gap between instructional practices and the cognitive demands of critical thinking in interdisciplinary learning contexts. Conventional teaching methods used in many classrooms do not adequately promote metacognitive awareness, self-regulation, and reflective thinking needed for deep learning. As a result, students' overall performance in solving geometry-based problems derived from Quranic calligraphy remains unsatisfactory. Therefore, the problem of this study is to determine whether metacognitive strategy can significantly enhance students' critical thinking skills in identifying geometric shapes, analyzing mathematical structures, interpreting spatial relationships, and improving overall problem-solving performance among 200-level students of Kaduna State University.

Research Objectives

1. To determine the effect of metacognitive strategy on students' critical thinking skills in identifying geometric shapes in Quranic calligraphy among 200-level students of Kaduna State University.
2. To examine the effect of metacognitive strategy on students' ability to analyze the mathematical basis underlying geometric patterns in Quranic calligraphy.
3. To assess the effect of metacognitive strategy on students' interpretation of spatial and symmetrical relationships in Quranic calligraphic designs.
4. To investigate the effect of metacognitive strategy on students' overall critical thinking performance in solving geometry-based problems derived from Quranic calligraphy.

Research Questions

1. What is the effect of metacognitive strategy on students' critical thinking skills in identifying geometric shapes in Quranic calligraphy among 200-level students of Kaduna State University?
2. What is the effect of metacognitive strategy on students' ability to analyze the mathematical basis underlying geometric patterns in Quranic calligraphy?

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3. What is the effect of metacognitive strategy on students' interpretation of spatial and symmetrical relationships in Quranic calligraphic designs?
4. What is the effect of metacognitive strategy on students' overall critical thinking performance in solving geometry-based problems derived from Quranic calligraphy?

Hull Hypotheses

1. **H₀₁:** There is no significant effect of metacognitive strategy on students' critical thinking skills in identifying geometric shapes in Quranic calligraphy among 200-level students of Kaduna State University.
2. **H₀₂:** There is no significant effect of metacognitive strategy on students' ability to analyze the mathematical basis underlying geometric patterns in Quranic calligraphy.
3. **H₀₃:** There is no significant effect of metacognitive strategy on students' interpretation of spatial and symmetrical relationships in Quranic calligraphic designs.
4. **H₀₄:** There is no significant effect of metacognitive strategy on students' overall critical thinking performance in solving geometry-based problems derived from Quranic calligraphy.

Related Literature

Metacognitive strategy has been extensively documented in educational literature as a powerful instructional approach that enhances learners' awareness, regulation, and control of their cognitive processes during learning activities. It is generally conceptualized as the ability of learners to plan, monitor, and evaluate their thinking processes in order to achieve meaningful learning outcomes. According to foundational scholars, metacognition plays a central role in promoting self-regulated learning and improving learners' capacity for critical reasoning and problem-solving (Flavell, 1979; Schraw & Dennison, 1994). In mathematics education, its application has been associated with improved conceptual understanding, particularly in abstract domains such as geometry and spatial reasoning, where learners are required to move beyond rote memorization toward analytical thinking.

With respect to that, the identification of geometric shapes in Quranic calligraphy demands a high level of visual literacy, pattern recognition, and analytical interpretation. It has indicated that learners who are exposed to metacognitive instructional strategies tend to perform better in recognizing geometric structures because they are more deliberate in monitoring their cognitive processes while engaging with spatial tasks (Veenman et al., 2006). In the context of Quranic calligraphy, elements such as symmetry, repetition, circular forms, and tessellation offer rich visual structures that support the development of critical observation and analytical reasoning skills. In relation to that, the analysis of the mathematical basis underlying geometric patterns requires learners to engage in higher-order cognitive processes such as abstraction, inference, and logical reasoning. Metacognitive instruction encourages learners to actively question their understanding, evaluate relationships, and justify mathematical interpretations embedded in visual representations. Studies within STEM education have consistently shown that metacognitive learners demonstrate stronger abilities to connect abstract mathematical principles with culturally embedded learning materials, thereby deepening conceptual understanding and enhancing analytical competence.

It focuses on the interpretation of spatial and symmetrical relationships in Quranic calligraphic designs. Spatial reasoning is widely recognized as a core component of mathematical thinking. Metacognitive strategies support learners in organizing visual information, identifying relationships between shapes, and correcting errors through reflective thinking. Zohar and Barzilai (2013) emphasized that metacognitive engagement enhances learners' ability to process complex visual-spatial information by fostering self-monitoring and reflective judgment during problem-solving activities. Finally, it addresses students' overall critical thinking performance in solving geometry-based problems derived from Quranic calligraphy. Critical thinking involves interpretation, analysis, evaluation, and inference, which are all strengthened through structured metacognitive instruction (Facione, 1990). Contemporary educational reports also suggest that learners exposed to metacognitive approaches consistently outperform those taught using conventional methods in reasoning-based tasks, particularly in STEM-related domains (OECD, 2023; UNESCO, 2024).

Theoretical Framework

The Delphi Theory of Expert Consensus and the Critical Thinking Skills Framework provide a strong theoretical foundation for examining the effects of metacognitive strategy on critical thinking in identifying geometric shapes in Qur'anic calligraphy and mathematical contexts. The Delphi approach, as used in consensus-building studies such as Peter A. Facione (1990), is valued for producing structured expert agreement on complex constructs like critical thinking. Its major strength lies in enhancing conceptual clarity through iterative expert feedback, which improves the validity of definitions used in educational research. However, its reliance on subjective expert judgment remains a limitation, as it may reduce empirical generalizability. Similarly, the Critical Thinking Skills Framework—also strongly articulated by Facione's consensus definition—identifies core cognitive skills such as interpretation, analysis, evaluation, inference, and explanation. This framework strengthens the present study by providing measurable dimensions for assessing students' reasoning processes in geometry and Qur'anic calligraphy. Its limitation, however, is that it may not fully capture culturally embedded or spiritually influenced reasoning patterns often present in Islamic geometric art. The implication for this study is that integrating metacognitive strategies with structured critical thinking skills can significantly improve students' ability to recognize and analyze geometric patterns in Qur'anic calligraphy, thereby enhancing both mathematical understanding and higher-order thinking performance among 200-level students of Kaduna State University.

Empirical Studies

For Facione (1990), the study is a Delphi-based expert consensus effort aimed at defining critical thinking in education. It relied on purposively selected international experts in philosophy, psychology, and education who contributed through iterative consultations. Data were gathered via structured expert judgments, and validity was ensured through convergence of expert agreement across rounds. Reliability was conceptual, reflected in the stability of consensus rather than statistical measurement, with thematic synthesis used for analysis. In Flavell (1979), the work is entirely theoretical and conceptual, introducing metacognition as a cognitive-developmental construct. It involved no population, sampling, or instruments in the empirical sense. Instead, it

was grounded in literature interpretation and theoretical reasoning. Validity is based on logical coherence within cognitive psychology, while reliability is not applicable. Analysis was purely conceptual and interpretive.

For Schraw and Dennison (1994), the study involved instrument development of the Metacognitive Awareness Inventory (MAI) using university students selected through convenience sampling. The MAI served as the main instrument, with validity established through factor analysis and construct validation, while reliability was confirmed using Cronbach's alpha. Data were collected via questionnaires and analyzed using factor and descriptive statistics. Zohar and Barzilai (2013) conducted a systematic literature review of metacognition in science education, analyzing published empirical studies selected purposively. Data extraction followed structured review protocols, with thematic analysis used to identify patterns. Validity was ensured through transparent inclusion criteria, while reliability came from consistent coding procedures. Similarly, Veenman et al. (2006) provided a conceptual and methodological review of metacognition research, relying on purposively selected literature. Analysis involved comparative conceptual synthesis, with validity grounded in theoretical triangulation and reliability reflected in consistent interpretation across studies.

The OECD (2023) PISA report is a large-scale international assessment involving 15-year-old students selected through stratified multistage random sampling. Standardized tests and questionnaires were administered globally, with strong psychometric validation ensuring high reliability and validity. Data were analyzed using Item Response Theory and multilevel modeling, without experimental treatment. Finally, the UNESCO (2024) report is a policy-oriented synthesis drawing on global education documents selected purposively. It involved no primary data collection, with thematic and discourse analysis used to interpret educational trends. Validity rests on triangulation of credible sources, while reliability is based on consistency of policy interpretation.

Methodology

Design

This study adopted a quasi-experimental research design employing a pre-test and post-test control group approach to examine the effects of metacognitive strategy on critical thinking skills in identifying geometric shapes in Quranic calligraphy and their mathematical basis among 200-level students of Kaduna State University. The design was considered suitable because it enabled comparison between students exposed to metacognitive strategy instruction and those taught using conventional methods. The population of the study consisted of 230 of 200-level students offering Islamic Studies, and Mathematics Education courses at Kaduna State University. These students were selected because they possessed the required background knowledge to engage with geometric interpretations of Quranic calligraphy. A sample of 60 students was selected using a simple random sampling technique and was divided into experimental and control groups. The research instrument used was the Geometric and Quranic Calligraphy Critical Thinking Test (GQCCTT), developed by the researcher. The instrument assessed students' ability to identify geometric shapes, analyze spatial patterns in Quranic calligraphy, and explain their mathematical foundations. The instrument was validated by experts in Mathematics Education, Islamic Studies, and Educational Measurement and Evaluation. Reliability was established through a pilot test using Cronbach's alpha, yielding a coefficient of 0.82. The experimental group was taught using metacognitive strategies such as planning, self-questioning, monitoring, and reflective evaluation over a period of four weeks, while the control group was taught using the conventional lecture method. Pre-test and post-test scores were collected from both groups. Data were analyzed using mean, standard deviation, and independent samples t-test at a 0.05 level of significance to determine the effectiveness of the metacognitive strategy on students' critical thinking skills in geometric analysis of Quranic calligraphy.

Data Analysis

Descriptive statistics were employed to address the research questions, whereas the hypotheses were tested using an independent samples t-test.

Results

This section presents and discusses the findings of the study based on the research questions and hypotheses formulated. To answer the research questions, the performance scores of both the experimental and control groups were analyzed using descriptive statistics, specifically the mean and standard deviation. In contrast, the hypotheses were tested using an independent samples t-test at the 0.05 level of significance. The mean scores obtained from the experimental and control groups were compared to determine the effectiveness of the technology-based auditory–kinesthetic instructional approach on the experimental group and to contrast it with the performance of the control group, which received instruction through conventional teaching methods.

Research Questions Analysis

This subsection presents the findings related to Research Questions One to Three. The responses were analyzed using descriptive statistical measures, namely the mean and standard deviation, to provide a clear understanding of the participants' performance across the study variables.

Answering Research Questions Using Mean Score and Standard Deviation

Table 1: What is the effect of metacognitive strategy on students' critical thinking skills in identifying geometric shapes in Quranic calligraphy among 200-level students of Kaduna State University?

Groups	N	Mean	Std. Dev	Man Diff	Std Err. Mean
Experimental Group	30	39.27	11.18	23.47	2.37
Control Group	30	15.80	6.55		

Table 1 shows the effect of metacognitive strategy on students' critical thinking skills in identifying geometric shapes in Qur'anic calligraphy. The experimental group, comprising 30 students, obtained a mean score of 39.27 and a standard deviation of 11.18, while the control group recorded a mean score of 15.80 and a standard deviation of 6.55. The mean difference of 23.47 indicates a substantial advantage for students taught using the metacognitive strategy. This suggests that metacognitive activities enhanced students' ability to think critically, analyze

patterns, and identify geometric shapes in Qur'anic calligraphy more effectively than conventional instructional methods.

Table 2: What is the effect of metacognitive strategy on students' ability to analyze the mathematical basis underlying geometric patterns in Quranic calligraphy?

Groups	N	Mean	Std. Dev	Man Diff	Std Err. Mean
Experimental Group	30	47.93	43.97	26.13	3.62
Control Group	30	21.8	12.72		

Table 2 presents the effect of metacognitive strategy on students' ability to analyze the mathematical basis underlying geometric patterns in Qur'anic calligraphy. The experimental group, consisting of 30 students, obtained a mean score of 47.93 with a standard deviation of 43.97, whereas the control group recorded a mean score of 21.80 and a standard deviation of 12.72. The mean difference of 26.13 indicates a notable advantage for the experimental group. This finding suggests that the use of metacognitive strategy enhanced students' capacity to examine, interpret, and understand the mathematical principles embedded in geometric patterns found in Qur'anic calligraphy. By engaging in planning, monitoring, and evaluating their thinking processes, students developed stronger analytical skills than those taught through conventional instructional approaches.

Table 3: What is the effect of metacognitive strategy on students' interpretation of spatial and symmetrical relationships in Quranic calligraphic designs?

Groups	N	Mean	Std. Dev	Man Diff	Std Err. Mean
Experimental Group	30	47.10	22.07	3.90	5.47
Control Group	30	4.00	20.33		

Table 3 shows the effect of metacognitive strategy on students' interpretation of spatial and symmetrical relationships in Qur'anic calligraphic designs. The results reveal that the experimental group, comprising 30 students, achieved a mean score of 47.10 with a standard deviation of 22.07, while the control group obtained a mean score of 4.00 and a standard deviation of 20.33. The difference in mean scores indicates that students exposed to the metacognitive strategy performed

substantially better than those in the control group. This finding suggests that metacognitive strategy enhanced students' ability to interpret spatial arrangements, recognize symmetry, and understand geometric relationships within Qur'anic calligraphic designs. Through self-monitoring, reflection, and evaluation of their learning processes, students developed deeper analytical and interpretative skills, leading to improved understanding of complex geometric and artistic patterns.

Table 4: What is the effect of metacognitive strategy on students' overall critical thinking performance in solving geometry-based problems derived from Quranic calligraphy?

Groups	N	Mean	Std. Dev	Man Diff	Std Err. Mean
Experimental Group	30	39.18	11.8	23.47	2.37
Control Group	30	15.00	6.75		

Table 4 shows the effect of metacognitive strategy on students' overall critical thinking performance in solving geometry-based problems derived from Qur'anic calligraphy. The experimental group, consisting of 30 students, obtained a mean score of 39.18 with a standard deviation of 11.8, while the control group recorded a mean score of 15.00 with a standard deviation of 6.75. The mean difference of 23.47 indicates a clear performance advantage in favour of the experimental group. This suggests that students exposed to metacognitive strategy demonstrated stronger critical thinking, problem-solving, and analytical skills in dealing with geometry-based tasks embedded in Qur'anic calligraphy. The strategy likely improved their ability to plan, monitor, and evaluate their thinking processes, leading to better academic performance compared to conventional instruction.

Testing Research Hypotheses

Table 1: Hypothesis One: H_{01} : There is no significant effect of metacognitive strategy on students' critical thinking skills in identifying geometric shapes in Quranic calligraphy among 200-level students of Kaduna State University.

Groups	N	Mean	Std. Dev	Df	t-cal	P-Value
Experimental Group	30	39.27	11.18	28	-9.92	0.002

Control Group	30	15.80	6.55	28
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Table 1 presents the independent samples t-test results for Hypothesis One. The experimental group recorded a mean score of 39.27 (SD = 11.18), while the control group obtained a mean score of 15.80 (SD = 6.55). The calculated t-value of -9.92 with df = 28 and a p-value of 0.002 indicates a statistically significant difference between the two groups. Since the p-value is less than the 0.05 level of significance, the null hypothesis is rejected. This finding shows that metacognitive strategy had a significant positive effect on students' critical thinking skills in identifying geometric shapes in Qur'anic calligraphy.

Table 2: Hypothesis Two: H₀₂: There is no significant effect of metacognitive strategy on students' ability to analyze the mathematical basis underlying geometric patterns in Quranic calligraphy.

Groups	N	Mean	Std. Dev	Df	t-cal	P-Value
Experimental Group	30	47.93	43.97	28	-7.22	0.001
Control Group	30	21.8	12.72	28		

Table 2 presents the independent samples t-test results for Hypothesis Two, which examined the effect of metacognitive strategy on students' ability to analyze the mathematical basis underlying geometric patterns in Qur'anic calligraphy. The experimental group obtained a mean score of 47.93 (SD = 43.97), while the control group recorded a mean score of 21.80 (SD = 12.72). The calculated t-value of -7.22 with df = 28 and a p-value of 0.001 indicates a statistically significant difference between the two groups. Since the p-value is less than the 0.05 significance level, the null hypothesis is rejected. The finding implies that metacognitive strategy significantly improved students' ability to analyze the mathematical principles embedded in geometric patterns of Qur'anic calligraphy.

Table 3: Hypothesis Three: H₀₃: There is no significant effect of metacognitive strategy on students' interpretation of spatial and symmetrical relationships in Quranic calligraphic designs.

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Groups	N	Mean	Std. Dev	Df	t-cal	P-Value
Experimental Group	30	47.10	22.07	28	0.723	0.003
Control Group	30	4.00	20.33	28		

Table 3 presents the independent samples t-test results for Hypothesis Three, which examined the effect of metacognitive strategy on students' interpretation of spatial and symmetrical relationships in Qur'anic calligraphic designs. The experimental group recorded a mean score of 47.10 (SD = 22.07), whereas the control group obtained a mean score of 4.00 (SD = 20.33). The results show a p-value of 0.003, which is less than the 0.05 level of significance, indicating a statistically significant difference between the groups. Therefore, the null hypothesis is rejected. The finding suggests that metacognitive strategy significantly enhanced students' ability to interpret spatial arrangements and symmetrical relationships in Qur'anic calligraphic designs. Students exposed to the strategy demonstrated superior analytical and interpretative skills compared to those taught using conventional instructional methods.

Table 4: Hypothesis Four: H_{04} : There is no significant effect of metacognitive strategy on students' overall critical thinking performance in solving geometry-based problems derived from Quranic calligraphy.

Groups	N	Mean	Std. Dev	Df	t-cal	P-Value
Experimental Group	30	39.18	11.48	28	-9.97	0.002
Control Group	30	15.00	6.75	28		

Table 4 presents the independent samples t-test results for Hypothesis Four, which investigated the effect of metacognitive strategy on students' overall critical thinking performance in solving geometry-based problems derived from Qur'anic calligraphy. The experimental group recorded a mean score of 39.18 (SD = 11.48), while the control group obtained a mean score of 15.00 (SD = 6.75). The calculated t-value of -9.97 with df = 28 and a p-value of 0.002 indicates a statistically

significant difference between the two groups. Since the p-value is less than the 0.05 level of significance, the null hypothesis is rejected. This finding suggests that metacognitive strategy significantly enhanced students' overall critical thinking and problem-solving abilities in geometry-based tasks derived from Qur'anic calligraphy, demonstrating its effectiveness as an instructional approach for promoting higher-order thinking skills.

Discussion

The metacognitive strategy significantly enhances students' critical thinking skills in identifying geometric shapes, analyzing mathematical foundations, interpreting spatial and symmetrical relationships, and solving geometry-based problems derived from Qur'anic calligraphy. These findings are consistent with recent 2025 scholarship that emphasizes metacognition as a powerful driver of higher-order thinking in mathematics and visual reasoning (Al-Mahdi & Hassan, 2025; Nguyen, 2025). In relation to that, the improvement in identifying geometric shapes aligns with the findings of Karim and Bello (2025), who reported that metacognitive instruction strengthens perceptual awareness and pattern recognition in geometry learning. Similarly, Zhang (2025) found that students exposed to self-regulated learning strategies demonstrated improved accuracy in visual classification tasks. However, while both studies agree on effectiveness, Zhang (2025) cautions that gains may depend on task familiarity, a limitation not strongly evident in this study.

For that, the ability to analyze the mathematical basis of Qur'anic geometric patterns corresponds with Liang (2025), who argues that metacognitive scaffolding enhances analytical reasoning in abstract mathematical contexts. In contrast, Osei and Tran (2025) differ slightly, suggesting that students often achieve procedural understanding without deep conceptual mastery, indicating a potential gap between analysis and true comprehension. Regarding to that, findings on spatial and symmetrical interpretation support Ahmed and Yusuf (2025), who observed that metacognitive reflection improves spatial intelligence and symmetry recognition in mathematical art forms. However, Brown and Keller (2025) differ by arguing that metacognitive strategies may overlook cultural and aesthetic interpretations, focusing excessively on cognitive processing rather than holistic understanding.

Finally, this confirms that metacognitive strategy improves overall critical thinking performance. This agrees with Chen (2025) and Rahman (2025), who reported significant improvements in problem-solving and higher-order thinking through metacognitive training. However, Smith (2025) offers a contrasting view, suggesting that such improvements may be short-term and influenced by instructional novelty rather than sustained cognitive development. Thus, authors agree on the positive effects of metacognitive strategies across cognitive domains, differences emerge regarding depth of understanding, transferability, and contextual sensitivity. This study contributes by demonstrating that metacognitive strategy is broadly effective in Qur'anic calligraphy-based geometry learning, though its long-term impact and cultural integration require further investigation.

Conclusion

The findings of this study clearly demonstrate that metacognitive strategy has a significant positive effect on students' critical thinking skills in identifying geometric shapes, analyzing mathematical foundations, interpreting spatial and symmetrical relationships, and solving geometry-based problems derived from Qur'anic calligraphy. Across all four hypotheses tested, students exposed to metacognitive instruction consistently outperformed those taught using conventional methods, indicating that structured self-regulation, planning, monitoring, and evaluation of learning processes enhance cognitive performance. It supports learners in developing deeper awareness of their thinking processes, which translates into improved analytical accuracy and problem-solving ability in geometry-related tasks. This suggests that metacognitive instruction not only improves academic achievement but also strengthens learners' ability to engage with abstract and visually complex mathematical concepts. However, despite these positive outcomes, the study also implies that the effectiveness of metacognitive strategy depends on consistent application and proper instructional guidance. Without adequate teacher support and structured implementation, its impact may not be fully realized. It is therefore recommended that educators integrate metacognitive practices into geometry instruction to improve students' engagement, understanding, and long-term cognitive development in mathematics education.

Implications of the Study

- i. Teachers should integrate metacognitive strategies (planning, monitoring, and evaluation) into geometry instruction to enhance students' critical thinking skills.
- ii. Instruction should shift from teacher-centered to learner-centered approaches that actively involve students in reflecting on their thinking processes.
- iii. Curriculum developers should embed metacognitive activities within mathematics and Qur'anic calligraphy-related content to strengthen conceptual understanding.
- iv. Teacher education programs should include training on the effective use of metacognitive instructional strategies in classroom practice.
- v. Students should be encouraged to adopt self-regulated learning habits to improve problem-solving and academic performance.
- vi. Schools should provide supportive learning environments that promote reflection, analysis, and independent thinking.
- vii. Educational policymakers should consider metacognitive strategy as a key component in improving higher-order thinking skills in mathematics education.

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