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EFFECT OF INQUIRY-BASED LEARNING ON COGNITIVE DEVELOPMENT AND RETENTION IN MATHEMATICS AMONG JUNIOR SECONDARY SCHOOL STUDENTS IN KUDAN, KADUNA STATE

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Abstract

The study examined the impact of inquiry-based learning on cognitive development and retention in mathematics among Junior secondary school students in Kudan, Kaduna State. It adopted a quasi-experimental design involving pre-test, post-test, and post-posttest control groups. The study population comprised 55,495 Junior secondary school students in public schools in Kudan, with JSS II students as the target population. A sample of 89 students, drawn from two intact classes in two randomly selected schools, was used. One school served as the experimental group (43 students), while the other was the control group (46 students). Two instruments were employed for data collection: the Mathematics Cognitive Development Test (MCDT), which assessed students' cognitive skills in mathematics, and the Mathematics Retention Test (MRT), administered four weeks later to evaluate retention. Both groups completed a pre-test on mathematics content. The experimental group was taught using inquiry-based learning, while the control group received instruction through traditional teaching methods. Hypotheses were tested using Analysis of Covariance (ANCOVA). The findings revealed that students exposed to inquiry-based learning demonstrated significant improvements in cognitive skills, such as critical thinking and problem-solving in mathematics ($F = 286.574$, $P = .000$). Additionally, the results showed a significant positive effect of inquiry-based learning on students' retention in mathematics ($F = 16.446$, $P = .000$). Based on these findings, it was recommended that inquiry-based learning be integrated into the mathematics curriculum. Furthermore, educators should undergo training on inquiry-based learning techniques and strategies to effectively manage inquiry-based classrooms.

Keywords: Inquiry-based learning, Cognitive Development, Retention Mathematics

Introduction

In recent years, inquiry-based learning (IBL) has gained significant attention as an innovative teaching approach that emphasizes active exploration, questioning, and problem-solving, aiming to develop deeper understanding and retention in learners (Lazonder & Harmsen, 2016). Traditionally, mathematics has often been taught through lecture-based methods, focusing on memorization rather than understanding the underlying concepts. However, evidence suggests that this approach may not adequately foster cognitive development, critical thinking, or long-term retention (Yildirim, 2020). Cognitive development in mathematics is essential for students to build logical reasoning and

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problem-solving skills, both of which are critical for future learning in Science Teachers Association fields.

Inquiry-based learning (IBL) has become a prominent instructional approach in mathematics education. IBL allows students to solve real-world problems, fostering skills such as logical thinking, analytical reasoning, and independent learning (Minner, Levy, & Century, 2010). A meta-analysis by Lazonder and Harmsen (2016) found that IBL significantly improves student understanding and retention across multiple subjects, including mathematics, by emphasizing discovery and critical thinking over rote memorization. Inquiry-based learning provides an interactive framework where students engage with mathematical concepts through questioning, investigation, and collaborative activities, thereby enhancing their cognitive skills (Anderson, 2021). Unlike traditional methods, IBL promotes active learning and motivates students to connect mathematical theories with real-world applications. The shift from passive learning to active, student-centered learning has shown promise in improving academic outcomes, particularly in subjects requiring complex reasoning, such as mathematics (Abu & Ghaith, 2022).

Cognitive development refers to the process by which learners acquire, process, and use knowledge. According to Bloom's Taxonomy, higher-order cognitive skills include analysis, synthesis, and evaluation, which are essential for mastering mathematics (Bloom et al., 1956). Studies show that IBL can effectively stimulate these cognitive processes in students, leading to a deeper understanding of complex mathematical concepts (Abu & Ghaith, 2022).

Retention, or the ability to recall learned concepts over time, is crucial in mathematics, where each new concept often builds on previous knowledge. Research by Yildirim (2020) shows that IBL not only improves initial understanding but also enhances long-term retention, as students actively engage with and apply concepts rather than passively receiving information. The study is grounded in constructivist learning theory by Piaget and Vygotsky, which suggests that learners actively construct knowledge through experiences and interactions with their environment. Inquiry-based learning aligns well with constructivism, as it encourages students to explore, ask questions, and build on prior knowledge, which can foster deeper cognitive engagement (Vygotsky, 1978; Piaget, 1970).

In recent studies, researchers have consistently identified the importance of Study on new innovative strategies like Inquiry Based Learning. Example, a study by Idowu and Aluko (2019) explored the impact of IBL on mathematics achievement among secondary school students in Nigeria. The results indicated that students taught through IBL showed significantly higher retention rates and cognitive gains compared to those taught through traditional methods. Similarly, research by Abu and Ghaith (2022) on Inquiry Based Learning in junior secondary schools in the Middle East, revealed that students in the IBL group demonstrated improved cognitive skills, including critical thinking and problem-solving, along with better retention of mathematical concepts. Analysis by Yildirim (2020) research in Turkey highlighted the positive impact of IBL on cognitive development and retention among middle school mathematics students. The study concluded that the inquiry-based approach led to a more profound understanding of mathematical principles, which contributed to better long-term retention.

In most of the schools in Nigeria mathematics is often taught through traditional methods, such as rote memorization and direct instruction. These methods may not fully engage students in the cognitive processes. Therefore, required to develop higher-order thinking skills, which are essential for understanding and retaining complex mathematical concepts. In Kudan, Kaduna State, where educational resources are limited, junior secondary school students may struggle with mathematics due to a lack of engagement and a lack of instructional methods that promote critical thinking and

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problem-solving.

Inquiry-Based Learning (IBL) has emerged as a student-centered approach that encourages exploration, questioning, and discovery, potentially enhancing cognitive development and promoting deeper learning in mathematics. However, limited research exists on the effectiveness of IBL in Nigerian junior secondary schools, particularly in rural areas like Kudan. It is unclear whether IBL can significantly impact students' cognitive development and improve retention of mathematical concepts in this context.

This study, therefore, seeks to investigate the effect of Inquiry-Based Learning on cognitive development and retention in mathematics among junior secondary school students in Kudan, Kaduna State. The findings of this study will help educators and policymakers understand whether IBL can serve as a viable alternative to traditional teaching methods, especially in under-resourced settings, and provide insights into best practices for mathematics instruction to enhance learning outcomes.

Objectives of the Study

The objectives of this study were to determine:

1. The effect of Inquiry-based learning on cognitive development in mathematics among junior secondary school students in Kudan, Kaduna State.

2. The effect of Inquiry-based learning on retention in mathematics among junior secondary school students in Kudan, Kaduna State.

Research Hypotheses

H01: There is no significant effect of Inquiry-based learning on cognitive development in mathematics among junior secondary school students in Kudan, Kaduna State.

H02: There is no significant effect of Inquiry-based learning on retention in mathematics among junior secondary school students in Kudan, Kaduna State.

Methodology

The study utilized a quasi-experimental design featuring pre-test, post-test, and delayed post-test (post-posttest) control groups. The population comprised 55,495 junior secondary school students in public schools in Kudan, Kaduna State, with JSS II students serving as the target population. A sample of 89 students was drawn, divided into two intact classes from two randomly selected schools using simple random sampling. One school was designated as the experimental group (43 students), while the other served as the control group (46 students).

Data collection employed two instruments: the Mathematics Cognitive Development Test (MCDT), which measured students' cognitive development in mathematics, and the Mathematics Retention Test (MRT), administered four weeks later to evaluate retention. To establish a baseline, both groups completed a pre-test on mathematics content. The experimental group was taught using inquiry-based learning, while the control group received traditional instruction. Following the intervention, both groups completed a post-test to evaluate cognitive development. Retention of concepts was measured through a delayed post-test administered four weeks later.

Analysis of Covariance (ANCOVA) was employed to compare cognitive development and retention between the groups, with pre-test scores controlled to ensure an accurate assessment of the intervention's effects.

Results

Table 1: ANCOVA Test on effect of Inquiry-based learning on cognitive development in mathematics among junior secondary school students in Kudan, Kaduna State.

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	6022.936a	2	3011.468	70.815	.000
Intercept	9715.257	1	9715.257	228.454	.000
Pretest	214.501	1	214.501	5.044	.027
GROUP	5946.366	1	5946.366	139.829	.000
Error	3657.244	86	42.526		
Total	128433.000	89			
Corrected Total	9680.180	88			

a. R Squared = .622 (Adjusted R Squared = .613)

Table 1 showed the effect of Inquiry-based learning on cognitive development in mathematics among participants. F = 286.574, P= .000 is less than the alpha level of 0.005 indicating that students who were exposed to Inquiry-based learning method showed an improvement in cognitive skills, including critical thinking and problem-solving in mathematics. Therefore, the hypothesis which state that there is no significant effect of Inquiry-based learning on cognitive development in mathematics among junior secondary school students in Kudan, Kaduna State is rejected.

Table 2: ANCOVA Test on effect of Inquiry-based learning on retention in mathematics among junior secondary school students in Kudan, Kaduna State.

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	6118.053a	2	3059.026	107.172	.000
Intercept	942.074	1	942.074	33.005	.000
Posttest	945.475	1	945.475	33.124	.000
GROUP	469.427	1	469.427	16.446	.000
Error	2454.711	86	28.543		
Total	126305.000	89			
Corrected Total	**8572.764**	**88**			

a. R Squared = .714 (Adjusted R Squared = .707)

Table 2 showed the effect of Inquiry-based learning on retention in mathematics among participants. F = 16.446, P= .000 is less than the alpha level of 0.005 revealing that students exposed to Inquiry-based learning strategy showed higher retention in Biology than those who were not exposed to. Therefore, the hypothesis which state that there is no significant effect of Inquiry-based learning on retention in mathematics among junior secondary school students in Kudan, Kaduna State is rejected.

Discussion

The study examined the effect of inquiry-based learning (IBL) on cognitive development and retention in mathematics among junior secondary school students in Kudan, Kaduna State. Results indicated that students exposed to the IBL method showed significant improvement in cognitive skills, including critical thinking and problem-solving in mathematics (F = 286.574, P = .000). This finding aligns with Idowu and Aluko (2019), who reported that students taught through IBL

demonstrated significantly higher cognitive gains and retention rates compared to those taught with traditional methods. Similarly, Abu and Ghaith (2022), in their study on IBL in junior secondary schools in the Middle East, found that students in the IBL group exhibited enhanced cognitive abilities, such as critical thinking and problem-solving, along with better retention of mathematical concepts.

Secondly, the study revealed a significant effect of IBL on retention in mathematics among the students in Kudan ($F = 16.446$, $P = .000$), showing that students taught using the IBL strategy retained concepts better than those taught through traditional methods. This finding is consistent with Yildirim (2020), who demonstrated the positive impact of IBL on cognitive development and retention among middle school mathematics students in Turkey. Yildirim concluded that the inquiry-based approach facilitated a deeper understanding of mathematical principles, contributing to improved long-term retention. Similarly, Abu and Ghaith (2022) also highlighted that students taught through IBL not only developed stronger cognitive skills, such as critical thinking and problem-solving, but also retained mathematical concepts more effectively.

Conclusion

The study concluded that there is significant effect of inquiry-based learning on cognitive development and retention in mathematics among junior secondary school students in Kudan, Kaduna State. Indicating that students who were exposed to Inquiry Based Learning showed positive cognitive development and higher retention.

Recommendations

Based on the findings of the study, the following recommendations are proposed:

1. Implementation of Inquiry-Based Learning in Mathematics Curriculum: Schools in Kudan and similar areas should consider integrating IBL into their mathematics curriculum to enhance students' cognitive development and retention.

2. Teacher Training on Inquiry-Based Methods: Educators should receive training on IBL techniques and strategies for effectively managing inquiry-based classrooms.

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