

Impact of Heuristic Approach on Students' Academic Performance and Retention in Algebra in Argungu Educational Zone of Kebbi State, Nigeria

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Citation: Kangiwa, U. A., Julius, E., & Samaila, K. (2026). Impact of Heuristic Approach on Students' Academic Performance and Retention in Algebra in Argungu Educational Zone of Kebbi State, Nigeria. *Equity Journal of Innovative Research in Education*, 3(1), 1-12: ISSN 2814-2187

ABSTRACT

The study investigated the impact of the heuristic approach on students' academic performance and retention in teaching algebra in the Argungu Educational Zone of Kebbi State, Nigeria. A quasi-experimental design was adopted, involving two groups: an experimental group that was taught using the heuristic approach, and a control group that was taught using the conventional method. Two research objectives, two research questions, and two null hypotheses guided the study. The target population comprised all senior secondary school students in Argungu Educational Zone of Kebbi State, totaling 3,576. A sample of 160 students were drawn from the population of purposively selected schools (267) using Yemani's Formula. The students were however selected using convenience sampling technique. The instrument used for the study was the Algebra Performance and Retention Test (APRT), which was validated by experts from the Department of Science Education, Faculty of Education, Abdullahi Fodio University of Science and Technology, Aliero and some secondary school mathematics teachers. The instrument was pilot-tested with 30 students using test-retest method, and the data obtained were analyzed using the Pearson Product Moment Correlation (PPMC), which yielded a reliability index of 0.83. However, descriptive statistics (means and standard deviations) were used to analyzed the responses. Inferential statistics, specifically t-tests, were employed to test the null hypotheses at a 0.05 level of significance. The study concluded that students taught using the heuristic approach performed significantly better and showed higher retention compared to those taught with the conventional method. The study recommended the integration of the heuristic approach into regular classroom instruction to enhance students' academic performance and retention, particularly in mathematics and algebra concepts.

ARTICLE HISTORY

Received 28 March 2026

Accepted 2 May 2026

KEYWORDS:

Heuristic approach,
academic performance,
retention, algebra

1. Introduction

Mathematics is a subject that is found useful in most fields of life. Hence it is made compulsory to both primary and secondary school students in Nigeria. It is an activity oriented subject to which practical activities that involve individual participation is very important. In Nigeria mathematics receives the full attention it deserves in the curriculum and in all related regulations, from elementary to advanced schooling. Unameh (2011) and Nyaumwe (2013) state that mathematics education is a bedrock and an indispensable tool for scientific and economic advancement of a person and a nation at large. Alio and Okafor (2015) stated that no nation can advance economically and technologically without laying emphasis on teaching and learning of mathematics education.

Algebra, a fundamental branch of mathematics, often challenges students due to its abstract concepts. In Nigeria, persistent poor performance in Algebra among secondary school students has motivated educators to explore more effective teaching methods. Educators attribute this partly to ineffective teaching approaches. The issue of poor academic performance in Nigeria has raised significant concern among educators, parents, and society at large. Academic performance refers to the measurable achievement of students following a specific instructional program (Aremu & Sokan, 2021; Yusuf, 2023). It reflects how students engage with their studies and complete tasks assigned by their teachers. According to Saba and Tarang (2011), performance is the visible demonstration of a person's understanding, skills, concepts, ideas, and knowledge, with grades serving as indicators of student performance. Therefore, it is crucial to manage students' academic performance effectively, taking into account the various factors that may positively or negatively influence it. The academic success of students in any given task has always been of great interest to educators, parents, and society (Saba, 2011).

Retention refers to the ability to maintain and recall learned information over time, either through recognition or recall. Julius and Jubert (2021) note that many students struggle with retaining mathematical concepts and skills. Several factors contribute to poor performance and weak retention in mathematics, including rote memorization of procedures without understanding underlying concepts, leading to diminished learning outcomes. Insufficient practice and review further contribute to forgetting and poor results (National Council of Teachers of Mathematics, 2014). Additionally, math anxiety poses a significant barrier to performance and retention, causing students to disengage and lose motivation (Ashcraft, 2002).

Teaching methods according to Omwirhiren and Khalil (2016) are means for helping students to study effectively. In other words, teaching methods are tactics teachers adopt in meeting teaching objectives, which include instructional organization and techniques, subject matter, and the use of teaching tools and materials (Ogunniyi, 2021; Eze & Okeke, 2023). Conventional Method is a term used to referred to a method of instruction where the teacher exhibits a major role in respect of teaching and learning situation. In this method of teaching, instructors initiate discussion in the classroom, and focus exclusively on knowing content in textbooks and notes. Students in this method receive information passively and reiterate the information memorized in test or examination. conventional model of teaching serve as a base for improvement of classroom instruction. Although, the method has been widely used in teaching mathematics it has many set-backs. It is highly considered teachers-centered approach limiting student participation in the class discussion (Okafor, 2024; Ibrahim & Musa, 2021).

The term heuristic method of teaching is aimed at removing the shortcomings attributed conventional methods used by the teachers. It is a method by which students learn to reason for themselves. This method has been found very useful in the teaching of mathematics (Brehovsky et al., 2013). This study, therefore, seeks to investigate the impact of the heuristic approach on students' academic performance and retention in Algebra within the Argungu educational zone of Kebbi State.

Statement of the Problem

Despite importance of Algebra in the school curriculum, student performance in this subject remains poor, especially in Argungu educational zone of Kebbi State. Several factors contribute to the low academic achievement and limited understanding of mathematical concepts, particularly the teaching methods employed by teachers. Traditional teaching methods have proven inadequate for effective mathematics instruction (WAEC 2020 Report). Most of the secondary school mathematics teachers still use the conventional method for teaching the subject (Azuka, 2013). Each of these methods had its limitations. Some of the common issues included: lack of connection to real-world applications traditional and problem-solving skills, insufficient attention to individual students' needs and learning styles, Overreliance on rote memorization and drill-and-practice exercises, Overemphasis on procedural fluency at the expense of conceptual understanding (National Council of Teachers of Mathematics, 2014). To address the above problems, this study aims to generate empirical data on the effectiveness of heuristic approach in improving students' academic performance and retention in algebra in the Argungu educational zone. The findings would serve as a mile stone for addressing the poor performance of students in Mathematics. It would also provide a way forward for mathematics teacher with other alternative methods which make them shift from their dogmatic conventional method of teaching the subject.

Research Questions

The study was guided by the following research questions:

- i. What are the impact of the heuristic approach and the conventional method on students' academic performance in teaching algebra in Argungu educational zone of Kebbi State?
- ii. What are the impact of the heuristic approach and the conventional method on the retention ability of students in teaching algebra in Argungu educational zone of Kebbi State?

Research Hypotheses

The study tested the following null hypotheses:

- i. There is no significant difference in the academic performance of students taught algebra using the heuristic approach compared to those taught using the conventional method in Argungu educational zone of Kebbi State.
- ii. There is no significant difference in the retention ability of students taught algebra using the heuristic approach and conventional method in Argungu educational zone of Kebbi State.

2. Literature Review

Teaching Methods

Teaching methods encompass the principles and strategies employed by educators to facilitate effective learning outcomes among students. The choice of these methods depends partly on the subject matter and partly on the characteristics of the learners. For a teaching method to be both appropriate and effective, it must align with the learners' attributes and the type of learning intended (Abdullahi, 2021; Eze & Nwosu, 2023). However, no single teaching method suits every situation or all students universally.

Heuristic Teaching Method

The word 'Heuristic' has been derived from the Greek word 'Heurisco' which means 'I find' or 'I discover'. Heuristic is a teaching method based on trial and error theory, emphasizing problem-solving, discovery-based learning, and experience-based learning to facilitate student learning and promote self-learning (Sanchita, 2023). It emphasizes active engagement, problem-solving, and experiential learning. Prior research has illustrated the efficacy of heuristic methods in enhancing students' critical thinking, problem-solving abilities, and knowledge retention (Nasrin and Tamim, 2016). It involves thorough inquiry and thorough study to gain a heuristic idea about the subject taught. Heuristic Teaching Strategy is the method where the student is a discoverer and is responsible for finding out or inquires about the topic being learnt or taught instead of only receiving teacher's explanation or demonstration (Nickerson et al., 2014). Various arguments have been done about the effectiveness and usefulness of the heuristic strategy (Hand et al., 2016).

Conventional Method

Conventional Method (CM) is that mode of instruction in which the teacher is the centre of teaching learning process. Conventional method of teaching refers to a teaching method involving instructors and the students interacting in a face-to-face manner in the classroom Yap, (2016). Conventional method of teaching basically involves a teacher standing in front of the students, in a class and close to the chalk board using chalk-talk in teaching. In this method of teaching, instructors initiate discussion in the classroom, and focus exclusively on knowing content in textbooks and notes. It is pertinent to note that in this method, classroom interaction should among other things create the desired and equal opportunity for understanding in students 'gender (Nnamani and Oyibe, 2016).

Academic Performance

Academic performance is defined as the measure of what a student has accomplished after undergoing an educational program (Khan et al., 2019). It serves as a key indicator of the student's mastery of course content. Evaluating academic performance through standardized testing is crucial for both schools and society, as learning goals and instructional standards are typically set by grade levels. Enhancing student performance requires both quality instruction and effective teaching methods. According to Sinha et al. (2017), the success of educational institutions hinges largely on students meeting these academic standards. Therefore, adopting superior teaching methods is essential to help students excel and navigate the learning experiences provided by educators. Assessing students' academic performance through standardized tests is crucial for the school system and society.

Retention

Retention refers to the ability to store and recall information or ideas when needed. Olarewaju, cited in Ugwu, Jatau, and Gwamna (2020), defines retention as the process of storing and recalling

acquired knowledge or experiences. The quality and quantity of retained information depend heavily on the nature of the content and the teaching techniques employed. Retention is critical in mathematics, where solving new problems requires the recall and application of previously learned concepts alongside new ones. Ugwuanyi (2009) emphasizes that the effectiveness of a teaching strategy significantly influences students' ability to retain and remember what they have learned. Consequently, mathematics performance could be increased (Madu 2018, Lubna 2017 and Lubna 2019). Thus, problems on mathematics performance could be resolved.

Algebra

Algebra, a fundamental branch of mathematics, involves the use of symbols and rules for manipulating these symbols to represent numbers and quantities within formulas and equations (OpenStax, 2021; Khan Academy, 2023). It is widely recognized as a core concept in mathematics worldwide, as evidenced by its inclusion in the curriculum of 65 countries participating in the Program for International Student Assessment (PISA), including Nigeria. This is probably due to the fact that algebra is the door to the extension of complex arithmetic articulations, and a progression leap from concrete to abstract concepts in learning mathematics (Skouras 2014). The placement of algebra within school syllabi varies by country; some integrate it within a general mathematics syllabus, while others treat algebra as a distinct strand alongside arithmetic and geometry.

Empirical Studies

Several studies have investigated the effectiveness of teaching methods in mathematics education. For example, Okechukwu and Virginia (2014) investigated the effects of heuristic method of teaching on students' achievement in algebra. The study employed a non-equivalent control group quasi experimental design. The Results of the study showed that the heuristic approach is superior to the conventional approach in fostering students' achievement in linear algebra. Also, Musa and Muhammad (2023) conducted a research on Effect of Heuristic Method on Students' Performance in Shorthand in Polytechnics of North Eastern States. The findings suggest that the integration of heuristic methods positively influences students' shorthand performance, fostering a deeper understanding of the subject math and enhancing skill development. Robert et al. (2022) investigated on Effect of Active Learning through the Heuristic Problem-Solving Approach on Students' Achievement in Linear Programming (LP). A mixed method approach was used. Specifically, a pretest posttest nonequivalent quasi experimental design was adopted. The findings revealed that the problem solving heuristic approach had a significant impact on students' achievement in LP (DID=15.40) Generally, although both groups (comparison vs treatment) appear to have improved their average scores (4%vs20%), the paired sample t-test ($t(607) = 18.41$, $p = .000$), and the effect size (Cohen's $d = 0.65$) showed that students from the treatment group exhibited proficiency in solving LP problems compared to their counterparts from the comparison group.

Paula and Davison (2020), conducted a research on causes of poor academic performance in Mathematics at ordinary level. A descriptive survey design as adopted for the research. The results showed that as a result of inappropriate teaching methods, pupils, teachers and parents' have negative attitudes towards mathematics, lack of teaching experience by some teachers and instability of teachers and lack of adequate resources are some of the causes of poor academic

performance in Mathematics at ordinary level. Ester (2022) also, published her work ‘‘Effects of Mathematics Anxiety on Mathematics Performance Among Secondary Schools Students in Tanzania’’. A survey designed was used and The results generally revealed a significant effect of mathematics anxiety on mathematics performance among secondary school students at a 0.05 level of significance (P-Value 0.00 2-tailed). A correlation coefficient $r = 0.304$ indicate a significant moderate positive relationship between the effects of mathematics anxiety and mathematics performance.

Lubna and Arshad, Ali (2017), this study aimed to investigate The Effect of Mastery Learning Strategy (MLS) on learning retention of secondary school students in the subject of Mathematics by comparing it with Conventional Teaching Method (CTM). The design of the study was quasi experimental. The result showed Significant difference in retention of students in favor of experimental group. Irene et al. (2020) in his paper, examined the factors contributory to memory retention affecting the academic performance in Mathematics of Grade 7 students of Kalumboyan High School, Bayawan City Division for SY 2019–2020. The study made use of the descriptive-correlational research design. The findings revealed that the extent of students’ perception on factors contributory to memory retention were “high” in terms of motivational practices, experiences, goal setting, accomplishments, and personalized learning, while they perceived the use of teaching strategies, learning activities, the utilization of educational resources and learning devices to be “very high”.

3. Methodology

Research Design A quasi-experimental design was employed for this study. The design incorporated pre-test, post-test, and delayed post-test (post post-test) assessments for both experimental and control groups, facilitating comparison between the two groups.

Population and Sample The population comprised all Senior Secondary students within the Argungu Educational Zone of Kebbi State with a total population of 3576. Two senior secondary schools were purposely selected with a population of 267 (SS2) students due to their accessibility and availability of students. Using Taro yemani’s formula, a sample size of 160 were drawn from the population, Hence, a convenience sampling technique was used to select respondents out of senior secondary students in the schools.

Instrumentation and Validation the Algebraic Performance and Retention Test (APRT) was developed and validated by mathematics experts. The test consisted of 20 multiple-choice questions covering key Algebraic concepts. The APRT was administered as a pre-test to assess group homogeneity, a post-test to evaluate treatment effectiveness, and a delayed post-test (post post-test) to measure retention in both the experimental and control groups.

Research Procedure The experimental group received instruction through the heuristic approach over six weeks, while the control group was taught using conventional teaching methods. A pre-test was administered before the intervention, followed immediately by a posttest. A retention test was conducted four weeks after the post-test to assess long-term retention.

Data Analysis the data collected were analyzed using SPSS software. Descriptive statistics (means and standard deviations) were computed to answer the research questions. Inferential statistics, specifically t-tests, were employed to test the null hypotheses at a 0.05 level of significance.

4. Results

The analysis was done by taking the research questions one after another in tabular form followed by description of the table systematically. The result of the analysis is presented in table 1.

Research Question 1: What are the impact of the heuristic approach and the conventional method on students' academic performance in teaching algebra in Argungu educational zone of Kebbi State?

Table 1: Mean and Standard Deviations in the impact of heuristic and conventional method on students' academic performance in algebra in Argungu educational zone of Kebbi State.

Method	N	Mean	S D	Mean Difference
Heuristic Approach	80	33.69	16.03	5.69
Conventional Method	80	28.00	12.62	

Source: field work, 2025

The result in Table 1 showed the mean and standard deviation of heuristic and conventional method on students' academic performance in teaching algebra in Argungu educational zone of Kebbi State. The result showed that; the heuristic approach had a total mean of 33.59 with a standard deviation of 16.03 while the conventional method had a total mean of 28.00 with a standard deviation of 12.62. From the aforementioned result, the heuristic approach is found to be more effective in teaching algebra with standard deviation of 16.03 and mean difference of 5.69 recorded.

Research Question 2: What are the impact of the heuristic approach and the conventional method on the retention ability of students in teaching algebra in Argungu educational zone of Kebbi State?

Table 2: Mean and Standard Deviations in the Impact of heuristic approach and conventional method on students' retention ability in algebra in Argungu educational zone of Kebbi State.

Method	N	Mean	SD	Mean Difference
Heuristic approach	80	38.5	12.1	8.3
Conventional method	80	30.2	11.4	

Source: field work, 2025

The result in Table 2 showed the mean and standard deviation of heuristic approach and conventional method on students' retention ability in teaching algebra in Argungu educational zone of Kebbi State. Result showed that; the heuristic approach had a total mean of 38.5 with a standard deviation of 12.1 while the conventional method had a total mean of 30.2 with a standard deviation of 11.4. From the above result, the students taught using heuristic approach had higher retention ability in teaching algebra compare to conventional method.

Testing the Null Hypotheses After answering the research Questions, all the null hypotheses were tested at 0.05 level of significance to express significant difference.

Null Hypothesis 1

Table 3: T-test Analysis of the significant difference in the mean performance of students taught using heuristic approach and those taught using conventional method in teaching algebra in Argungu educational of Kebbi State.

Method	N	Mean	SD	DF	t-test	P-Value	Decision
Heuristic Approach	80	33.69	16.03	158	2.49	0.004	Rejected
Conventional Method	80	28.00	12.62				

Source: field work, 2025 **$\alpha = 0.05$**

The result in Table 3 shows the t-test analysis of the significant difference in the mean performance of students taught using heuristic approach and those taught using conventional method in teaching algebra in Argungu educational zone of Kebbi State. Result shows that; the students taught using heuristic approach has the higher mean score of 33.69 as compared to that of conventional method with mean score of 28.00. The t-test calculated value was 2.49 while the p-value is 0.004 which was less than $\alpha = 0.05$ level of significance at 158 degree of freedom. Hence, the null hypothesis which stated that there is no significant difference in the performance of students taught using heuristic approach and those taught using conventional method in teaching algebra in Argungu educational zone of Kebbi State was rejected. Therefore, there is a significant difference in the performance of students taught using heuristic approach and those taught using conventional method in teaching algebra in Argungu educational zone of Kebbi State, favouring heuristic approach.

Null Hypothesis 2

Table 4: T-test Analysis of the significant difference in students' retention ability when taught using heuristic approach and conventional method in teaching algebra in Argungu educational zone of Kebbi State.

Method	N	Mean	SD	DF	t-test	P-Value	Decision
Heuristic approach	80	38.5	12.1	158	3.12	0.003	Rejected
Conventional Method	80	30.2	11.4				

Source: field work, 2025 **$\alpha = 0.05$**

The result in Table 4 shows the t-test analysis of the significant difference in the mean of students' retention ability when taught using heuristic and conventional approach in teaching algebra in Argungu educational zone of Kebbi State. Result shows that; the students taught using heuristic approach has the higher mean score of 38.5 as compared to that taught using conventional approach with mean score of 30.2. The t-test calculated value was 3.12 while the p-value is 0.003 which was less than $\alpha = 0.05$ level of significance at 158 degree of freedom. Hence, the null hypothesis which stated that there is no significant difference in the mean between students' retention ability when taught using heuristic approach and conventional approach in teaching algebra in Argungu educational zone of Kebbi State was rejected. Therefore, there is a significant difference in the retention ability of students taught using heuristic approach and those taught using conventional method in teaching algebra in Argungu educational zone of Kebbi State, favouring heuristic approach.

5. Discussions of findings

The data were presented in tabular form, with detailed analysis conducted using means and standard deviations to address all research questions. Independent t-tests were employed to test the null hypotheses at the 0.05 level of significance. The results revealed that both Hypotheses 1 and 2 were rejected. Each hypothesis was tested at the specified level of significance ($\alpha = 0.05$). The findings indicate that the heuristic approach significantly improved students' academic performance and retention in the teaching of Algebra when compared to the conventional method.

Implications of the Findings

The findings of this study had tremendous implications. There was a significant difference in the mean performance of students taught using heuristic approach and those taught using the conventional method in algebra in senior secondary schools in Argungu Educational Zone of Kebbi State. Similarly, the result revealed a significant difference in the mean performance of students taught using the heuristic approach compared to those taught with the conventional method. These findings imply that the method of teaching was a significant factor in determining students' academic performance and retention in algebra in senior secondary schools in Argungu Educational Zone of Kebbi State. Furthermore, there was a significant difference between the heuristic approach and the conventional method on students' retention ability in algebra. This reinforces the conclusion that the method of teaching strongly influences both academic performance and retention.

These results align with prior research and support the Constructivist idea of learners constructing knowledge through active discovery. The findings are consistent with those of Mona and Sereen (2012), Okechukwu and Virginia (2014) and Robert et al. (2022), Musa and Muhammad (2023), all of whom reported that the heuristic approach had a greater impact on students' academic performance than the conventional approach.

6. Conclusion

The study concluded that the heuristic approach is more effective than the conventional method in teaching Algebra to senior secondary school students within the Argungu Educational Zone of Kebbi State. It also enhances students' retention of mathematical concepts, underscoring its value in improving mathematics instruction.

7. Recommendations

Based on the study's findings, the following recommendations are proposed:

- i. The heuristic approach should be integrated into regular classroom instruction to improve students' academic performance and retention in mathematics, particularly in Algebra.
- ii. Teachers should receive training and encouragement to adopt the heuristic approach as a core instructional strategy.

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