E-ISSN: 1116 - 3240 P-ISSN: 3026-9334
MPRI-JAIMR | INTERNATIONAL JOURNAL OF AFRICAN INNOVATION & MULTIDSCIPLINARY RES.
VOL. 14 NO. 2 – OCTOBER, 2026

EFFECT OF SPACED LEARNING STRATEGY ON JUNIOR SECONDARY SCHOOL STUDENTS' PERFORMANCE IN ALGEBRAIC PROCESSES IN KATSINA STATE, NIGERIA

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DOI: https://doi.org/10.70382/mejaimr.v14i2.0137

Abstract

This study investigated the effect of spaced learning strategy on performance in algebraic processes among Junior Secondary School Students in Mani Quality Assurance Zone, Katsina State, Nigeria. It was guided by two research questions and two hypotheses. The design of the study was a quasi-experimental design using two groups: experimental and control. The population comprised all JSS 2 students in public secondary schools in the zone. Two coeducational schools were randomly selected, and from each, one intact JSS 2 class was chosen. The sample included 110 students (84 males, 26 females). Data was collected using the Algebraic Processes Performance Test (APPT) with a reliability coefficient of 0.78. The mean and standard deviation addressed the research questions; hypotheses were tested using independent t-tests at a significance level of $\rho \leq 0.05$. Results showed a significant difference in favour of the experimental group taught with spaced learning, but no performance difference between male and female students exposed to the strategy. The study concluded that spaced learning is more effective and is gender friendly for teaching algebraic processes in junior secondary schools. It is recommended that teachers adopt spaced learning in Katsina State to improve mathematics performance.

Keywords: Spaced learning, Mathematics Education, Algebraic processes, Academic Performance, Gender.

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Introduction

Mathematics is widely regarded as the foundation of science and technology. This leads to the question: What is mathematics all about? It serves as the language for expressing logical ideas, shapes, quantities, sizes, order, change, and dynamics within a system. Additionally, it helps explain the complexities of modern society in various fields such as business, economics, academia, engineering, and medicine (Abdurrahaman & Bolaji, 2018). Mathematics is a critical component of the school curriculum, with algebraic processes being a significant focus. However, many junior secondary school students in Katsina State face challenges in learning these algebraic processes (Abdurrahaman et al., 2021). Several factors contribute to students' poor algebra performance, including a lack of interest and motivation, inadequate teaching strategies, and the perceived irrelevance of the subject to their daily lives. To address these issues, this study investigates the effectiveness of spaced learning strategy in improving the understanding of algebraic processes among junior secondary school students in Katsina State.

Spaced learning is a learning method in which highly condensed learning content is repeated three times, with two 5 – 10 minutes breaks during which distractor activities such as physical activities are performed by the students. It is a method that enhances the retention of material by repeating the same content several times with intervals between each repetition. Research by Ace and Remalyn (2017) shows that this approach is effective in improving long-term retention and learning among students. It is based on the spacing effect, which suggests that alternating study sessions with other activities aids in the learning process (Mat-jizat et al., 2020). The spaced learning process consists of three main steps: initial education, a brief targeted lesson, and a separate activity conducted during a break. Kelley and Whatson (2013) developed a structured system for spaced instruction across curriculum subjects, which includes three 20-minute lessons separated by 10-minute intervals. In the first session (20 minutes), a new topic is introduced, followed by a 10-minute break. In the second session (20 minutes), key points from the presentation are reinforced, and students engage in physical activities. The third session (20 minutes) allows students to apply their knowledge through problem-solving activities. As Muhammad and Umar (2020) noted, spaced learning can be an effective teaching strategy in mathematics, providing students with opportunities to practice and consolidate their learning over time.

Algebra is a fundamental branch of mathematics taught at all educational levels in Nigeria, as outlined by the National Policy on Education (FME, 2013). It is defined as a mathematical discipline in which letters from the English alphabet—such as x, y, q, and p—are used to represent numbers to solve problems (Abdurrahaman et al., 2021). The application of algebra to equations and word problems is known as algebraic processes. These processes focus on generalised numbers (variables) and investigate the relationships between different quantities. Algebra can effectively explain and represent real-world situations (Decker-Woodrow et al., 2023). It requires some abstract thinking and can be introduced to students as they transition from a more concrete way of understanding to a more abstract level of thinking, typically between the ages of 14 and 16. If students comprehend the uses and limitations of this mathematical tool, the algebraic process can become a valuable asset in their learning (Abdurrahaman et al., 2020). Many students have engaged with mathematics without fully understanding its necessity, leading to a relaxed attitude and frequent errors. Nowadays, algebra, along with mathematics in general, is increasingly

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contextualised. The focus is on applying mathematics to comprehend real-world events and replicate those scenarios in problem-solving.

STATEMENT OF THE PROBLEM

The poor academic performance of students in mathematics in Nigeria, especially among junior secondary school students, is a significant concern. This issue stems from factors such as low interest and motivation, inadequate teaching strategies, a perceived lack of relevance to daily life, and negative attitudes towards the subject (Chand et al., 2021; Ohanyelu, 2019). All of these appeared to have been investigated, yet the problems seem to have remained persistent, given the recurring mass failure in Mathematics external examinations in the state. The prevailing teacher-centred instructional approach, primarily based on lectures, promotes passive learning and does not cater to the diverse abilities of students, resulting in negative attitudes towards mathematics (Abdurrahaman et al., 2021; Gambari et al., 2017). Research indicates that improved instructional methods are necessary to comprehend mathematical concepts better (Mohammed et al., 2021). Given that mathematics requires interactive learning, there is a need to adopt modern teaching strategies like spaced learning that can enhance students' engagement and performance. Evidences abound that spaced learning could be used to effectively facilitate better performance in Mathematics. This study, therefore, is conducted to investigate the effect of spaced learning on students' performance in algebraic processes.

OBJECTIVES OF THE STUDY

The study examined the effect of spaced learning strategy on performance in algebraic processes among junior secondary school students. Specifically, the study has the following objectives:

1. To determine the effect of spaced learning strategy on junior secondary school students' academic performance in algebraic processes.
2. To examine the academic performance of male and female junior secondary school students taught algebraic processes using spaced learning strategy.

RESEARCH QUESTIONS

The following research questions guide the study:

1. What is the difference between the mean academic performance scores of the students taught algebraic processes using the spaced learning strategy and those of their counterparts taught the same concept using the conventional method?
2. What is the difference between the mean academic performance scores of the male and female students taught algebraic processes using the spaced learning strategy?

RESEARCH HYPOTHESES

The following null hypotheses were formulated and tested at $\rho \leq 0.05$ level of significance;

Ho_1: There is no significant difference between the mean academic performance scores of the students taught algebraic processes using the spaced learning strategy and those of their counterparts taught the same concept using the conventional method.

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Ho_2: There is no significant difference between the mean academic performance scores of the male and female students taught algebraic processes using the spaced learning strategy.

METHODOLOGY

Research Design

The study adopted a quasi-experimental design of the pretest-post-test control group design. The study has two groups: the experimental group and the control group. The experimental group (EG) is exposed to the spaced learning strategy as treatment (X_1), while the control group (CG) is taught algebraic processes using the lecture method (X_0). The groups were pretested (O_1) on performance to ensure the selection of samples with comparable abilities. This was followed by treatment administration. The experimental group was taught the concepts of algebraic processes using the spaced learning strategy, while the control group was taught using the lecture method for six weeks. Post-test (O_2) was administered to the groups to assess the effectiveness of the treatment on the students' performance in algebraic processes after the intervention. Scholars (Gopalan et al., 2020; Maciejewski, 2020; Miller et al., 2020; Sambo, 2008) established that this design is useful in determining the abilities of students before exposure to instructional treatment and served as a yardstick for determining gain in mastery of the concepts after treatment.

Population and Sample

The population of this study covered all public Junior Secondary Schools' Year Two (JSS 2) students in Mani Quality Assurance Zone, Katsina State. Most of the Junior Secondary Schools are co-educational schools. Uniform condition prevails with respect to the Curriculum and Academic Calendar within the schools under study.

The study's sample size was 110 students (54 in the experimental group and 56 in the control group), with 84 males and 26 females. The samples were chosen using purposeful and simple random sampling. In the first stage, Mani Quality Assurance Zone was purposefully chosen, and two (2) schools were chosen at random via balloting. The two schools chosen were divided into experimental and control groups. In the second stage of the randomization process, one intact class was chosen from among the total number of JSS 2 classes in each school. The intact classes were chosen to prevent interference with school operations.

Instrumentation

The instrument used for data collection was Algebraic Processes Performance Test (APPT). APPT contained two sections. Section A sought for personal information of the students whereas section B is made to measure the background knowledge of the participants in the domain of Algebraic processes and are items drawn from the mathematics textbooks used in JS II classes in the selected schools and consists of twenty (20) multiple-choice questions with four options. The test items covered four Algebraic processes topics, which are expansion of Algebraic expressions, factorisation of Algebraic expressions, word problems involving simple Algebraic equations and fractions, and linear inequality in one variable. The instrument was validated by two experts from the Science Education Department of Federal University Dutsin-Ma and the Department of Mathematics Education, Isa Kaita College of Education, Dutsin-Ma. After careful study, corrections

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were made based on their recommendations before administering. In addition, a pilot test was conducted to ascertain the effectiveness of the instrument. To ensure the reliability of APPT, the test-retest method was observed, and the Pearson Product-Moment Correlation Coefficient (PPMc) was used in the analysis involving the SPSS package. The result revealed that the reliability of APPT is 0.78, indicating a strong reliability and could be used for the research.

Ethical Considerations

1. Permission was obtained from the relevant educational authorities and school principals.
2. Participants were informed and consented voluntarily.
3. Participants' anonymity and confidentiality was ensured.
4. Data were handled in accordance with ethical research standards.

RESULTS AND DISCUSSIONS

In answering the research questions, the data collected was analysed using Descriptive statistics, while the null hypotheses were tested using independent sample t-test statistic at $\rho \leq 0.05$. The results obtained were as follows:

Research Question 1: What is the difference between the mean academic performance scores of the students taught algebraic processes using the Spaced learning strategy and those of their counterparts taught the same concept using the conventional method?

Table 1: *Descriptive Statistics of the Academic Performance Scores in Algebraic processes of the Experimental and Control Groups.*

Variable	Group	N	M	SD	MD
Academic Performance in Algebraic Processes	Experimental	54	25.56	4.30	18.06
	Control	56	7.50	2.23	

Key: N = Sample Size, M = Mean, SD = Standard Deviation, MD = Mean difference

From Table 1, it could be seen that the experimental group had a mean score of 25.56 (*SD = 4.30*) while the control group had a mean score of 7.50 (*SD = 2.23*), giving a mean difference of 18.06. This indicates that the students taught algebraic process concepts using the Spaced learning Strategy (Experimental group) had a higher mean score than students taught using the conventional method (Control group). Thus, in answer to research question one, the mean academic performance score of the experimental group differs from that of their counterparts in the control group by 18.06 in favour of the experimental group. However, a corresponding null hypothesis was tested to establish the significance or otherwise of the difference.

Ho_1: There is no significant difference between the mean academic performance scores of the students taught algebraic processes using the Spaced learning strategy and those of their counterparts taught the same concept using the conventional method.

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Table 2: *Independent Samples t-test Analysis of the Performance in Algebraic processes of the Experimental and Control Groups*

Variable	Group	N	M	SD	df	t	ρ	Decision
Academic Performance in Algebraic Processes	Experimental	54	25.56	4.30	108	27.77	0.001	*Sig.
	Control	56	7.50	2.23				

*Significant at $\rho \leq 0.05$

Table 2 revealed the difference between the mean academic performance of the students taught algebraic processes using Spaced learning Strategy (i.e. the experimental group) (*M = 25.56, SD = 4.30*) and that of their counterparts taught the same concept using the conventional method (i.e. control group) (*M = 7.50, SD = 2.23*), df = 108, $\rho < 0.05$ is statistically significant. Thus, the null hypothesis was rejected, and it was therefore concluded that the experimental group students taught algebraic processes using spaced learning Strategy performed better than the control group students taught using the conventional method. Therefore, the use of spaced learning Strategy in teaching algebraic process concepts in Mathematics could lead to better academic performance of students compared to the Conventional Method.

Research Question 2: What is the difference between the mean academic performance scores of the male and female students taught algebraic processes using the Spaced learning Strategy?

Table 3: *Descriptive Statistics of the Academic Performance Scores in Algebraic processes of the Male and Female Students*

Variable	Gender	N	M	SD	MD
Academic Performance in Algebraic Processes	Male	38	25.26	9.78	-0.43
	Female	16	25.69	9.53	

Key: N = Sample Size, M = Mean, SD = Standard Deviation and MD = Mean Difference

From Table 3, it could be seen that the male students in the experimental group had a mean score of 25.26 (*SD = 9.78*) while their female counterparts had a mean score of 25.69 (*SD = 9.53*). This indicates that the performances of the male and female students are similar, with a negligible mean difference of - 0.43 in favour of the female students. Thus, in answer to research question two, the mean performance score of male and female students taught algebraic processes using spaced learning Strategy is not different. However, a corresponding null hypothesis was tested to establish the significance or otherwise of the negligible difference.

Ho_2: There is no significant difference between the mean academic performance scores of the male and female students taught algebraic processes using the Spaced learning strategy.

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Table 4: *Independent Samples t-test Analysis of the Performance in Algebraic processes of the Male and Female Students.*

Variable	Group	N	M	SD	df	t	ρ	Decision
Academic Performance in Algebraic processes	Male	38	25.26	9.78	52	0.70	0.706	Not Sig.
	Female	16	25.69	9.53				

Not Significant at $p > 0.05$

Table 4 revealed the difference between the mean academic performance of male and female students taught algebraic processes using spaced learning Strategy, with male having ($M = 25.26$, $SD = 9.78$) and female ($M = 25.69$, $SD = 9.53$), df = 52, $\rho = 0.706$ is not statistically significant. The null hypothesis was not rejected, and it was therefore concluded that the use of spaced learning strategy in teaching algebraic process concepts in Mathematics does not affect gender. This finding shows that the use of spaced learning Strategy in teaching algebraic process concepts in Mathematics is gender friendly.

DISCUSSION

This study investigated the effect of spaced learning strategy on performance in algebraic processes among Junior Secondary School Students, Mani Quality Assurance Zone, Katsina State, Nigeria. To achieve this, students in the experimental group were taught algebraic process concepts using spaced learning strategy, while students in the control group were taught the same concepts using the conventional lecture method. The students in the experimental group and control group were both pre-tested and post-tested, and their academic performance was compared and measured. The result of the testing of hypothesis one, as shown in Table 2, revealed that the experimental group students taught algebraic processes using spaced learning strategy performed significantly better than their counterparts in the control group who were taught using the traditional lecture method. The significant difference in academic performance in favour of the experimental group suggests a greater effectiveness of the spaced learning strategy over the conventional lecture method in teaching algebraic processes. This shows that the use of the spaced learning strategy in teaching algebraic processes is viable in enhancing students' academic performance at the junior secondary school level of education. This might be that the spacing employed gave the students less stress in the class and switched on their brain, providing room for long-term memory retention, which improved their performance. This finding agrees with Seweje (2010) cited in Fabiyi and Binuyo (2023) that good teaching strategies have the potent to improve cognition of students. This also indicates that spaced learning could facilitate meaningful learning of Mathematics. The finding emerging from this study agrees with the findings of Fabiyi and Binuyo (2023) that students in the spaced learning group performed better in mathematics than those in the conventional method. The finding also agrees with Lekyong and Muodumogu (2025), who found that the use of spaced learning strategy improved students' self-efficacy in reading comprehension better than the conventional learning strategy. This finding may be a result of spaced learning teaching strategy being an effective strategy in mathematics, providing students with opportunities to practice and consolidate their learning over time.

Hypothesis two focused on gender-related differences in the academic performance of male and female students exposed to algebraic processes using spaced learning strategy. The post-test result of testing hypothesis two, as shown in Table 4, shows that there is no statistically significant difference between the post-test mean scores of male and female students. This implies that the level of academic performance in algebraic processes of male and female students exposed to spaced learning strategy is relatively the same. This finding disagrees with some earlier findings, which showed that gender was a significant factor in mathematics performance. Shafi and Areelu (2010), and Usman and Musa (2015) reported male students' superiority in mathematics performance, while Akande (2017) and Muhammad and Maitama (2018) reported female students' superiority in mathematics performance. This finding, however, consolidates the findings of Kolawole (2012), Oludipe (2012), Anyor and Iji (2014) and Ogoke et al (2018), who in their study found out that male and female students did not differ significantly in their mathematics performance. The finding from this study shows that the spaced learning strategy does not discriminate against gender but rather provides opportunities to every student in their quest to improve their algebraic processes performance.

CONCLUSION

Findings from the study disclosed a significant difference between the post-test mean performance of the experimental and control groups in favour of the experimental group, and there was no significant difference in the mean performance scores of male and female students in the experimental group. Based on the findings from this study, it was concluded that the spaced learning strategy is a more effective instructional method in improving students' performance in algebraic processes than the lecture method. This is perceptible in the higher mean performance scores obtained by students who were taught using the spaced learning strategy. It was also observed that the strategy is gender friendly, as revealed by the male and female students' academic performances.

LIMITATIONS OF THE STUDY

The study has the following limitations.

1. **Small and Uneven Sample Size:** The study was conducted with a relatively small total sample of 110 students. The limited sample size may restrict the ability to generalize the results to the broader student population of Katsina State and beyond.
2. **Gender Imbalance:** The significant gender imbalance in the experimental group (38 males and 16 females) in the sample is another notable limitation. This disparity means the results may be disproportionately influenced by the male perspective, potentially limiting the applicability of the findings to female students.
3. **Short Intervention Duration:** The six-week duration of the intervention may be too short to fully capture the long-term effects of the program. While the study may show immediate impacts, it cannot assess the longevity of the effects or whether the intervention leads to sustained change over time. A longer-term study would be necessary to determine if the benefits persist beyond the initial six-week period.

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4. **Limited Geographic Scope:** This research was confined to students within the Mani Quality Assurance Zone of Katsina State. While this focus provides a deep understanding of the local context, it restricts the generalizability of the findings to students in other Quality Assurance Zones within Katsina State or other states in Nigeria. Differences in local educational policies, socioeconomic conditions, and cultural factors were not accounted for, which may influence the intervention's effectiveness in different settings.

IMPLICATIONS FOR FUTURE RESEARCH

Future studies should address these limitations by incorporating a larger, more diverse, and more evenly distributed sample to increase statistical power and improve generalizability. Additionally, a longer intervention period would help in assessing the durability of the observed effects. Furthermore, expanding the geographic scope to include multiple Quality Assurance Zones or states would provide a more comprehensive understanding of the intervention's broader applicability. Finally, similar researches should be conducted across different topics in Mathematics, different subjects, and different educational levels.

RECOMMENDATIONS

1. Teachers should adopt spaced learning strategy in teaching algebraic processes to junior secondary school students in Katsina State. This strategy can help enhance students' performance in mathematics.
2. Teacher training programs should incorporate the use of spaced learning strategy in teaching mathematics. This will help equip teachers with the necessary skills and knowledge to effectively use this strategy in their classrooms.
3. School administrators and policymakers should provide support for teachers to adopt spaced learning strategy in their teaching. This can be done by providing necessary resources such as learning materials and technology, and creating opportunities for teachers to collaborate and share best practices.
4. Further research should be conducted to investigate the effectiveness of spaced learning strategy in teaching other mathematics topics and in other subject areas. This will help to provide a more comprehensive understanding of the potential benefits of this teaching strategy.

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