



Effects of Spaced Learning Strategy on Senior Secondary School Students Performance and Retention in Mathematics in Niger State, Nigeria

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ABSTRACT

This research delved into investigating the impacts of implementing a spaced learning strategy on the academic performance of senior secondary school students studying mathematics in Niger State, Nigeria. The primary objective was to explore the potential advantages of employing a learner-centered approach, specifically focusing on the spaced learning strategy, to enhance students' proficiency in mathematics. To guide the research, three research questions were formulated, each accompanied by a corresponding hypothesis, with a significance level set at 0.05. In the pursuit of these objectives, a quasi-experimental design with both pre-test and post-test measurements was adopted. The research involved a sample of 180 SS2 students, ensuring an equal distribution between male and female participants. The research instrument, known as the Mathematics Performance Test (MPT), was employed to collect relevant data. Subsequently, statistical methods were applied to rigorously analyze the data, evaluating the effects of the spaced learning treatment and investigating potential gender differences. The outcomes of this study yield valuable insights into the effectiveness of the spaced learning strategy within the context of mathematics education in Niger State. Consequently, the study recommends the incorporation of spaced learning by mathematics educators during instructional delivery, as it has demonstrated the potential to not only boost academic performance but also enhance the retention capabilities of students. This suggests that adopting a spaced learning approach can contribute significantly to the pedagogical landscape, offering a valuable tool for mathematics teachers to optimize the learning experience and outcomes for their students.

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INTRODUCTION

Mathematics holds a critical position as a compulsory and core subject at both the basic and post-basic levels of education in Nigeria. However, there has been a decline in students' performance in mathematics, as evidenced by

the Senior School Certificate Examinations (SSCE) conducted by the West African Examinations Council (WAEC), the National Examination Council (NECO), and the National Board of Technical Examination (NABTEB). This decline poses concerns for the government and

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other stakeholders due to its implications for students' future opportunities and the negative attitudes towards the subject. Several factors have been identified as contributing to this decline, including the abstract nature of mathematical concepts, ineffective teaching methods, inadequate learning resources, lack of laboratory facilities, large class sizes, and a shortage of qualified teachers, among others (Allouche, 2017; Ba, 2019).

To address these challenges and improve students' performance in mathematics, there is a need to explore and adopt effective teaching methods that promote active learning, engagement, and mastery of mathematical concepts (Musa, 2019). The traditional teacher-centered approach, where instructors primarily convey information to students, has shown limitations in fostering deep understanding and problem-solving skills. Thus, there is a call to shift towards learner-centered strategies that empower students to take an active role in their learning process. One such strategy is spaced learning.

Spaced learning is an instructional approach that involves the repetition of learning materials over spaced intervals of time, with intermittent breaks for non-academic and extracurricular activities (Brame and Biel, 2015; Nurudeen, 2020). This approach capitalizes on the spacing effect, which suggests that distributing learning sessions over time enhances long-term retention and retrieval of information. Spaced learning allows students to engage with the material multiple times, reinforcing their understanding and memory of mathematical concepts (Kalley, 2013; Erinnocho, 2015; Frank, 2021).

Spaced learning is a method in which condensed learning content is repeated many times with a few minutes break to allow distraction activities such as games, chats, and other extracurricular activities. The technique minimizes the boredom associated with long-time learning and tends to enhance assimilation of content within these break times. Spaced learning was designed as a way of boosting the declining performance of

students in mathematics by removing the psychological stress and anxiety associated with learning abstract and difficult concepts.

Estu (2020) stated that spaced learning comprises breaking a long course into several sessions or modules of shorter duration with breaks in between the sessions. With this strategy, the learner can retain the information and skills taught in the course. The adoption and integration of spaced learning may be new to some teachers; however, its overwhelming advantage is that it guarantees quick understanding and enhances long-term retention. Students' attention, performance, and retention are important factors that promote technological advancement and sustain greater interest and empathy towards learning mathematics.

Only limited studies have been conducted on the use of spaced learning techniques to promote students' performance and retention with mixed findings. While some scholars believe that the method is acceptable and student-centered, others believe that the breaks in the learning session could be dangerous to understanding and comprehension (Abdullahi, 2019; Adeniyi, 2021). However, there is a need to conduct an in-depth investigation into the effect of spaced learning on secondary students' performance and retention so that a valid stand and decision on the teaching method can be taken in favor or against. Thus, this justifies the extreme and urgent need for the current study.

Purpose of the Study

The objectives of the study are specifically set to:

1. Compare the difference in the mean performance scores of students taught mathematics using Spaced learning and those taught using the traditional teaching method
2. Investigate the mean performance score of the male and female students taught mathematics using the spaced learning strategy.
3. Find out the retention capability of students' taught using the spaced and

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their counterparts taught using the traditional lecture method.

Research Questions

1. What is the difference in the mean performance scores of students taught mathematics using spaced and those taught mathematics using the traditional teaching method?
2. What is the mean performance score of the male and female students taught mathematics using the spaced learning strategy?
3. What is the mean difference in retention ability of students taught mathematics using the spaced and the traditional lecture method?

Hypotheses

1. There is no significant difference in the mean performance scores of students taught mathematics using spaced learning and those taught mathematics using the traditional teaching method.
2. There is no significant difference in the mean retention ability of students taught mathematics using the spaced learning strategy and those taught same content using lecture method

METHODOLOGY

A quasi-experimental design with a pre-test and post-test was employed to examine the effects of the spaced learning strategy on students' performance and retention in mathematics. The target population for the study comprised all the Senior Secondary School (11) students of public schools in Minna (Bosso and Chanchanga Local Government Area) in the Niger East Senatorial Zone. There are thirty (30) schools within the study environment of the two (2) LGAs. The total estimated population of the students in these schools was (3,240) comprising (1,500) males (1,740) females (Niger State Ministry of Education Digest, 2022). The choice of the study area was informed by the strategic location of Niger State within the North-Central geopolitical zone which link the North West and

North South of the State. All the Schools are co-educational in both urban and rural settlement.

With the large number of secondary schools and students population, it will be difficult to cover all the schools in the Senatorial Zone of Niger State given the time frame and financial implication of the study. A simple random sampling was employed to select to 9 schools within Bosso and Chanchanga local government LGAs. Niger state has 70 co-educational Senior Secondary Schools out of which 30 Schools lie in the study area. A reasonable representation of the population is needed for the study and the researcher thus employed simple random sampling technique to select nine (9) schools with estimated student's population of 2476. The students in the nine (9) schools were pretested using the mathematics performance test. Three (3) schools whose results tends to be very similar or the same was selected and used for the study representing 10% of the total co-educational Schools within the study environment and thus appropriate representation of population according to Krejcie and Morgan (1975), Kefan (2017) and the central limit theorem. They stated that a sample size of 8% - 15%, 10% and greater or equal to 30 respectively is a fair representation in a scientific research. MPT are items drawn from mathematics textbooks used in S.S.S II in the selected schools.

The test items were made up of 50 items with four (4) options (A –D). MPT, items were drawn from Geometry, inequalities, Statistics probability and Trigonometry covered during the treatment and consists of 50 items with four (4) (A – D). The instrument was subjected to both face and content validity by experts from Science education of ABU Zaria. A pilot test was conducted to ascertain the effectiveness of the instrument the reliability coefficient of 0.91 was obtained. The experimental group were taught selected topics using the spaced learning technique while the control group were taught same topics using the traditional lecture method. The researcher and two research assistants administered the test instrument on both the experimental and control groups simultaneously. T-test statistics was

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applied to test hypotheses 1 and 3 on treatment, at 0.05 significance level using statistical package for social sciences (SPSS) version 23 to analyze the data gathered. The application of t-test takes care of the differences between groups before treatment (pre-test).

In answering the research questions, the data collected were analyzed using Descriptive statistics of Means and Standard deviation. While in analyzing the null hypotheses, the data collected were analyzed using inferential statistical of t-test at $p \leq 0.05$. The details of the analysis were as follows;

Table 1: Pre-test Scores of Experiment and Control Groups

Group	N	Mean	SD	Mean Difference
Experimental	90	38.85	16.115	
Control	90	39.105	13.369	0.20

The result in Table 1 indicated that the mean performance scores of the experimental groups was 38.85 (SD = 16.115) and that of the control group was 39.05 (SD = 13.369). The mean performance score difference between the groups was 0.02. The mean pre-test score difference was negligible which shows that both there was no much difference between the

groups (their entry-level equivalence is confirmed).

Research Question One: What is the effect of spaced learning instruction and massed learning instruction on the performance of students taught Mathematics concept?

To answer this question, a descriptive statistics using means and standard deviations were carried out. The result is showed in table 2.

Table 2: Means and Standard Deviation of Experimental and Control Groups in Post-Test

Group	N	Mean	SD	Mean Difference
Experimental (spaced)	90	56.82	16.93	
Control (lecture)	90	47.42	21.50	9.40

The Table 2 showed that mean score of the experimental group 56.82 (SD= 16.93) and control group was 47.42 (SD = 21.50). The recorded mean difference of (9.40) in favour of experimental group after treatment was significant. This result shows that student taught mathematics using spaced learning outperform

than their counterparts taught same content using the traditional lecture method.

Research Question Two: What is the mean difference in the retention ability of student taught mathematics using spaced learning and those taught using the traditional lecture method?

Table 3.0: Mean and standard deviation of the retention ability of the experimental group and control group

Group	N	Post-test 1		Post-test 2		Retention Mean Gain
		x ₁	SD	x ₂	SD	
Experimental	90	56.82	16.930	59.96	8.730	3.14
Control	90	47.42	21.502	48.32	9.265	0.90

Table 3.0 above the post-test and post-test scores of both the experimental and control group. The group of students taught mathematics using spaced learning technique had a score of

56.82 and 59.96 for post-test and post post-test respectively. This mean a retention (mean difference) of 3.14, while the control group had 47.42 and 48.32 respectively with a mean gain of

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0.90. The figures in table 3.0 above indicates a higher mean gain (retention) of 3.14 for the

experimental group as compared to the mean gain (retention) of 0.90 for the control group.

Table 4: T-test analysis of retention ability of the experimental and control group

Group	N	Mean	Df	t-value	P-value	Remark
Experimental	90	56.82				
Control	90	53.35	178	0.225	0.102	Sig.

Table 4.0 above revealed the t-test analysis of retention scores of both the experimental and control group in the post post-test. The P-value of 0.0102 is less than t-value of 0.225 at a 0.05 level of significance indicates that the null hypothesis is rejected.

This result shows that the group of student taught mathematics using the spaced learning (experimental) had better retention ability than those taught using the traditional lecture method. Thus, the use of spaced learning

is seen as memory booster and promoter of problem solving skills in mathematics.

Null Hypothesis One: There is no significant difference between the mean performance scores of students taught Mathematics using Spaced Learning Instruction and those taught using conventional Learning Instruction. To test this hypothesis an inferential statistics of an independent sample t-test was carried out and presented in Table 4.0.

Table 5: Independent t-test Analysis of Post-test between Experimental Group and Control group

Group	N	Mean	SD	Df	t-value	P-value	Remark
Experimental	90	56.82	16.93				
Control	90	41.42	21.50	178	2.757	0.012	Sig.

*Significant at $p < 0.05$

From the result in Table 4.0 above, the P-value of 0.012 which is less than t-value of 2.257 at $\alpha = 0.05$ level of significance. This showed there was significance difference in the mean performance scores of students taught with spaced learning instruction and students taught using traditional lecture method. The null hypothesis was therefore rejected, which indicated that the treatment has enhance

performance of mathematics students in the post-test.

Null Hypothesis Two: There is no significant difference in the mean score of male and female students using Spaced Learning Instruction. In order to test the hypothesis, a post-posttest scores of the students in the experimental and control groups were subjected to an independent sample t-test statistics and the result was presented in Table 5.

Table 6: T-test of Analysis of male and female in the experimental group

Group	N	Mean	SD	Df	t-value	p-value	Remark
Male	45	54.85	12.804				
Female	45	53.35	21.11	126	0.002	0.001	Sig.

*Significant at $p < 0.05$

From the result of the analysis in Table 5, the p-value obtained (0.001) is greater than t-value of 0.002 at 0.05, which was no indication that there was significance in the mean score of

male and female students in the experimental group. Therefore, the null hypothesis was rejected (accepted). This result indicated that the spaced learning is gender friendly and does not

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discriminate between the male and female mathematics students.

DISCUSSION OF RESULT

The computed p-values for the null hypotheses were less than 0.05 (level of significance). The first hypothesis is rejected. This implies that there exists a significant difference in the mathematics performance of students taught through the Spaced and Traditional Lecture Method. The difference favors students in the Spaced Learning group. This finding aligns with Bala (2006), Mile (2014), and Kinton (2015), suggesting that students instructed through Spaced Learning had better performance compared to those taught through the lecture method. The result statistically reveals that the spacing group significantly performed better than the non-spaced group. The implications of this study can make teachers aware that teaching through spaced intervals can provide better results than teaching through the traditional lecture technique.

The second hypothesis was also accepted since the p-value is greater than at the 0.5 level of significance. The acceptance of hypothesis two signifies that there was no significant difference in the mean performance of male and female students in the post-test. This result indicates that the treatment is gender-friendly and thus boosts the understanding of both male and female mathematics students in secondary schools in Minna, Niger state. The result is in agreement with the longitudinal study conducted by Ogunlade (2019) on the effect of spaced learning in primary science achievement.

Hypothesis three was rejected because of a substantial difference in retention ability. The difference favors the spaced learning group. This finding confirms the positions of Miles (2015) and Ace & Remalyn (2017), suggesting that spacing provides improvement in long-term retention. They also maintained that the performance and retention ability of students exposed to spaced teaching attained high scores in performance and retention compared to students exposed to Massed teaching, and their attitude towards learning the content becomes more responsive.

Thalheimer (2015) also stated that students with high retention or long-term memory are able to get high scores in tests.

CONCLUSION

Spaced learning instruction has consistently proven to be more effective than traditional lecture-based learning. This concept was initially demonstrated by Ebbinghaus (1885), over a century ago, who observed that spaced learning sessions resulted in higher retrieval scores compared to traditional lecture-based sessions when the total learning time was held constant for both conditions. However, the current study suggests that learning efficiency is further enhanced when the time interval between retrieval sessions is progressively increased in successive sessions, a strategy known as "expanding retrieval practice."

While spaced learning has demonstrated superiority over traditional lecture learning in the long term, the findings of this study also corroborate and support this conclusion. The study underscores that the time dependency of comprehension is closely linked to the spacing effect, as comprehension levels are influenced by various factors affecting performance. Additionally, the challenge with spaced learning is that it typically requires more time overall, including rest breaks, compared to the more hurried traditional lecture learning approach. Hence, Mathematics teachers in senior secondary schools are encouraged to adhere to the timetable for Mathematics instruction and not rely solely on traditional teaching methods. Efforts should be made to integrate spaced learning strategies, recognizing its potential for more effective and lasting comprehension.

RECOMMENDATIONS

Based on the findings of this study, the researcher recommended that;

1. Spacing Instruction should be fully integrated into Nigeria Education Curriculum so that mathematic teachers can fully utilized it as supplement for teaching difficult concepts.

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2. Teachers of Mathematics should be exposed to spacing learning instruction through seminar, symposium and in-service training to boost their capacity in teaching and curriculum development for schools.
3. Teachers of Mathematics should be made to adhere to the period allotted for the teaching of Mathematics and provides periodic breaks so that students can engage in extra-curricular activities outside classrooms.

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