Influence of Reinforcement on Achievement in Mathematics among Senior Secondary School Students in Aba North Local Government Area, Abia State, Nigeria

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Abstract

This study assessed the influence of reinforcement on academic achievement in mathematics among senior secondary school students in Aba North LGA, Abia State, Nigeria. The study employed descriptive survey design. The population comprised the entire senior secondary school students in Aba North LGA, Abia State. One hundred students (100) were randomly drawn from five schools to constitute the sample of the population. The instrument for data collection was a researcher-made questionnaire tagged Reinforcement and Academic Achievement in Mathematics Questionnaire (RAAMQ) comprising twenty items with each of the four variables contributing five items. Cronbach Alpha reliability technique was used to estimate the reliability coefficient and an estimate 0.80. The mathematics scores were collected from mathematics teachers in the sampled schools. It was assumed that the scores were generated from valid and reliable mathematics achievement tests. To achieve the purpose of the study, four research questions were posed and four null hypotheses formulated. The research questions were answered using descriptive statistics by calculating mean scores and standard deviation. All hypotheses were tested at 0.05 levels of significant using paired t-test. The findings revealed that fixed interval schedule reinforcement, variable interval schedule reinforcement, fixed ratio schedule reinforcement, and variable ratio schedule reinforcement have statistically significant influence on academic achievement in mathematics among senior secondary students in Aba North LGA, Abia State. Based on the findings, teachers are recommended that utilize reinforcement involve on reinforcement training and retraining to boost students achievement in Mathematics, policy makers in education are to encourage more research on reinforcement as well as promote inclusion of reinforcement in curricular, while students must be free to identify the best reinforcement that can engage them as well as boost their achievement in Mathematics.

Keywords

Achievement, Learning, Mathematics, Performance, Reinforcement

1. Introduction

Education is a fundamental human right that must be accessible to all without discrimination [1]. It is widely recognized as a powerful instrument for nurturing national culture, shaping character, and building future generations. Through education, societies produce individuals capable of driving social transformation, addressing societal challenges, and contributing meaningfully to national development. Among the important components that ensure education's effectiveness, the teacher remains central. Teachers are indispensable agents of educational progress, responsible for guiding, motivating, and inspiring students to realize their potential [2]. However, rapid technological advancement has broadened students' access to information beyond the classroom, sometimes even surpassing their teachers' knowledge. This transformation calls for innovative pedagogical strategies that sustain students' interest, encourage active participation, and promote lifelong learning. Teachers must move beyond traditional roles to become facilitators of inquiry and critical thinking, adapting their practices to meet evolving student needs and classroom contexts. Their effectiveness depends on employing strategies that not only transmit knowledge but also spark curiosity and motivation, thereby bridging the gap between knowledge acquisition and its meaningful application.

One of the most critical challenges in contemporary education is motivating students to learn effectively and achieve optimal academic outcomes. Stakeholders in Nigeria's education sector including teachers, parents, counselors, and policymakers are increasingly concerned about declining academic performance, particularly at the secondary school level. Academic achievement extends beyond personal accomplishment, it is a crucial driver of national development, underpinning scientific and technological innovation, socio-economic growth, political advancement, and individual empowerment. As Sund, and Gericke, [3] observe, every subject taught at the secondary school level contributes

uniquely to the educational process. Mathematics, in particular, is a core subject that is compulsory at the basic, upper basic, and post-basic levels of education in Nigeria [4]. It serves a dual purpose, developing students' intellectual capacity and enhancing their numerical, analytical, and problem-solving skills. Despite its significance, students' engagement with Mathematics remains low, often due to negative attitudes, anxiety, and ineffective instructional methods. These challenges make it imperative for educators to explore motivational strategies that can enhance students' interest, confidence, and perseverance in Mathematics learning.

Despite its foundational role, Mathematics performance among Nigerian students has remained persistently poor. Conventionally, the performance of students in other school subjects has always been higher than that of mathematics thereby making poor performance in mathematics a topical issue in Nigeria. From 1991 to 2016, 27.31% of students in Nigeria got credit and above (A1-C6) while 72.69% had pass and below (D7-F9) in the May/June WASSCE in general mathematics [5]. This report implies that a large percentage of the students failed to acquire the requisite level of proficiency authorized by the West African Examinations Council and the Ministry of Education in mathematics. The annual deterioration in performance in mathematics shows that students are not proficient in the core curriculum in mathematics. While most of the concern is focused on the poor performance, little attention is given to the contributor(s) of this poor performance [6]. Also, data from the National Examination Council (NECO) reveal alarming trends, with only 35.26%, 23.58%, and 33.45% of students achieving credit passes in Mathematics between 2017 and 2019 [7]. This chronic underachievement has far-reaching implications for Nigeria's scientific and technological aspirations. Many students actively avoid Mathematics, and those who engage with it often struggle to achieve satisfactory results. In Aba North Local Government Area (LGA) of Abia State, as in many parts of the country, Mathematics underperformance is a pressing educational concern. Factors contributing to this problem include inadequate teaching methods, low student motivation, and insufficient use of reinforcement strategies. These challenges highlight the urgent need for instructional approaches that not only convey content but also stimulate sustained student interest and active participation. Addressing the systemic weaknesses in Mathematics education is crucial if Nigeria is to equip its youth with the competencies necessary for national development and global competitiveness.

Reinforcement, a fundamental concept in learning theory, plays a pivotal role in shaping students' academic performance by strengthening desired behaviours through consistent feedback, encouragement, and rewards [8]. In Mathematics education, reinforcement can encourage students to persist in the face of challenges, cultivate a growth mindset, and build confidence in their problem-solving abilities. Despite its documented effectiveness, reinforcement remains underutilized in many Nigerian secondary schools, where teacher-centered approaches dominate [9]. This study seeks to investigate how reinforcement influences students' performance in Mathematics in secondary schools in Aba North LGA, Abia State. By examining this relationship, the research aims to generate evidence-based insights into how reinforcement can be strategically applied to improve learning outcomes and deepen students' understanding of mathematical concepts. Furthermore, it explores how reinforcement contributes to building motivation, resilience, and positive attitudes toward Mathematics, which are key factors that enhance learning engagement and achievement. Understanding the dynamics of reinforcement in educational contexts is essential for designing interventions that promote sustained academic success.

Academic achievement refers to the extent to which learners, teachers, or institutions realize their educational objectives, whether short-term or long-term [10]. According to Rury, [11] standardized test performance often dominates discussions on achievement, however, classroom assessments and course grades provide more immediate indicators of daily teaching and learning processes. Academic success encompasses not only cognitive outcomes but also extracurricular engagement, communication skills, confidence, and other non-cognitive attributes. Mathematics holds a particularly significant position within this framework. As Ikechukwu [12] notes, Mathematics is deeply embedded in everyday life and indispensable for solving societal issues. Abd Algani, [13] further assert that Mathematics develops in response to societal needs and equips individuals with competencies essential for meaningful and productive living. Its historical role in human progress, transforming societies from primitive stages to advanced civilizations [14]. The pervasive application of Mathematics in daily life underscores its relevance beyond the classroom, making proficiency in the subject essential for individual success and societal advancement.

Given its critical importance, many nations mandate Mathematics as a compulsory subject from primary through secondary education and invest heavily in its development. In Nigeria, the establishment of the National Mathematical Centre in Abuja through Decree No. 40 of 1989, later formalized by the 2004 Act, underscores the government's commitment to Mathematics education [15]. Mathematics is widely regarded as the bedrock of scientific, technological, economic, and societal development. Disparities in mathematics education have even been cited as a key factor distinguishing developed from developing nations [16]. Research on the educational values of mathematics reveals multiple dimensions that highlight the subject's versatility beyond computational skills. Awofala and Ojaleye [17] identified key educational values such as practical, disciplinary, cultural, social, moral, aesthetic, and recreational values, finding significant correlations between these values and positive attitudes toward mathematics.

Reinforcement strategies, when effectively implemented, can transform classroom dynamics and significantly improve learning outcomes. Positive reinforcement involves systematically rewarding desired behaviors to encourage their recurrence. Groskreutz, [18] categorize reinforcement schedules into continuous and intermittent (or partial) types. Continuous reinforcement provides rewards each time a desired behavior occurs, such as praise for correct answers, but

risks rapid extinction when rewards stop. Partial reinforcement, by contrast, provides rewards intermittently, increasing behavior persistence. Partial reinforcement can follow interval schedules based on time or ratio schedules based on response frequency. Fixed interval schedules offer reinforcement at regular intervals, while variable interval schedules introduce unpredictability, sustaining motivation. Similarly, fixed ratio schedules reward after a set number of correct responses, fostering competition, whereas variable ratio schedules reward unpredictably, and maintaining engagement. Uzoka [19] confirms the effectiveness of these methods in sustaining productive behaviour and improving performance. Strategic application of these schedules can significantly enhance Mathematics learning, motivation, and resilience among students.

Despite the proven benefits of reinforcement, its application in Nigerian classrooms remains limited, with many teachers relying on teacher-centered methods that promote rote learning and passive reception of knowledge. Such approaches often fail to address diverse learning needs, leading to low motivation and poor performance in Mathematics. Addressing this challenge requires evidence-based pedagogical interventions grounded in educational psychology. This study investigates how various reinforcement strategies continuous, fixed interval, variable interval, fixed ratio, and variable ratio affect students' academic performance in Mathematics in secondary schools in Aba North LGA, Abia State. It further explores how reinforcement influences motivation, engagement, and persistence essential components of successful learning. The findings are expected to inform teacher training, curriculum development, and classroom practices, eventually enhancing Mathematics outcomes. By improving Mathematics performance, this study contributes to Nigeria's broader scientific, technological, and socio-economic advancement, affirming education's role as a cornerstone of national development.

1.1 Theoretical Framework

Reinforcement is a central concept in educational psychology, referring to any stimulus that strengthens or increases the probability of a behaviour's recurrence. In learning, reinforcement involves the deliberate use of rewards or consequences to encourage desirable academic behaviours and discourage undesirable ones. It is closely linked to motivation, which is essential for sustaining students' engagement and achievement. Mathematics, as a core subject in secondary education, demands sustained effort and problem-solving skills, yet many students experience anxiety, low motivation, or negative attitudes toward it. These factors often contribute to poor achievement outcomes, as seen in many Nigerian schools. Reinforcement provides a practical approach to addressing these challenges by shaping students' behaviours through consistent feedback, praise, recognition, and rewards. It not only enhances students' interest and participation but also builds confidence and resilience in confronting mathematical tasks. By linking reinforcement to mathematics achievement, this study is situated within the broader field of educational psychology, exploring how reinforcement principles can be applied to improve cognitive outcomes, motivation, and academic performance among senior secondary school students in Aba North Local Government Area of Abia State, Nigeria.

Two foundational theories underpin this study: Classical Conditioning Theory by Ivan Pavlov (1927) and Operant Conditioning Theory by B. F. Skinner (1953).

1.2 Classical Conditioning Theory by Ivan Pavlov (1927)

Pavlov's classical conditioning emerged from his experiments where he discovered that an organism could learn to associate a neutral stimulus with an unconditioned stimulus to produce a conditioned response. Pavlov also introduced the concept of reinforcement as a stimulus that strengthens the association between stimulus and response [20]. In educational, classical conditioning explains how repeated pairings of academic tasks (stimuli) with positive reinforcement (e.g., praise, encouragement) can bring about favourable emotional and behavioural responses to learning. Reinforcement becomes a motivational tool, shaping students' attitudes and readiness to engage with challenging subjects such as mathematics. It also illustrates how consistent positive classroom experiences can condition students to associate mathematics with success and satisfaction rather than fear or failure.

1.3 Burrhus Frederic Skinner's Operant Conditioning Theory (1953)

Skinner's Operant Conditioning Theory (1953) builds on Pavlov's work but emphasizes the role of consequences in shaping voluntary behaviour. Skinner proposed that behavior followed by positive consequences (reinforcement) is more likely to be repeated, while behaviour followed by negative consequences is less likely to recur. Operant conditioning introduces two primary types of reinforcement: positive reinforcement, which involves presenting a rewarding stimulus after a desired behaviour, and negative reinforcement, which involves removing an aversive stimulus to encourage behaviour [21]. Skinner also outlined reinforcement schedules, continuous and partial (fixed/variable interval, fixed/variable ratio), which influence the strength and persistence of behaviours. These principles are highly relevant to classroom settings, where teachers can reinforce participation, accuracy, effort, and persistence in mathematics learning. By strategically applying reinforcement, educators can strengthen students' learning behaviours, increase engagement, and ultimately enhance achievement.

Both classical and operant conditioning theories provide powerful explanatory frameworks for understanding how reinforcement influences mathematics achievement. Pavlov's work suggests that repeated positive reinforcement associated with mathematical tasks can condition students to respond positively to the subject, thereby reducing anxiety and promoting engagement. For instance, when teachers consistently reward effort and problem-solving attempts,

students begin to associate mathematics learning with success and satisfaction. This conditioned response can lead to improved motivation and willingness to persist through difficult problems.

Skinner's operant conditioning offers more direct applications to classroom practice. Mathematics teachers can use positive reinforcement (such as praise, grades, recognition, or tangible rewards) to increase desirable behaviours like class participation, homework completion, and problem-solving attempts. Negative reinforcement can also be employed by removing aversive stimuli such as extra assignments or corrective drills, once desired behaviours are displayed, thereby encouraging continued effort. Also, understanding and applying different reinforcement schedules can help teachers sustain students' motivation over time. For example, a fixed ratio schedule (rewarding students after a set number of correct answers) can increase practice frequency, while a variable interval schedule (rewarding at unpredictable times) can sustain consistent effort. These strategies align with the study's focus on how reinforcement affects students' motivation, engagement, and achievement in mathematics.

The integration of these theories also supports the formulation of the study's research questions and hypotheses. If reinforcement strengthens learning behaviors as both Pavlov and Skinner suggest, then classrooms that systematically use reinforcement should exhibit higher levels of student motivation and better mathematics performance. This theoretical foundation, therefore, not only guides the design of the study but also informs its interpretation of findings, linking observed changes in behavior and achievement to well-established psychological principles.

The theoretical lens provided by classical and operant conditioning theories shapes this study's approach to investigating the influence of reinforcement on mathematics achievement. Pavlov's work highlights the importance of stimulus-response associations and the role of reinforcement in creating positive learning dispositions, while Skinner's theory provides a framework for actively shaping and sustaining desired academic behaviours through reinforcement schedules. Together, these theories explain how reinforcement can function as both a motivational catalyst and a behavioural guide, influencing students' cognitive engagement and achievement in mathematics.

The study, therefore, positions reinforcement not merely as a classroom technique but as a theoretically grounded intervention with the potential to address persistent underachievement in mathematics. By applying these theoretical perspectives to the context of senior secondary schools in Aba North LGA, the study aims to generate evidence-based recommendations for improving teaching practices, curriculum design, and policy interventions that support mathematics education and, by extension, Nigeria's broader scientific and socio-economic development.

2. Methodology

2.1 Research Design

This study adopted a descriptive survey research design, which is appropriate for examining relationships among variables by collecting data from a representative sample of a population (Ukeje, 2018). This design facilitated the investigation of how reinforcement influences students' achievement in mathematics.

2.2 Study Area

The research was conducted in Aba North Local Government Area (LGA) of Abia State, Nigeria, located in the South-East geopolitical zone. The area is predominantly inhabited by the Igbo ethnic group and is recognized as a major commercial hub. It is characterized by a high concentration of public secondary schools serving students from different social strata, making it a relevant context for studying reinforcement practices and their impact on academic outcomes.

2.3 Population and Sample

The target population comprised all students enrolled in public secondary schools within Aba North LGA. A sample of 100 students was drawn from five schools using a cluster random sampling technique, with 20 students selected from each school. This approach ensured that the sample was representative of the wider student population and minimized sampling bias.

2.4 Instruments and Data Collection Procedures

Data were collected using a researcher-designed questionnaire, the Reinforcement and Academic Achievement in Mathematics Questionnaire (RAAMQ), supplemented by students' mathematics test scores obtained from their teachers. The RAAMQ consisted of demographic items and 20 statements organized into four thematic clusters, designed to measure reinforcement practices and their relationship to mathematics performance. The validated instrument was administered by the researcher with the assistance of four trained research assistants, who provided standardized instructions and ensured accurate responses from participants.

2.5 Validity and Reliability

The instrument's content and face validity were established through expert review by three specialists in educational research, psychology, and measurement and evaluation. Their feedback on clarity, relevance, and item formulation was incorporated into the final version. Instrument reliability was determined through a pilot study involving 40 students from a school outside the main study sample. The internal consistency of the questionnaire, assessed using Cronbach's alpha, yielded a coefficient of 0.80, indicating an acceptable level of reliability for research purposes.

2.6 Data Analysis

Data were analyzed using both descriptive and inferential statistical techniques. Means and standard deviations were computed to answer the research questions, while independent-samples t-tests were employed to test the hypotheses at a 0.05 level of significance. Questionnaire items were rated on a four-point Likert scale (4 = Very High Extent to 1 = Very Low Extent). Mean scores of 3.50 and above were interpreted as high, while scores of 2.49 and below were considered low. In hypothesis testing, null hypotheses were rejected when the calculated t-value was less than the critical table value at the specified significance level

2.7 Data Analysis, Interpretation, and Discussion of Findings

This section presents the results of the data analysis, organized according to the research questions and hypotheses that guided the study. Descriptive statistics (mean and standard deviation) were used to answer the research questions, while inferential statistics (independent-samples t-tests) were employed to test the hypotheses at the 0.05 level of significance. The results are presented in tables and followed by interpretations and discussions in line with existing literature.

Research Question 1:

What is the influence of fixed interval schedule reinforcement on students' academic achievement in mathematics in Aba North LGA of Abia State?

Table 1. Mean Score and Standard Deviation of Influence of Fixed Interval Schedule Reinforcement on Achievement in Mathematics

Variables	N	$\bar{x}$	SD
Fixed interval schedule reinforcement	100	17.06	1.64
Achievement in mathematics	100	45.70	19.37

Table 1 showed that the mean score and standard deviation of fixed interval schedule reinforcement to be (= 17.06, SD = 1.64) and mean score and standard deviation of academic achievement in mathematics was (= 45.70, SD = 19.37). The mean score of fixed interval schedule reinforcement was less than that of academic achievement in mathematics; this means that fixed interval schedule reinforcement has no influence on academic achievement in mathematics among senior secondary school students in Aba North LGA, Abia State.

Research Question 2:

What is the influence of variable interval schedule reinforcement on students' academic achievement in Mathematics in Aba North LGA of Abia State?

Table 2. Mean Score and Standard Deviation of Influence of Variable Interval Schedule Reinforcement on Achievement in Mathematics

Variables	N	$\bar{x}$	SD
Variable interval schedule reinforcement	100	16.96	1.1.89
Achievement in mathematics	100	45.70	19.37

Table 2 showed that the mean score and standard deviation of variable interval schedule reinforcement to be (= 16.69, SD = 1.89) and mean score and standard deviation of academic achievement in mathematics was (= 45.70, SD = 19.37). The mean score of variable interval schedule reinforcement was less than that of academic achievement in mathematics; this implied that variable interval schedule reinforcement has no influence on academic achievement in mathematics among senior secondary school students in Aba North LGA, Abia State.

Research Question 3:

What is the influence of fixed ratio schedule reinforcement on academic achievement in Mathematics among secondary school students in Aba North LGA of Abia State?

Table 3. Mean Score and Standard Deviation of Influence of Fixed Ratio Schedule Reinforcement on Achievement in Mathematics

Variables	N	$\bar{x}$	SD
Fixed ratio schedule reinforcement	100	17.38	2.33
Achievement in mathematics	100	45.70	19.37

Table 3 revealed that the mean score and standard deviation of fixed ratio schedule reinforcement was (= 17.38, SD = 2.33) and mean score and standard deviation of academic achievement in mathematics was (= 45.70, SD = 19.37). The mean score of fixed ratio schedule reinforcement was less than that of academic achievement in mathematics; this means that fixed ratio schedule reinforcement has no influence on academic achievement in mathematics among senior secondary school students in Aba North LGA, Abia State.

Research Question 4:

What is the influence of variable ratio schedule reinforcement on academic achievement in Mathematics among secondary school students in Aba North LGA of Abia State?

Table 4. Mean Score and Standard Deviation of Influence of Variable Ratio Schedule Reinforcement on Achievement in Mathematics

Variables	N	$\bar{x}$	SD
Variable ratio schedule reinforcement	100	17.13	1.80
Achievement in mathematics	100	45.70	19.37

Table 4 indicated that the mean score and standard deviation of variable ratio schedule reinforcement was (= 17.13, SD = 1.80) and mean score and standard deviation of academic achievement in mathematics was (= 45.70, SD = 19.37). The mean score of variable ratio schedule reinforcement was less than that of academic achievement in mathematics; this implied that variable ratio schedule reinforcement has no influence on academic achievement in mathematics among senior secondary school students in Aba North LGA, Abia State.

2.8 Testing of Null Hypotheses

All hypotheses were tested at .05 levels of significance using paired t-test.

Hypothesis 1: There is no significant influence of fixed interval schedule reinforcement on students' academic achievement in Mathematics among secondary school students in Aba North LGA of Abia State.

Table 5. Paired t –test Analysis of Influence of Fixed Interval Schedule Reinforcement on the Academic Achievement in Mathematics (N=100)

Variable	$\bar{x}$	SD	t-value	df.	Sig.
Fixed interval schedule reinforcement	17.06	1.64			
			14.90	99	.000
Achievement in Mathematics	45.70	19.37			

Table 5 indicated that t-value (99) = 14.90 and level of significance (.000) is less than the alpha level (.05). Based on this, the hypothesis that stated that there is no significant influence of fixed interval schedule reinforcement on students' academic achievement in Mathematics among secondary school students in Aba North LGA of Abia State, was rejected. This implied that fixed interval schedule reinforcement has a statistically significant influence on the academic achievement in mathematics among senior secondary school students in Aba North LGA, Abia State.

Hypothesis 2: There is no significant influence of variable interval schedule reinforcement on students' academic performance in Mathematics among secondary school students in Aba North LGA of Abia State.

Table 6. Paired t –test Analysis of Influence of Variable Interval Schedule Reinforcement on the Academic Achievement in Mathematics (N=100)

Variable	$\bar{x}$	SD	t-value	df.	Sig.
Variable interval schedule reinforcement	16.96	1.89			
			14.76	99	.000
Achievement in Mathematics	45.70	19.37			

Table 6 indicated that t-value (99) = 14.76 and level of significance (.000) is less than the alpha level (.05). Based on this, the hypothesis that stated that there is no significant influence of variable interval schedule reinforcement on students' academic achievement in Mathematics among secondary school students in Aba North LGA of Abia State, was rejected. This implied that variable interval schedule reinforcement has a statistically significant influence on the academic achievement in mathematics among senior secondary school students in Aba North LGA, Abia State.

Hypothesis 3: There is no significant influence of fixed ratio schedule reinforcement on students' academic performance in Mathematics among secondary school students in Aba North LGA of Abia State .

Table 7. Paired t –test Analysis of Influence of Fixed Ratio Schedule Reinforcement on the Academic Achievement in Mathematics (N=100)

Variable	$\bar{x}$	SD	t-value	df.	Sig.
Fixed Ratio schedule reinforcement	17.38	2.33			
			14.33	99	.000
Achievement in Mathematics	45.70	19.37			

Table 7 indicated that t-value (99) = 14.33 and level of significance (.000) is less than the alpha level (.05). Based on this, the hypothesis that stated that there is no significant influence of fixed ratio schedule reinforcement on students' academic achievement in Mathematics among secondary school students in Aba North LGA of Abia State, was rejected. This implied that fixed ratio schedule reinforcement has a statistically significant influence on the academic achievement in mathematics among senior secondary school students in Aba North LGA, Abia State.

Hypothesis 4: There is no significant influence of variable ratio schedule reinforcement on academic performance in Mathematics among secondary school students in Aba North LGA of Abia State.

Table 8. Paired t –test Analysis of Influence of Variable Ratio Schedule Reinforcement on the Academic Achievement in Mathematics (N=100)

Variable	$\bar{x}$	SD	t-value	df.	Sig.
Variable ratio schedule reinforcement	17.13	1.80			
			14.48	99	.000
Achievement in Mathematics	45.70	19.37			

Table 8 indicated that t-value (99) = 14.48 and level of significance (.000) is less than the alpha level (.05). Based on this, the hypothesis that stated that there is no significant influence of variable ratio schedule reinforcement on students' academic achievement in Mathematics among secondary school students in Aba North LGA of Abia State, was rejected. This implied that variable ratio schedule reinforcement has a statistically significant influence on the academic achievement in mathematics among senior secondary school students in Aba North LGA, Abia State.

3. Summary of Findings

This study examined the influence of different reinforcement schedules on students' academic achievement in mathematics among secondary school students in Aba North Local Government Area, Abia State. Four null hypotheses were tested using paired t-tests, and all were rejected. The major findings are summarized as follows:

- Fixed interval schedule reinforcement significantly influences students' academic achievement in mathematics.
- Variable interval schedule reinforcement significantly influences students' academic achievement in mathematics.
- Fixed ratio schedule reinforcement significantly influences students' academic achievement in mathematics.
- Variable ratio schedule reinforcement significantly influences students' academic achievement in mathematics.

These findings indicate that reinforcement, regardless of the schedule type, plays a significant role in shaping students' learning outcomes and enhancing their mathematics performance.

4. Discussion of Findings

4.1 Fixed Interval Schedule Reinforcement and Academic Achievement

The results indicated that fixed interval schedule reinforcement significantly influences students' mathematics achievement ($t(99) = 14.90$, $p < .05$), even though initial mean comparisons suggested a limited direct effect. This finding supports Skinner's (1953) operant conditioning theory, which posits that reinforcement schedules shape learning behaviour by strengthening stimulus–response connections. It also aligns with Bonghawan, and Macalisang, [22] who emphasize that reinforcement serves as a powerful external motivator that enhances academic engagement and performance. However, scholars such as Dewar [23] caution that excessive reliance on reinforcement may reduce intrinsic motivation, as students may perform primarily in anticipation of rewards rather than developing genuine interest in the subject. Cognitive learning theorist, Fritscher, [24] argue that reinforcement interacts with internal cognitive processes, and its structured application can develop disciplined study habits that improve learning outcomes.

4.2 Variable Interval Schedule Reinforcement and Academic Achievement

The analysis also revealed a statistically significant effect of variable interval schedule reinforcement on students' mathematics performance ($t(99) = 14.76$, $p < .05$). This finding supports Dewar's [25] view that unpredictable

reinforcement can sustain students' attention and intrinsic motivation, as learners remain engaged in anticipation of rewards. Fritscher [26] and Hurtado, Carter, and Spuler [27] further explain that such reinforcement schedules promote adaptability and resilience, enhancing learning processes and academic outcomes. While Lee, et al [28] notes that variable reinforcement may not yield immediate improvements, its sustained application fosters consistent motivation and learning behaviour. The present study confirms that variable interval reinforcement is an effective pedagogical tool in mathematics instruction, though its effectiveness may vary depending on individual learning styles and classroom contexts.

4.3 Fixed Ratio Schedule Reinforcement and Academic Achievement

The findings demonstrated that fixed ratio schedule reinforcement significantly affects students' achievement in mathematics ($t(99) = 14.33$, $p < .05$). This is consistent with Maisarah, [29] who observed that reinforcement strategies can strengthen intrinsic motivation and support sustained academic improvement. Although raw mean scores suggested a limited direct influence, the statistical evidence indicates that fixed ratio reinforcement fosters persistence and improved performance. Brunstein, and Heckhausen, [30] asserts that reinforcement enhances achievement motivation, while Fritscher [31] emphasize its role in promoting task persistence and focus, skills crucial for mastering complex problem-solving in mathematics. However, Dewar [32] again warns that reinforcement must be carefully balanced to avoid undermining intrinsic motivation.

4.4 Variable Ratio Schedule Reinforcement and Academic Achievement

Finally, the study found that variable ratio schedule reinforcement significantly influences students' mathematics achievement ($t(99) = 14.48$, $p < .05$). This result is in line with Brunstein, and Heckhausen, [33] who highlight reinforcement as a key determinant of motivation and learning performance. Dewar [34] notes that variable ratio reinforcement, in particular, sustains student engagement and can lead to long-term academic gains. While reinforcement is a critical factor, Ramesh, [35] point out that cognitive development and environmental conditions also shape learning outcomes. The findings here align with Gazzaniga and Heatherton's [36] and Zajda, [37] cognitive learning theory, suggesting that reinforcement not only shapes behaviour but also enhances cognitive engagement. These results underscore the effectiveness of variable ratio reinforcement in improving mathematics performance. However, the study suggests that reinforcement strategies should be integrated with other instructional and motivational approaches to optimize learning outcomes.

5. Summary of the Study

This study examined the influence of reinforcement schedules on students' academic achievement in mathematics among senior secondary school students in Aba North Local Government Area (LGA), Abia State. A descriptive survey design was employed, and a sample of 100 students was randomly selected from the study population. Data were collected using a researcher-developed instrument, the Reinforcement and Academic Achievement in Mathematics Questionnaire (RAAMQ), with a Cronbach's alpha reliability coefficient of 0.80. Mathematics scores were obtained from teachers' records and assumed to be derived from valid and reliable assessments.

Four research questions and corresponding null hypotheses guided the study. Descriptive statistics (mean and standard deviation) were used to address the research questions, while paired t-tests at the 0.05 significance level tested the hypotheses. The results revealed that fixed interval, variable interval, fixed ratio, and variable ratio schedule reinforcement each exert a statistically significant influence on students' academic achievement in mathematics.

6. Conclusion

Based on the findings, the study concludes that reinforcement, whether administered at fixed or variable intervals or ratios significantly enhances students' academic achievement in mathematics. The results underscore the importance of structured reinforcement strategies as effective pedagogical tools capable of improving motivation, engagement, and performance in mathematics.

6.1 Recommendations

- Teacher Professional Development: Teachers should receive continuous training on the application of reinforcement strategies in mathematics instruction. Such training should emphasize how reinforcement influences student learning and how teaching methods can be adapted to maximize its benefits.
- Student Engagement: Students should be encouraged to actively engage in discussions about reinforcement strategies and how these affect their learning. Involving students in this process may enhance their motivation, participation, and understanding, leading to improved achievement in mathematics.
- Curriculum and Policy Implications: Education policymakers should integrate reinforcement principles into curriculum design and teacher education programmes. Incorporating reinforcement techniques into mathematics curricula can promote more effective instruction. Additionally, sustained research on reinforcement and learning outcomes should be supported to inform evidence-based educational policy and practice

6.2 Suggestions for Further Research

In light of the findings of this study, the following areas are recommended for future research:

- Future studies could employ alternative research designs or methodologies to further examine the effects of reinforcement practices on students' academic achievement.
- Replicating this study in other states or regions would enhance the generalizability of the findings.
- Comparative studies could investigate the differential impact of reinforcement practices on students' academic achievement in public versus private secondary schools.
- Further research should explore the distinct effects of positive and negative reinforcement on academic achievement in various school settings.
- The perceived relevance of reinforcement in subjects beyond mathematics among junior secondary students in both public and private schools warrants further investigation.

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