



## Effects of Mastery Learning Strategy on Academic Performance and Retention in Threshold Concepts among Undergraduate Students in Kaduna State University, Kaduna, Nigeria

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### Abstract

*The study examined the effect of the Mastery Learning Strategy (MLS) on academic performance and retention of threshold concepts in Chemistry among 200-level students at Kaduna State University. Recognizing the critical role of Chemistry in scientific and technological advancement, mastering its foundational concepts is essential for students' academic success. Despite this, persistent challenges such as low academic performance and poor retention of threshold Chemistry concepts have been observed, highlighting the need for more effective instructional strategies. A quasi-experimental design was employed to investigate the problem. Three research questions and three null hypotheses guided the study. The population consisted of 190 200-level Chemistry students at Kaduna State University, and a simple random sampling technique was used to assign students to the experimental and control groups. The sample included all 190 students. Data were collected using the Threshold Concept Performance Test (TCPT), which had a reliability coefficient of 0.79. Analysis of the results indicated that students taught using the MLS achieved significantly higher post-test scores and demonstrated better retention of Chemistry concepts compared to students taught using conventional methods. Additionally, the study found that gender had no significant effect on students' academic performance after exposure to MLS. Based on these findings, it was recommended that students be trained in MLS to enhance their academic performance in Chemistry.*

**Key words:** Mastery Learning, Academic Performance, Retention.

### Introduction

Science is fundamentally an evidence-based discipline aimed at answering questions and solving problems. Given that many problems can have multiple solutions, students are encouraged to engage in critical thinking, observation, data collection, and inference-making to develop logical conclusion (Hassan, 2021). Through these processes, they acquire knowledge, conceptual understanding, and essential scientific skills that enhance their grasp of principles, models, and theories. As scientific knowledge continues to expand and technological advancements reshape every aspect of life, the role of science and technology in societal progress has become more pronounced (Hassan, 2021). This ever-growing interconnection highlights the necessity of a strong scientific foundation, as emphasized by Isa (2022), who describes science and technology as inseparable twins. The ability to analyze evidence, generate solutions, and apply scientific principles remains crucial in navigating the complexities of the modern world, further reinforcing the need for robust science education. The British Science Council (2021) defines science as the pursuit and application of knowledge about the natural and social world, guided by a systematic methodology based on evidence. Similarly, Zakaryyas and Bello, (2018) and Agar (2020) defines technology as the process of developing and applying techniques to convert resources into useful material objects. Among the sciences, chemistry stands out as a fundamental pillar of scientific and technological advancement (Hassan, 2021). As the central science, it serves as a unifying force among other scientific disciplines and plays a crucial role in both daily life and industrial applications. Its significance is undeniable chemistry permeates nearly every aspect of human activity and is often regarded as the cornerstone of modern science (Isa, 2023). However, despite its vital role in fostering innovation and improving quality of life, the academic performance of Nigerian secondary school students in chemistry has remained a persistent concern for many years (Muhammad, 2017; Isa, 2018; Isa & Usman, 2021). This highlights the urgent need for the implementation of effective instructional strategies to enhance students' understanding and mastery of key chemistry concepts. Traditional teaching methods, such as lectures and recitations, have been found to be relatively ineffective in achieving this goal (Wood & Gentile in Hassan, 2021). These approaches often



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promote passive rather than active learning, restricting students' ability to develop reflective thinking, critical thinking, creativity, and problem-solving skills. Recognizing the abstract nature of certain chemistry concepts, it is crucial to adopt instructional strategies that actively engage students and sustain their interest in the subject. To improve learning outcomes, chemistry instruction must be dynamic and flexible, integrating multiple strategies that foster meaningful and productive learning experiences (Muhammad and Isa 2019). One promising instructional strategy is the Mastery Learning Approach (MLA), which focuses on ensuring that all students achieve a high level of understanding before progressing to the next concept. Bloom (1968) proposed that nearly all students can attain mastery if provided with the right instructional support and opportunities for reinforcement. MLA structures learning into well-defined units, each with specific objectives, allowing for a more individualized and effective learning experience. By managing student learning within a group-based classroom setting, MLA increases the likelihood of achieving academic success and enhances overall student performance. This approach is particularly relevant for improving students' comprehension and retention of chemistry concepts, making it a valuable tool for educators seeking to enhance learning outcomes. Given that some chemistry concepts serve as threshold concepts which are challenging yet transformative ideas that open new ways of thinking. Threshold concepts are essential ideas within a discipline that, although often difficult or 'troublesome' to grasp at first, lead to a profound and transformative understanding once mastered. They act as conceptual gateways that open up new ways of thinking and understanding, enabling students to progress in their subject knowledge (Meyer & Land, in Hassan, 2018). These concepts are transformative, integrative, and irreversible changing students' perceptions, revealing interconnections, and being unlikely to be forgotten. However, the transition through these conceptual thresholds can be challenging and may involve significant cognitive restructuring. Understanding threshold concepts not only helps educators identify key learning targets but also highlights past misconceptions that may hinder students' progress. Therefore, recognizing and effectively teaching these pivotal concepts is vital for fostering deep and lasting learning (Davies & Mangan- Hassan, 2021). Certain fundamental chemistry concepts, such as atomic structure, the mole, enthalpy, chemical equations, and electrolysis, are particularly challenging for students to grasp (Agogo, 2013 & Andy, 2015). These concepts, identified as threshold concepts, require deep understanding to unlock further learning in the subject. To enhance students' performances and retention of these concepts, innovative instructional strategies like Mastery Learning can be employed. Mastery of these key concepts enables students to recognize connections that were previously unclear. Therefore, this study investigates the efficacy of Mastery Learning Strategy (MLS) on academic performance and retention in threshold concepts in Chemistry among 200-level students at Kaduna State University, Kaduna, Nigeria.

### **Statement of The Research Problem**

Chemistry education research continues to explore more effective teaching strategies to enhance meaningful learning and address the persistent challenges of low conceptual performance among students (Isa and Muhammad 2019). Many fundamental concepts in Chemistry are highly abstract, making it difficult for students to grasp and retain essential knowledge. Consequently, there is a need for instructional approaches that systematically break down these complex concepts, ensuring mastery and improving students' academic performance in threshold concepts. Reports from the West African Examinations Council (WAEC) between 2017 and 2024 consistently highlight Chemistry as one of the poorest-performing subjects, with examiners attributing students' failures to ineffective teaching methodologies, limited student engagement, and a lack of commitment from teachers (WAEC, Chief examiners' Report 2024). This poor performance extends to tertiary institutions where students find it difficult to pass courses involving such as atomic structure, the mole, enthalpy, chemical equations, and electrolysis, are particularly challenging for students to grasp (Andy, 2015; Isa, 2023). These concepts, identified as threshold concepts, require deep understanding to unlock further learning in Chemistry. Several studies in Nigeria (Muhammed, 2021, Isa and Usman 2021 and Usman and Isa, 2025) have observed that Chemistry teachers often rush through the curriculum to cover all topics within a limited timeframe. This approach neglects essential pedagogical elements such as differentiated instruction, formative assessment, feedback, and corrective procedures, which are critical for mastery learning (Bloom, 1971). Moreover, research by Isa (2018) and Hassan (2021) has shown that students' poor performance in Chemistry is largely due to the inappropriate use of teaching strategies, with an over-reliance on lecture-based instruction. Additionally, the issue retention further compounds the problem, as students are rarely taken through structured learning processes that reinforce improved retention of the threshold concepts through continuous assessment and feedback mechanisms at tertiary institutions. In view of these challenges, this study investigates the effectiveness of Mastery Learning Strategy (MLS) in enhancing academic performance and retention of threshold concepts



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in Chemistry among 200-level students at Kaduna State University, Kaduna, Nigeria. While previous research has primarily explored general instructional methods in Chemistry, this study focuses on the unique role of MLS in addressing threshold concepts which are fundamental yet complex topics that often hinder students' academic performance in Chemistry. Through the use of MLS as a structured, student-centered instructional approach, this research aims to provide empirical evidence on its potential to foster deeper conceptual understanding/ improved performance and long-term retention among threshold concepts in Chemistry at tertiary-level, particularly Kaduna State University, Kaduna, Nigeria.

### Objective of the Study

The objectives of the study are set to:

1. Examine the effects of Mastery Learning Strategy on the performance mean score of students taught threshold concepts in chemistry among 200- level Chemistry students in KASU
2. Determine the retention ability of students taught threshold concepts in chemistry using the Mastery Learning Strategy among 200 level students in KASU
3. Investigate the difference in the performance mean scores of male and female students taught using Mastery Learning Strategy among 200-level Chemistry students in KASU

### Research Questions

1. What is the mean performance scores of 200-level Chemistry students taught threshold concepts using Mastery Learning Strategy and those taught using Conventional method in KASU?
2. What is the mean retention scores of 200-level Chemistry students taught threshold concepts using Mastery Learning Strategy and those taught using Conventional method in KASU?
3. Is there any difference in the mean performance scores of male and female 200-level Chemistry students taught threshold concepts using the Mastery Learning Strategy in (KASU)?

### Null Hypotheses

- H<sub>01</sub>: There is no significant difference in the mean performance scores of 200-level Chemistry students taught threshold concepts in using the Mastery Learning Strategy and those taught using the conventional method at KASU.
- H<sub>02</sub>: There is no significant difference in the retention ability of 200-level students taught threshold concepts in Chemistry using the Mastery Learning Strategy and those taught using the conventional method at KASU.
- H<sub>03</sub>: There is no significant difference in the mean performance scores of male and female 200-level students taught threshold concepts in Chemistry using the Mastery Learning Strategy at KASU.

### Research Methodology

#### Research Design

The study adopted a quasi-experimental research design involving two groups: an experimental group and a control group. The experimental group was taught using the Mastery Learning Strategy (MLS) for a period of six (6) weeks, while the control group received instruction on the same concepts through the conventional lecture method. At the end of the six-week treatment period, a post-test was administered to assess the effectiveness of the treatment in improving students' knowledge of Chemistry. In addition, a post-post test was conducted to determine the retention ability of students who were taught the threshold concepts in Chemistry.

#### Population of the Study

The population for this study consisted of all 200-level Chemistry Education students and B.Sc. (Hons) Chemistry students offering CHM202 (Physical Chemistry I) at Kaduna State University. The selection of 200-level students as the target population was based on the fact that they enroll in CHM202, a course that contains several threshold concepts in Chemistry. Therefore, fostering a positive academic orientation toward Chemistry at this stage of study is considered important. In total, the population comprised 190 students drawn from the two programmes, including 118 females and 72 males. The detailed distribution of the population is presented in the table below;

Table 1 Population of the Study

S/No.	Program	Number of Enrollment		
		Male	Female	Total
1	BSc.Ed Chemistry	27	48	75
2	BSc. Hons. Chemistry	45	70	115



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Total	72	118	190
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**Source:** Data from the Field, (2026)

### Sample and Sampling Techniques

Two departments offer the CHM 202 course. These include B.Sc. Ed. Chemistry in the Department of Science Education and B.Sc. (Hons) Chemistry in the Department of Pure and Applied Chemistry. For the purpose of this study, the B.Sc. Ed. Chemistry group was randomly assigned as the experimental group, while the B.Sc. (Hons) Chemistry group served as the control group. Intact classes from both departments were used for the study. The distribution of the sample is presented in the table below.

**Table 2. Sample for the Study**

S/No.	Program	Number of Enrollment		
		Male	Female	Total
1	BSc.Ed Chemistry	27	48	75
2	BSc. Hons. Chemistry	45	70	115
	Total	72	118	190

**Source:** Data from the Field, (2026)

### Instrumentation

One validated instrument titled Threshold Concept Performance Test (TCPT) was used for data collection in the study. The TCPT yielded a reliability coefficient of 0.79 when tested using Cronbach's Alpha statistics.

### Presentation of Results

The research hypotheses were tested using Analysis of Covariance (ANCOVA) and t-test statistics at a 0.05 level of significance ( $P \leq 0.05$ ). All statistical analyses were carried out using the Statistical Package for Social Sciences (SPSS), version 21.

**H<sub>01</sub>:** There is no significant difference in the mean performance scores of 200-level Chemistry students taught threshold concepts in using the Mastery Learning Strategy and those taught using the conventional method at KASU

The data were analyzed using Analysis of Covariance (ANCOVA) as the statistical technique. The results of this hypothesis are presented in Table 3.

**Table 3. ANCOVA Test of the Difference in Post-Threshold Concept Performance Test Scores between Students Exposed to Mastery Learning Strategy (MLS) and those taught using the Conventional Method**

Source of Variation	Type III Sum of Squares	Df	Mean Square	F	Sig.	Remark
Covariate (pretest)	.019	1	.019	.002	.969	*NS
Intercept	6964.998	1	6964.998	544.866	6964.998	*S
Group (Treatment)	10232.552	1	10232.552	800.485	.000	*S
Corrected Model	10327.042 <sup>a</sup>	2	5163.521	403.938	.000	*S
Residual (Error)	2390.411	187	12.783			
Total	100416.000	190				
<b>Corrected Total</b>	<b>12717.453</b>	<b>189</b>				

Where \*S = Significant at  $P \leq 0.05$ , \*NS= Not significant

The result presented in Table 3 shows that the Mastery Learning Strategy (MLS) had a significant effect on the post-test scores of the Threshold Concept Performance Test (TCPT) after controlling for the influence of confounding variables,  $F(1,187) = 800.485$ ,  $P = 0.000 < 0.05$  level of significance. This indicates that there is a significant difference in the post-test Chemistry performance of students who were exposed to MLS and those taught using the conventional method. The finding suggests that students taught with MLS achieved higher performance than those taught through the traditional lecture approach. Therefore, the null hypothesis which states that "there is no significant difference in the mean performance scores of 200-level Chemistry students taught threshold concepts using the Mastery Learning Strategy and those taught using the conventional method at KASU" is rejected.

**H<sub>02</sub>:** There is no significant difference in the retention ability of 200-level students taught threshold concepts in Chemistry using the Mastery Learning Strategy and those taught using the conventional method at KASU.



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A Student t-test was employed to test this hypothesis using the post–post test scores of students in both the experimental and control groups. The detailed results of the analysis are presented in Table 4.

**Table 4: t-test Analysis of post post test Scores of Students taught using MSL and those exposed to Conventional Method**

Retention	N	Mean	Std. Deviation	<i>t-cal.</i>	<i>Df</i>	<i>P value</i>	Remark
Experimental	75	30.61	4.287	-28.499	188	0.000	*S
Control	115	15.53	3.007				
<b>Total</b>	<b>190</b>						

\*Significant at  $P \leq 0.05$  level of significance

Table 4 presents the findings of the study, which show that the post–post test mean score of students in the experimental group was 30.61, while the control group recorded a mean score of 15.53. The P-value of 0.000 indicates that the difference in the retention ability of students in the experimental and control groups is statistically significant. This result favours the experimental group that was taught using the Mastery Learning Strategy (MLS). Therefore, the null hypothesis which states that “there is no significant difference in the retention ability of 200-level students taught threshold concepts in Chemistry using the Mastery Learning Strategy and those taught using the conventional method at KASU” is rejected.

**H<sub>03</sub>:** There is no significant difference in the mean performance scores of male and female 200-level students taught threshold concepts in Chemistry using the Mastery Learning Strategy at KASU

Student’s t-test was used to analyze the null hypothesis as shown in Table 5 below;

**Table 5: t-test Analysis of Mean Performance Scores of Male and Female Students taught using Mastery Learning Strategy**

Sex	N	Mean	Std. Deviation	<i>t-cal.</i>	<i>Df</i>	<i>P value</i>	Remark
Male	27	31.56	5.064	1.438	73	0.155	*NS
Female	48	30.08	3.735				
Total	75						

Significant at  $P \leq 0.05$ , \*NS= Not significant

The results presented in Table 5 indicate that the Mastery Learning Strategy (MLS) did not significantly influence the performance scores of male and female Chemistry students. This is evident from the t-calculated value of 1.438 and the p-value of 0.155, which is greater than the alpha level of 0.05. This shows that there is no statistically significant difference between the mean performance scores of male and female students taught using MLS. Therefore, the null hypothesis which states that “there is no significant difference in the mean performance scores of male and female 200-level students taught threshold concepts in Chemistry using the Mastery Learning Strategy at KASU” is retained.

## Discussion of Findings

The analysis of the results in Table 3 revealed that students exposed to the Mastery Learning Strategy (MLS) demonstrated improved academic performance compared to those taught using the conventional teaching method. This finding aligns with previous studies by Jack, (2019), Sani (2018) and Hassan (2021), which reported that students taught Chemistry threshold concepts through MLS performed better than their peers instructed via traditional methods. The effectiveness of MLS can be attributed to its structured instructional process. Initially, students received direct instruction on the topic, followed by group discussions to deepen understanding. Each student then completed a formative assessment, which was marked, and detailed positive feedback was provided. Students who mastered the topic proceeded to enrichment activities, while those who had not yet achieved mastery were given additional formative assessments until mastery was attained. Only then did the entire class move to the next topic. This combination of group discussions, timely feedback, and parallel/enrichment assessments facilitated meaningful learning and produced positive academic outcomes. Consequently, a significant difference in performance was observed, with students taught using MLS outperforming those taught through the conventional teaching method.



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The findings on the mean retention scores of students in the experimental and control groups for Chemistry lessons are presented in Table 4. The results indicate that students in the experimental group, who were taught using the Mastery Learning Strategy (MLS), achieved higher overall scores on the delayed retention test, demonstrating greater retention of Chemistry concepts compared to the control group taught through the conventional method. These findings align with the studies of Ishtiaq and Qaiser (2016), Sani (2018) and Jack (2019), which also reported that mastery learning positively influences students' retention. This suggests that the Mastery Learning Strategy enhances both learning and retention more effectively than the conventional approach, as it ensures that students fully master each learning unit before progressing to more advanced topics. The results presented in Table 5 indicate that there was no significant difference in the performance of male and female students taught threshold concepts using the Mastery Learning Strategy (MLS). This suggests that MLS does not differentiate the academic outcomes of male and female students. The observed gender equality can be attributed to the interactive nature of MLS, which allows both male and female students in the experimental groups to engage in topic discussions and complete individual assessments at the end of each unit. This approach enhances understanding, improves performance, and effectively bridges any performance gap between genders. In this study, male and female students were exposed to the same concepts, taught by the same instructor using the same method, demonstrating that MLS is gender-friendly. These findings are consistent with the studies of Sani (2018) and Jimoh (2021), who also reported no significant gender differences in academic performance among students exposed to MLS. However, the findings contrast with Udo and Udofia (2014), who reported that gender significantly influenced performance, with male students outperforming their female counterparts when MLS was applied.

## Conclusion

Based on the findings of this study, it can be concluded that the Mastery Learning Strategy (MLS) is an effective approach for teaching Chemistry Threshold concepts in Kaduna State University. Students taught using MLS demonstrated higher academic performance and better retention compared to those instructed through the conventional method. Furthermore, the strategy was equally beneficial for both male and female students, suggesting that gender had no significant influence on performance. In other words, gender differences do not exist when Chemistry threshold concepts are taught using the Mastery Learning Instructional Strategy in Kaduna State University.

## Recommendations

In the light of the findings, the following recommendations were made:

1. It is recommended that MLS be incorporated into the learning processes at the secondary, primary, and other tertiary levels. This method can help improve the students' performance because it provides them with long-term learning skills.
2. To make sure that their lessons are learner-centered, curriculum planners should establish MLS as a component of the school's curricula. This will help teachers develop a more effective and engaging teaching style. According to studies, students who are taught with a learner-centered approach are more likely to become active participants in the learning process. Instead of focusing on rote memorization and excessive teacher talk, lessons should be learner-centered. This will help prevent students from becoming disinterested in the lessons.

## Acknowledgement

This work was supported/funded by TETFund institutional Based Research (IBR: Batch 5) grants under the Directorate of Research and Development, Kaduna State University, Kaduna, Nigeria.

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