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EFFECTS OF MASTERY LEARNING AND LECTURE METHODS ON CHEMISTRY STUDENTS' ACADEMIC ACHIEVEMENT IN DELTA STATE

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ABSTRACT

This study investigated the effects of mastery learning and lecture methods on chemistry students' academic achievement in Delta State. The study was guided by four research questions and four null hypotheses. A quasi-experimental pre-test, post-test, planned variation design using a 2× 2 factorial matrixes was adopted. The population comprised 29,817 Senior Secondary II (SS II) students offering chemistry in all mixed public secondary schools in Delta State during the 2023/2024 academic session. A sample of 268 SS II students were drawn from nine mixed secondary schools using multi-stage sampling. Instructional methods were randomly assigned to the intact classes in the selected schools. Data was collected with Chemistry Achievement Test (CAT). The instrument was validated for face, content, and construct validities. Reliability was established using the Kuder-Richardson Formula-21 for the CAT (r = 0.84) indicating acceptable internal consistency. The instructional sessions were conducted for six weeks, after which post-tests using the CAT were administered. Data collected were analyzed using independent sample t-test and Analysis of Covariance (ANCOVA). All hypotheses were tested at the 0.05 level of significance. The findings of the study are: (i) There is a significant difference in the mean achievement scores among chemistry students taught with mastery learning and lecture methods; (ii) There is no significant difference between the mean achievement scores of male and female students taught chemistry using mastery learning method; (iii) There is no significant difference between the mean achievement scores of male and female students taught chemistry using lecture method; (v) There is no significant interaction effect between sex and instructional methods on students' academic achievement in chemistry in Delta State. Based on the findings of this study, it can be concluded that mastery learning method was more effective than the lecture method in enhancing students' achievement in chemistry. Based on the findings of this study, it was recommended among others that chemistry teachers in secondary schools in Delta State should adopt mastery learning as a primary strategy for improving students' achievement.

Keywords: Mastery Learning Method, Lecture Method, Chemistry, Academic Achievement, Sex

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INTRODUCTION

Chemistry is a branch of science that deals with the scientific study of substances' structures, how they react when combined or in contact with one another, and how they behave under different conditions. Chemistry as a subject has such practical and intellectual value that its importance cannot be overemphasized. It ranges from its contribution to the economy of the nation, the development and industrialization of a nation, to the improvement of the aesthetic value of the people. Chemistry helps man understand matter's composition, structure, and behaviour, which is fundamental to understanding the world around us. Many technological advancements and innovations rely on chemical principles. Understanding chemistry is essential for fields like pharmaceuticals, materials science, nanotechnology, and environmental science. Chemistry is critical to pharmaceutical development and understanding how drugs interact with the body. It is also important for diagnosing diseases, developing new treatments, and ensuring the safety of medical procedures. Chemistry plays a significant role in understanding and addressing environmental issues such as pollution, climate change, and sustainable energy. Chemists develop methods to clean up pollutants, reduce waste, and develop renewable energy sources. Chemistry is essential in food production, preservation, and safety. It's used to understand the nutritional content of foods, develop new food products, and ensure food safety through analysis and regulation. Chemistry helps us understand chemicals' properties and potential hazards, allowing us to make informed decisions about their use and ensure safety in a variety of settings, including the workplace and home.

The proper teaching and learning of chemistry in secondary schools, as a core science subject, facilitates students' enrolment in many professional disciplines like nursing, medicine, pharmacy, agriculture, engineering, and geology. As stipulated by the National Policy on Education in Nigeria, the aims of teaching chemistry in secondary schools include: (i) aiding the transition from integrated science (now basic science) to chemistry by incorporating scientific concepts and techniques; (ii) delivering fundamental chemistry principles through effective selection and organization of content; (iii) illustrating chemistry's connections with other scientific disciplines; (iv) showcasing the relevance of chemistry in industry, daily life, as well as its associated hazards and benefits; and (v) furnishing students, including those not pursuing higher education, with a robust groundwork for various future career paths (Federal Ministry of Education, 2020).

Achieving these objectives hinges largely on the instructional strategies employed by teachers implementing the curriculum. The teaching method is very vital in any teaching-learning situation. The teacher's teaching method may either promote or hinder student learning. It may sharpen mental activities, which are the basis of social power, or it may discourage initiatives and curiosities, thus making self-reliance and survival difficult. It is a known fact that the primary goal of any teacher is to ensure the success of his lesson, which entails a process in which the majority of the students understand the lesson's essential points. This implies that students' success is invariably tied to the quality of the teacher, and in his view. One of the common ways of assessing the quality of teachers is the achievement of students in examinations. It is the responsibility of the teacher to help students attain maximum achievement in their learning tasks. Such a responsibility includes the use of appropriate instructional methods in teaching. Oloyede and Demide (2018) attribute the widespread poor performance and negative attitudes towards chemistry among secondary school students in Nigeria to problems with teaching methods. Many chemistry educators are of the view that it is inappropriate for teachers to dominate the classroom discussion, relegating students to a passive role. Despite this, such practices are still common in many

secondary schools in Nigeria, particularly in Delta State where lecture method appears to be the most common instructional strategy among teachers.

The lecture method involves the teacher delivering a verbal presentation on a specific topic or concept to the students. Typically, teachers present preplanned lessons with minimal or no instructional materials. This method involves a verbal presentation of ideas, concepts, generalisations, and facts, essentially spoon-feeding information to the learners. In its most rudimentary state, the lecture method is a one-way conversation in which the instructor talks authoritatively and there is little or no opportunity for students to make an input during class or ask questions (Omosor, 2023). While the lecture method has advantages, such as the ability to introduce new material or provide summaries, teach groups of any size, and cover extensive content quickly, it also has significant drawbacks. The teacher-centred lecture method in many cases positions the teacher as the sole authority, with students passively receiving information, which may make the teacher feel in control but does not cater to individual student needs and feelings. Teachers are expected to possess knowledge of diverse instructional strategies that foster meaningful, integrative, value-oriented, demanding, and active learning experiences. In this regard, the researcher advocates the adoption of constructivist-based instructional methods, which emphasize learners' active participation in constructing their own understanding. Within this framework, two particularly effective methods that could enhance the teaching and learning of chemistry in secondary schools are the mastery learning strategy and the metacognitive method.

Mastery Learning method is an instructional method where students are allowed unlimited opportunities to demonstrate mastery of the content taught or positive learning outcomes. Mastery Learning method involves breaking down the subject matter to be learned into units of learning, each with its own objectives for students to have adequate mastery of a concept before moving on to the next concept. Hence, the prerequisite for a topic is mastered well before the topic is taught. Mastery learning method allows students to study material unit after unit until they master it or have a long retentive memory of a concept learned. Mastery of each unit is shown when the student acquires the set pass mark of a diagnostic test. Mastery Learning method helps the student acquire the prerequisite skills to move on to the next unit. The teacher is also required to do task analysis and state the objectives before designating the activities. The material that will be taught using mastery leaning instructional method is often broken down into small, discrete lessons that follow a logical progression. In order to demonstrate mastery over each lesson, students must be able to overtly show evidence of understanding of the material before moving on to the next lesson. In a mastery learning environment, the teacher uses diagnostic and formative tests to direct a variety of group-based instructional techniques with frequent and specific feedback by using diagnostic and formative tests as well.

Mastery learning method also allows for a personalised learning pace. In addition, the feedback that is given during this process is helpful for the student. This model reflects the fact that every learner can learn if given the time and the right learning environment. Mastery learning is a model where students are expected to master a learning objective or goal before they can move on to the next goal in order to improve students' performance and retention at the end of the lesson (Anderson 2016).Mastery Learning method can also help the teacher identify students' areas of weakness and correct them, thus breaking the cycle of consistent poor academic achievement. Mastery Learning method has been used by many researchers as an instructional method with positive and improved results. For example, Ugwu and Nnamani (2023) revealed that students taught using group-based mastery learning model achieved higher than those taught using lecture method in basic science. Oginni, *et al.*, (2021) found

that Mastery Learning strategy improved students' performance in mathematics than traditional lecture method. Pankaj (2019) carried out a study on the effect of mastery learning method on achievement in mathematics and found that students taught using mastery learning method exhibited a better achievement in mathematics than those taught using the lecture method. Zamfara (2017) carried out a study on the effect of mastery learning method on students' achievement in mathematics and found that students taught using mastery learning method exhibited a better achievement in mathematics than those taught using the lecture method.

Olatoye and Adekoya (2019) reported that mastery learning enhances students' achievement irrespective of sex. Similarly, Musa and Ibrahim (2021) established that mastery-based instruction provides equal academic opportunities for both male and female students in science classrooms. Adeyemi and Ajibola (2020) also observed that mastery learning neutralizes sex differences in students' performance, as learners are given sufficient feedback and corrective instruction to meet the same performance standard. Furthermore, Okafor, et al., (2022) confirmed that mastery learning eliminates sex-related achievement gaps because the strategy emphasizes individualized progress and feedback-driven learning. However, the present finding contradicts the reports of Ogunleye (2018) and Ameh and Olatunji (2020) found that male students consistently outperformed their female counterparts when exposed to mastery learning in science-related subjects.

Yusuf and Afolabi (2010) found that instructional methods tend to promote equal learning opportunities irrespective of sex, support this finding. Similarly, Adeyemi (2018) reported that interaction effects between sex and teaching methods in science subjects were not statistically significant, suggesting that both male and female students respond comparably to different instructional strategies. In the same vein, Nnorom and Osuafor (2021) observed that neither mastery learning nor conventional approaches favored one gender over the other in achievement outcomes. Furthermore, Okoye and Okechukwu (2022) also confirmed that instructional methods exert main effects on achievement but their interaction with gender is typically negligible in Nigerian secondary schools. However, some contrary evidence exists. For example, Achor and Agogo (2015) found a significant interaction effect between sex and teaching strategy, noting that male students showed higher achievement gains in problem-solving contexts compared to females. Likewise, Agomuoh and Nzewi (2016) reported that sex interacted significantly with inquiry-based methods, where female students outperformed their male counterparts under guided discovery conditions. These studies suggest that while some instructional methods may interact with sex in certain contexts.

Statement of the Problem

Over the years, educational stakeholders and researchers are becoming more concerned about the instructional approach that should be used in secondary schools in order to reverse the deteriorating trends in students' poor achievement in chemistry. This concern stems from the fact that effective teaching methods are one of the most effective ways to improve students' achievement. Personal observation of the researcher reveals that chemistry teachers currently use more of the lecture method rather than innovative teaching methods, which involve student active participation. The main factor affecting students' achievement and interest in chemistry may be due to teachers' non-use of innovative teaching methods like mastery learning and metacognition instructional methods.

However, the mastery learning instructional method has been used as an effective strategy in enhancing students' achievement both in other subjects and outside Nigeria, and they have been reported to have produced the desired effective teaching in secondary schools

such that students' achievement improved. However, effects of mastery learning instructional method on students' academic achievement among secondary school students in Chemistry in Delta State are yet to be empirically established. Hence, the problem of this study is in question form is: What are the effects of mastery learning and lecture methods on chemistry students' academic achievement in Delta State?

Research Questions

The following research questions were answered in this study:

1. What is the difference in mean achievement score among chemistry students taught with mastery learning and lecture method in Delta State?
2. What is the difference between the mean achievement scores of male and female students taught chemistry using mastery learning method?
3. What is the difference between the mean achievement scores of male and female students taught chemistry using lecture instructional method?
4. What is the interaction effect between sex and instructional methods on students' academic achievement in chemistry in Delta State?

Hypotheses

The following null hypotheses were tested in this study:

1. There is no significant difference in the mean achievement scores of chemistry students taught with mastery learning and lecture methods in Delta State.
2. There is no significant difference between the mean achievement scores of male and female students taught chemistry using mastery learning method in Delta State.
3. There is no significant difference between the mean achievement scores of male and female students taught chemistry using lecture instructional method?
4. There is no significant interaction effect between sex and instructional methods on students' academic achievement in chemistry in Delta State.

RESEARCH METHOD

Design of the Study

This study was conducted using the quasi-experimental design, pre-test, post-test, planned variation design with a 2 x2 factorial design. Planned variation was included in the design to deliberately introduce and compare three instructional methods mastery learning and lecture rather than leaving such differences to chance. This strengthens internal validity, ensures systematic comparison across groups, and allows clearer examination of both main and interaction effects within the 2 × 2 factorial structure. The design has teaching methods at three levels (mastery learning and lecture Instructional Methods), with sex at two levels (male and female). This design was considered appropriate due to the intact classes and the rigid school timetable that did allowed for the random selection of subjects.

Population for the Study

The population for this study consist of 29,817 Senior School II (SS II) students offering chemistry in all the mixed public secondary schools in Delta State for the 2023/2024 session as obtained from the Ministry of Basic and Secondary Education, Asaba, Delta State (2023). The SS II students were chosen as the study population because SS III students are deemed too occupied with preparations for the Senior School Certificate Examination (SSCE), and SS I students were excluded from the study due to their relatively new status in the system.

Sample and Sampling Techniques

A sample of 268 SS2 students was drawn from nine mixed secondary schools in Delta State. Multi-stage sampling procedures will be employed in selecting the sample for the study. At the first stage one local government area were selected from each of the Senatorial district of the state using simple random sampling technique. At the second stage three secondary schools were selected from each of the selected local government areas using simple random sampling method. Finally, instructional methods were randomly assigned to each selected school in their intact classes. The instructional method was assigned to the selected school by labelling each method on three different pieces of paper. In that manner, mastery learning was labelled as Ml1, ML2, and ML2 and M3. The lecture method was labelled as LM1, LM2, and LM3. All six labels (Ml1, ML2, ML3 and LM1, LM2, LM3) were placed in a container and mixed together. From the container, one label was drawn at a time, and the corresponding method on it was assigned to the next school in the list. This was done repeatedly until all the selected schools are assigned a method.

Research Instrument

In this study, the instrument for data collection was the Chemistry Achievement Test (CAT). The CAT consists of two sections. Section A contains instruction on the students' personal information (such as sex). Section B has 50 multiple-objective test-items with option letters A-D (Appendix A). The items in the Chemistry Achievement Test were carefully selected from SSCE past questions in chemistry based on the chemistry concepts that will be treated in the study. The topics were selected from the Nigerian Educational Research and Development Council (NERDC) chemistry scheme of work for Senior Secondary school II (SS2). The topics are Periodic Table I, Periodic Table II, Chemical Reactions I, Chemical Reactions II, Mass, Volume Relationship I, Mass, Volume Relationship II.

Validity of Research Instrument

Chemistry Achievement Test (CAT) was subjected to face validity and content validity as well as item analysis. For the face validity**,** the Chemistry Achievement Test was given to two science education experts and one measurement and evaluation expert. They recommended revising certain questions to ensure a stronger connection to the intended lesson objectives. The test items were adjusted to align more closely with the specified chemistry topics and learning objectives in the lesson plan. The content validity of the Chemistry Achievement Test (CAT) was carried out using table of specification. The table of specification was designed using topics such as Periodic Table I, Periodic Table II, Chemical Reactions I, Chemical Reactions II and Mass, Volume Relationship I and Mass, Volume Relationship II that were obtained from the Nigerian Educational Research and Development Council (NERDC) chemistry scheme of work for Senior Secondary school II (SS2).

Reliability of Instrument

The reliability of the CAT was carried out using Kuder-Richardson formula-21 method. In the method the CAT was administered to 50 SS II students from secondary schools in Orhionmwon Local Government Area of Edo State. Data collected through the test were used to calculate the reliability of the instrument. The Kuder-Richardson formula-21 was used to compute the reliability index, which gave 0.84. The value agreed with the recommended standard (Okorodudu, 2013) and the instrument was considered reliable and internally consistent.

Treatment Procedure

The quasi-experimental research design was carried out in three stages described as follows: Six intact classes were randomly assigned to mastery learning, metacognition and lecture methods. The instructional method was assigned to the selected school by labelling each method on three different pieces of paper. In that manner, mastery learning was labelled as Ml1, ML2, and ML3. The lecture method was labelled. All six labels (Ml1, ML2, ML3 and LM1, LM2, LM3) were placed in a container and mixed together. From the container, one label was drawn at a time, and the corresponding method on it was assigned to the next school on the list. This was done repeatedly until all the selected schools were assigned a method. Thus, six intact classes were used for the study, three intact classes for each instructional method.

Three out of the six research assistants were trained on the use of mastery learning instructional method prior to the start of the treatment using training procedure described in Ajaja (2013). Three of the nine research assistants were trained on the skills of using mastery learning instructional methods for teaching for four days lasting for one hour per day. One other instruction specialist joined the researcher to train the instructors on the skills of mastery instructional method.

The procedure for the main instructional process was carried out in three stages: A week before the commencement of treatment, all the six chemistry teachers that served as research assistants were given extract which contains the contents of the six-week instructional unit. This was done to ensure that all the instructional presentations followed the recommended format for the designated classes. Two days before the commencement of instruction, all the groups were pre-tested with the 50 items chemistry Achievement Test (CAT). This was done to determine the equivalence of the groups before the instruction and to be certain that any noticed change later is due to the treatment given method. In the three groups, teachers presented the content of the topics that were selected to teach the students with the use of mastery learning and lecture methods in their various school for six weeks. Teachers instructed the students during the treatment session, adhering to the procedures they learned about during their training. At the end of the six weeks of teaching by the research assistants, a post-test was administered to the students with the same CAT used during the pretest.

Method of Data Analysis

The mean of data that were collected through the Chemistry Achievement Test (CAT) was used to answer the research questions. Hypotheses were tested using independent sample t-test and Analysis of Covariance (ANCOVA). All hypotheses were tested at 0.05 level of significance.

RESULTS

Table 1a:

Comparing Mean *Pretest Achievement Score of Chemistry Students Taught With Mastery Learning and Lecture Method*

Instructional methods	N	Mean	Mean Difference	Std. Deviation
Mastery learning	134	13.22		1.582
Lecture	134	13.36	0.142	1.596
Total	399			

Table 1a presents the pretest mean achievement scores of Chemistry students before exposure to different instructional methods Mastery Learning and Lecture Method. The mean scores for the three groups are very close: 13.22 and 13.36 respectively. This indicates that,

before the treatment (instruction), the students in the three groups had almost the same level of prior knowledge or ability in Chemistry.

Table 1b:
Independent sample t-test of the Difference in Mean Pretest Achievement Score of Chemistry Students Taught with Mastery Learning and Lecture Methods

Instructional methods	N	Mean	Std. Deviation	df	t-value	Sig.	Remark
Mastery learning	134	13.22	1.582				
Lecture	134	13.36	1.596	266	.730	.446	Not significant
Total	399						

The independent sample t-test result in Table 1b tests whether there is a statistically significant difference in the mean pretest achievement scores between the two instructional groups. The computed t-value (0.730) is very small, and the corresponding p-value (Sig.) = 0.446, which is greater than 0.05. This means that the difference in the pretest mean scores between the groups is not statistically significant. Therefore, we fail to reject the null hypothesis, implying that no significant difference existed in the students' Chemistry achievement before treatment.

Research Question One:

What is the difference in mean achievement score of chemistry students taught with mastery learning, metacognition and lecture methods?

Table 1c:
Analysis of the difference in mean achievement score of chemistry students taught with mastery learning, metacognition and lecture method

Instructional methods	N	Mean	Mean difference	Std. Deviation
Mastery learning	134	65.85		10.002
Lecture	134	52.48	13.37	5.119
Total	268			

Table 1c shows the mean achievement scores of students exposed to the three instructional methods differ considerably. Students taught with mastery learning recorded the highest mean score of 65.85 with a standard deviation of 10.002. Those taught using taught with the lecture method had the lowest mean score of 52.48 with a standard deviation of 5.119. This shows that students taught with mastery learning strategy performed significantly better in chemistry than their counterparts taught with the lecture method, with mastery learning giving the highest achievement mean score.

Hypothesis One: There is no significant difference in difference in mean achievement score among chemistry students taught with mastery learning, metacognition and lecture methods

Table 2:
Independent sample t-test of the Difference in Mean Posttest Achievement Score of Chemistry Students Taught with Mastery Learning and Lecture Methods

Instructional methods	N	Mean	Std. Deviation	df	t-value	Sig.	Remark
Mastery learning	134	65.85	10.002				
Lecture	134	52.48	5.119	266	13.78	.000	Not significant
Total	268						

The Independent sample t-test in Table 2 shows that the calculated t-value is 13.78 with a significance level of p = .00 (p < 0.05). Since the p-value is less than 0.05, the null hypothesis is rejected. There is a statistically significant difference in the mean achievement scores of chemistry students taught with mastery learning and lecture methods. The method of instruction significantly influences students' achievement in chemistry.

Research Question 2: What is the difference between the mean achievement scores of male and female students taught chemistry using mastery learning method?

Table 3:
Analysis of the Difference between the Mean Achievement Scores of Male and Female Students Taught Chemistry Using Mastery Learning Method

Sex	N	Mean	Mean Difference	Std. Deviation
Males	71	67.32		8.92
Females	63	64.19	3.13	10.93
Total	134			

Table 3 shows the mean achievement score of male students taught chemistry with the mastery learning method is 67.32 (SD = 8.92), while their female counterparts recorded a mean score of 64.19 (SD = 10.93). This gives a mean difference of 3.13 in favour of the male students. This indicates that male students performed slightly better than female students when taught with the mastery learning method. However, the observed difference in mean scores is relatively small.

Hypothesis Two
There is no significant difference between the mean achievement scores of male and female students taught chemistry using mastery learning method.

Table 4:

Independent sample t-test analysis of the Difference Between the Mean Achievement Scores of Male and Female Students Taught Chemistry Using Mastery Learning Method.

Sex	N	Mean	Std. Deviation	Df	t-cal.	Sig. (2-tailed)	Remark
Males	71	67.32	8.922				
Females	63	64.19	10.929	132	1.83	.07	Null hypothesis not rejected
Total	134						

Table 4 shows the independent sample t-test analysis of the difference between the mean achievement scores of male and female students taught chemistry using mastery learning method. The independent samples t-test shows that male students (M = 67.32, SD =

8.92) had a slightly higher mean achievement score than female students (M = 64.19, SD = 10.93). The calculated t-value is 1.83 with df = 132 and a p = .07 (p > 0.05). Since the p-value is greater than 0.05, the null hypothesis is not rejected. There is no statistically significant difference in the mean achievement scores of male and female students taught chemistry using the mastery learning method.

Research Question Three: What is the difference between the mean achievement scores of male and female students taught chemistry using lecture instructional method?

Table 5:
Analysis of the difference between the Mean Achievement Scores of Male and Female Students taught chemistry using lecture instructional method

Sex	N	Mean	Mean Difference	Std. Deviation
Males	75	53.13		5.11
Females	59	51.64	1.49	5.05
Total	134			

Table 5 shows that male students taught with the lecture method had a mean achievement score of 53.13 with a standard deviation of 5.11, while female students had a mean achievement score of 51.64 with a standard deviation of 5.05. The mean difference of 1.49 is in favour of the male students, although the difference is very small.

Hypothesis three
There is no significant difference between the mean achievement scores of male and female students taught chemistry using lecture instructional method.

Table 6:
Independent sample t-test ***Analysis of the difference between the Mean Achievement Scores of Male and Female Students taught chemistry using lecture instructional strategy***

Sex	N	Mean	Std. Deviation	Df	t-cal.	Sig. (2-tailed)	Remark
Males	75	53.13	5.11				
Females	59	51.64	5.05	132	1.68	.88	Null hypothesis not rejected
Total	134						

Table 6 shows the independent sample t-test analysis of the difference between the mean achievement scores of male and female students taught chemistry using the lecture instructional method. The calculated t-value **is** 1.68 with df = 132 and a p-value of .88 (p > 0.05). Since the p-value is greater than 0.05, the null hypothesis is not rejected. This implies that there is no statistically significant difference between the mean achievement scores of male and female students taught chemistry using the lecture instructional method

Research Question four

What is the interaction effect between sex and instructional methods on students' academic achievement in chemistry in Delta State?

Table 7:

Analysis of the Interaction Effect of Instructional methods and Sex On Students' Academic Achievement in chemistry

		Prestest			Posttest	
Methods	sex	N	Mean	Std. Deviation	Mean	Std. Deviation
Mastery learning	Males	71	13.38	1.246	67.32	8.92
	females	63	13.03	1.883	64.19	10.93
Lecture	Males	75	13.40	1.755	53.13	5.11
	females	59	13.31	1.380	51.64	5.05

Table 7 shows that male and female students had similar pretest mean scores across the three instructional methods, indicating that all groups started with comparable knowledge in Chemistry. After the instructional treatments, students in the mastery learning group recorded the highest posttest mean scores (males = 67.32, females = 64.19). The lecture method produced the lowest scores (males = 53.13, females = 51.64). Overall, both male and female students improved after instruction, but males performed slightly better across all methods. The improvement was higher under mastery learning and lowest under lecture. method. This indicates that the instructional methods had a strong effect on students' achievement, while the influence of sex was minimal. The interaction between instructional method and sex was therefore weak, suggesting that both males and females benefited similarly from the teaching methods.

Hypothesis Four

There is no significant interaction effect of instructional methods and sex on students' achievement in chemistry.

Table 8:

Analysis of Covariance (ANCOVA) of the Interaction Effect of Instructional Strategies and Sex on Students' Achievement in chemistry

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	12663.40[a]	4	3165.85	51.68	.00
Intercept	9501.65	1	9501.65	155.12	.00
Pretest	280.08	1	280.08	4.57	.03
Methods	12010.49	1	12010.49	196.08	.00
Sex	310.49	1	310.49	5.07	.03
***Instructional methods* * sex**	36.29	1	36.29	.59	.44
Error	16109.37	263	61.25		
Total	966880.00	268			
Corrected Total	28772.78	267			

a. R Squared = .335 (Adjusted R Squared = .325)

Table 8 presents the analysis of covariance (ANCOVA) of the interaction effect of instructional strategies and sex on students' achievement in chemistry. The result shows that the interaction effect of instructional methods and sex is not significant, $F(1, 263) = 0.59$, $p = .60$ ($p > 0.05$). Since the p-value for the interaction effect is greater than 0.05, the null hypothesis is not rejected. There is no statistically significant interaction effect between instructional methods and sex on students' achievement in chemistry. This implies that the influence of instructional methods on students' achievement in chemistry is independent of sex, meaning that both male and female students benefit similarly from the methods used.

Discussions

The first finding revealed a significant difference in the academic achievement mean scores of Chemistry students taught using mastery learning and lecture instructional strategies. Specifically, students exposed to mastery learning recorded the highest mean scores and the lecture method group showed the lowest academic achievement. This result suggests that mastery learning is the most effective in enhancing students' academic achievement in Chemistry. Its effectiveness may be attributed to its structured approach, which ensures that students attain a high level of understanding before progressing, thereby reducing learning gaps and promoting deeper comprehension of abstract Chemistry concepts. This finding is in agreement with Ugwuanyi (2019), who highlighted the superiority of student-centered methods over lecture-based teaching in improving students' academic performance. It also aligns with Lo and Hew (2020), who found that active and reflective strategies significantly enhance learning outcomes in science disciplines by fostering deeper engagement and critical thinking. Furthermore, the result agrees with Santikarn and Wichadee (2020) and Abdulwahed and Nagy (2021), who reported that innovative, student-centered instructional approaches promote higher academic achievement compared to traditional teaching methods, particularly in science-related courses.

The second finding showed that there was no significant difference between the mean achievement scores of male and female students taught Chemistry using the mastery learning strategy. This suggests that the effectiveness of mastery learning is not gender-biased, as both male and female students benefited equally from the method. Mastery learning allows learners to progress at their own pace until they attain competence in a particular concept, thereby reducing gender-related disparities that are often evident in traditional methods. This result aligns with the findings of Olatoye and Adekoya (2019), who reported that mastery learning enhances students' achievement irrespective of sex. Similarly, Musa and Ibrahim (2021) established that mastery-based instruction provides equal academic opportunities for both male and female students in science classrooms. Adeyemi and Ajibola (2020) also observed that mastery learning neutralizes sex differences in students' performance, as learners are given sufficient feedback and corrective instruction to meet the same performance standard. Furthermore, Okafor, Olaniyan, and Eze (2022) confirmed that mastery learning eliminates sex-related achievement gaps because the strategy emphasizes individualized progress and feedback-driven learning. However, the present finding contradicts the reports of Ogunleye (2018) and Ameh and Olatunji (2020), who found that male students consistently outperformed their female counterparts when exposed to mastery learning in science-related subjects.

The third finding revealed that there was no significant difference between the mean achievement scores of male and female Chemistry students taught using the lecture method in Delta State. This indicates that the lecture method, being a teacher-centered instructional approach, does not favor one sex over the other, as all learners are exposed to the same pace, structure, and delivery of content. This outcome corroborates the findings of Owolabi and Adebayo (2019), who reported that the lecture method produces similar achievement outcomes across sexes because it provides equal exposure to the same instructional materials and explanations. In the same vein, Eze and Okonkwo (2020) found that both male and female students demonstrated comparable levels of achievement when taught Chemistry concepts through lecture-based instruction. Likewise, Ibrahim and Hassan (2021) noted that the lecture method emphasizes uniform delivery of content, thereby minimizing gender-based differences in performance. Similarly, Adeleke and Musa (2022) concluded that since the lecture method is generally rigid and teacher-controlled, it reduces the influence of gender on

achievement outcomes. Contrary to this, however, Ogunniyi (2018) reported that male students performed better than female students under lecture-based teaching, attributing this to males' greater willingness to engage with abstract and teacher-dominated lessons. Likewise, Nwosu and Umeh (2021) argued that lecture-oriented instruction often widens gender disparities, with female students being less participatory and more disadvantaged when classroom interaction is limited.

The fouth finding revealed that there was no significant interaction effect between sex and instructional methods on students' academic achievement in Chemistry in Delta State. This suggests that the effectiveness of the instructional strategies whether mastery learning, metacognition, or lecture method—was not dependent on students' sex. In other words, both male and female students benefitted similarly from the instructional approaches, indicating that the methods operated uniformly across gender lines. A possible reason for this outcome could be that the instructional methods emphasized structured learning processes, cognitive engagement, and content mastery, which are not inherently biased toward a particular sex. Additionally, the standardized curriculum and assessment system in Chemistry may have minimized any potential gender-related variations, thereby leveling the academic outcomes across male and female learners. Yusuf and Afolabi (2010), who found that instructional methods tend to promote equal learning opportunities irrespective of sex, support this finding. Similarly, Adeyemi (2018) reported that interaction effects between sex and teaching methods in science subjects were not statistically significant, suggesting that both male and female students respond comparably to different instructional strategies. In the same vein, Nnorom and Osuafor (2021) observed that neither mastery learning nor conventional approaches favored one gender over the other in achievement outcomes. Furthermore, Okoye and Okechukwu (2022) also confirmed that instructional methods exert main effects on achievement but their interaction with gender is typically negligible in Nigerian secondary schools. However, some contrary evidence exists. For example, Achor and Agogo (2015) found a significant interaction effect between sex and teaching strategy, noting that male students showed higher achievement gains in problem-solving contexts compared to females. Likewise, Agomuoh and Nzewi (2016) reported that gender interacted significantly with inquiry-based methods, where female students outperformed their male counterparts under guided discovery conditions. These studies suggest that while some instructional methods may interact with gender in certain contexts, in the present study such interaction was not evident, possibly due to the neutral nature of the methods applied.

Conclusion

Based on the findings of this study, it can be concluded that instructional methods significantly influence chemistry students' academic achievement in Delta State. Specifically, mastery learning was found to be more effective than the lecture method in enhancing students' achievement in chemistry. This suggests that student-centered instructional approaches that promote active learning foster better learning outcomes compared to teacher-centered methods. Furthermore, the study revealed that sex does not significantly affect students' academic achievement or interest in chemistry between the instructional methods. Male and female students performed comparably when exposed to mastery learning and lecture methods. Additionally, there was no significant interaction effect between sex and instructional methods on students' achievement, indicating that these instructional strategies are equally effective for both male and female students.

Recommendations

Based on the findings of this study, the following recommendations are made:

1. Since mastery learning was found to be the most effective instructional strategy in enhancing students' academic achievement in chemistry, chemistry teachers in secondary schools in Delta State should adopt mastery learning as a primary strategy for improving students' achievement outcomes.
2. Chemistry teachers should be trained in the development and implementation of mastery learning strategy.
3. Despite no significant differences in achievement and interest based on sex across the instructional strategies, teachers should ensure inclusive practices that promote equal engagement of male and female students in all classroom activities.

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