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PERSONALISED AND GROUP-BASED MASTERY LEARNING STRATEGIES AND STUDENTS' ACADEMIC ACHIEVEMENT IN CHEMISTRY IN SECONDARY SCHOOLS IN AKWA IBOM STATE, NIGERIA

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Abstract

The study determined the effects of personalised and group-based mastery learning strategies on students' academic achievement in Chemistry in secondary schools in Akwa Ibom State. Three specific purposes, two research questions and three hypotheses guided the study. The study used the quasi-experimental, pre-test, post-test research design. The population of the study comprised 16,786 senior secondary class two (SSII) students from 253 public secondary schools in the state. A sample of 146 students made up of 84 boys and 62 girls was selected from three intact classes using multi-stage procedure and purposive sampling technique. Two instruments were used in the study namely Mastery Learning Instructional Packages (MLIP) and Chemistry Achievement Test (CAT). The instruments were face validated by three lecturers from Michael Okpara University of Agriculture, Umudike, Abia State. The reliability of the Chemistry Achievement Test obtained through test-retest method was 0.84. The three intact classes were randomly assigned to the two experimental groups and a control group. The mastery learning instructional packages constituted the treatment that was given to the experimental groups 1 and 2 while the control group was taught with the conventional lesson plans. The experiment lasted for six weeks covering six lessons. The mean and standard deviation were used to answer the research questions while the hypotheses were tested using Analysis of Covariance (ANCOVA) at 0.05 level of significance. It was found that students taught chemistry using personalized Mastery Learning strategy performed better than those taught with group-based Mastery Learning strategy and lecture method. There was a significant difference between the mean post-test scores of students in Chemistry when taught with personalized and group-based Mastery Learning Strategies and lecture method. There was no significant difference in the mean

achievement scores of male and female students in Chemistry when exposed to Mastery Learning Strategies. Moreover, there was a significant interaction effect of teaching strategy and gender on students' academic achievement in Chemistry. It is recommended, among others, that Chemistry teachers in Akwa Ibom state secondary schools should henceforth adopt the mastery learning strategies (personalized and group-based) in teaching important topics in Chemistry while the conventional teaching methods should be de-emphasized.

Keywords: Mastery Learning Strategies (Personalized and Group-based), Academic Achievement, Chemistry, Gender.

Introduction

Chemistry is obviously one of the most significant science subjects taught in Nigerian secondary schools. Amos and Mkpa (2023) defined Chemistry as that branch of science which is concerned with the study of matter as it relates to energy as well as the study of laws that determine the structure of the universe with reference to the matter and energy in the universe. The study of chemistry enables us to understand the composition and interactions of atoms and molecules thus helping us to explain natural phenomena and their composition. Indeed, chemistry is a very vital subject due to its wide application to our daily life directly and indirectly. Its domain encompasses every aspect of our daily lives from food, healthcare, agriculture, energy, cleaning, cooking as well as environmental issues. According to Amos and Mkpa (2023), the importance of Chemistry in Nigeria is buttressed by the fact that it serves as a pre-requisite to the study of all science - based professional courses in Nigerian tertiary institutions. Thus, a credit pass in Chemistry is required at the senior secondary school certificate examination for admission into science, and technology-related professional courses in Nigerian tertiary institutions such as medicine and surgery, dentistry, nursing, pharmacy, forestry, fisheries, agricultural sciences and all branches of engineering. In view of its abstract nature, there is need for the use of appropriate teaching strategies in the teaching of Chemistry in order to facilitate a very good understanding of the subject which is very critical for effective scientific advancement. One of the teaching strategies that is of interest to this study is mastery learning.

Mastery learning is an instructional approach where students need to demonstrate a deep level of understanding of a topic or unit before progressing into another topic or unit. Salihu and Francis (2018) described Mastery Learning Strategy (MLS) as an instructional approach where students are allowed unlimited opportunities to demonstrate mastery of content taught. The strategy allows students to repeatedly study material until they master it. Mastery of each unit is shown when the student acquires competencies evident by the set pass mark of a diagnostic test. The authors added that mastery learning strategy helps the students to acquire prerequisite skills before moving to the next unit. The teacher also is required to do task analysis and state the objectives clearly and explicitly before designating the activities. Oginni, Akinola, Fadiji and Amole (2021) stated that mastery learning strategy consists of several steps which include distribution of lesson content into smaller parts, formulation of objectives related to each subdivision, organization of teaching for realizing objectives of each subdivision, administering formative test to evaluate the mastery level and diagnosing the knotty areas, giving remedial instructions to remove the ambiguities and finally, attainment of mastery level by every student. Toheed & Ali (2019) explained that in using Mastery Learning strategy, the teacher first defines the acceptable mastery level for a particular task and then organizes a variety of individual or group-based instructional techniques to fulfil the requirements of all students. Formative assessment with regular

feedback are used to diagnose the weak areas and to improve the instructional process rather than to measure achievement. Corrective assignments are also used to ensure the achievement of learning objectives. Finally, at the end of each unit, criterion referenced tests are used for the evaluation of students' performance.

Two major models of mastery learning strategies have been developed namely individualized or personalized model (also known as Keller's model) and group- based model (otherwise known as Bloom's model). Both models adopt the same procedure except that while the individualized model seeks to promote mastery learning of a pre-specified set of objectives for each learner in a subject or course, the Group-Based model seeks to promote mastery learning of a unit of instruction for all members of a class or group in a subject or course. Also, in the individualized model, students are attended to individually and each student works through a series of self- paced modules and learns independently. This approach uses the system of reading and studying prepared study guides. Proctors are provided to give immediate feedback to the students and to assist them in their areas of difficulty. The study guide may take different forms from print-based, to computer-based and internet-based instruction. This study used both the personalised and group based models of mastery learning for the experimental groups 1 and 2 respectively and lecture method for the control group in order to compare the effectiveness of the three methods on the students' academic achievement in Chemistry. Academic achievement refers to students' performance in a school subject as designated by a score obtained in an achievement test (Adika and Adika, 2015). It can also be seen as the learning outcomes of students which include the knowledge, skills and ideas acquired and retained through a course of study within and outside the classroom situation (Hassan, *et al* 2021). Academic achievement is an indication of how well an individual student has done his cognitive tasks. It is an indication of the general ability of students concerning their offered subjects compared to a specified standard called "Pass Marks" which is relative and can be arbitrarily defined as 40% or 50%. Eze, et al (2016a) pointed out that academic achievement could be high, average or low/poor. They described a high academic achievement as one where the score is above the pass mark while a poor academic achievement is any performance score that falls below a desired standard or pass mark.

Despite the importance of Chemistry in national development and everyday life, numerous research reports such as Ojukwu (2016); and Chikendu (2022) showed declining students' performance in the subject. Majority of the studies attributed the possible causes of candidates' persistent poor performances in Chemistry to the use of poor instructional strategies by teachers. Ojukwu (2016) specifically pointed out that eighty percent of the scientific information that students receive form their teachers in Nigerian secondary schools come through the lecture method. It is worthy to note that students' academic achievement in science subjects may vary according to gender. Gender is the socially constructed differences between males and females. Studies abound on gender differences and students' achievement in science subjects but their findings are conflicting. While some studies such as Ogini, et al (2021) and Nkok (2022) reported that there is no significant difference in achievement between male and female students in science subjects, others like Iserameiyaa and Ibeneme (2018) and Catherine (2023) found that there was significant difference between boys and girls in their academic achievement. In view of these controversial findings, there is need for more investigation with respect to mastery learning strategies and students' academic achievement in chemistry. Several studies have been conducted to examine the effects of mastery learning strategies on students' academic

achievement in many science subjects such as Physics, Mathematics, and Basic Technology. However, not much work has been done on the effect of mastery learning strategy on students' academic achievement in Chemistry in secondary schools in Akwa Ibom State. It therefore becomes imperative to explore the efficacy or otherwise of mastery learning strategies on students' academic achievement in Chemistry in this study area.

Statement of the Problem

Chemistry students are expected to perform creditably in both internal and external examinations. It is however disheartening to observe that students' academic achievement in Chemistry in the senior secondary school certificate examinations are below expectation as indicated by chief examiners reports from examination bodies like the West African Examinations Council (WAEC) and National Examinations Council (NECO). This has been an issue of great concern to science educators considering the relevance of Chemistry education to the nations' development.   Despite much efforts by teachers to improve students learning outcomes, many students still struggle to understand and retain chemistry concepts. Research by Egolum, Samuel and Okonkwo (2021) and Chikendu (2022) have attributed the poor students' achievement in Chemistry to the use of poor instructional strategies by most chemistry teachers. It is observed that the teaching method commonly used by chemistry teachers in secondary schools in Akwa Ibom State is the lecture method. The lecture method is a teacher-centred method which does not emphasize mastery of previous lessons before a new one, hence, it may not be effective in facilitating deep learning and understanding among students. The continuous use of the lecture method in teaching Chemistry which is widely perceived as a conceptually tough and abstract subject might partly account for the apathy and poor interest shown by many students towards Chemistry which culminate in their poor achievement in the subject. On this basis, there is need to explore new strategies such as mastery learning instructional strategies. Several studies have shown that the use of mastery learning strategies (personalized and group-based) considerably improve students' academic achievement, in many subjects such as Mathematics, Physics, Biology and Basic Science and Technology. However, there is dearth of empirical evidences on its effectiveness in Chemistry in secondary schools in Akwa Ibom State. The absence of research studies that address these issues therefore solicits a study to answer the question: What are the effects of mastery learning strategies on students' academic achievement in Chemistry in secondary schools in Akwa Ibom State? This is the problem to which this study is addressed.

Purpose of the Study

The main purpose of the study was to determine the effects of mastery learning instructional strategies on Secondary Schools students' achievement in Chemistry in Akwa Ibom State. The specific objectives of the study are:-

i.   To find out the difference in the mean achievement scores of students in Chemistry when taught with Mastery Learning Strategies (personalized and group-based) and lecture method.

ii. To ascertain the difference in the mean achievement scores of male and female students in Chemistry when exposed to personalized and group-based Mastery Learning Strategies .

iii. To determine the interaction effects of teaching strategies and gender on the mean achievement scores of students in Chemistry.

Research Questions

The following research questions guided the study:-

i. What is the difference in the mean achievement scores of students in Chemistry when taught with Mastery Learning Strategies (personalized and group-based) and lecture method?

ii. What is the difference between the mean achievement scores of male and female students in Chemistry when taught with personalized and group-based Mastery Learning Strategies?

Hypotheses

The following null hypotheses formulated to guide the study were tested at 0.05 level of significance:

HO 1: There is no significant difference in the mean achievement scores of students in Chemistry when taught with Mastery Learning Strategies (personalized and group-based) and lecture method

HO 2: There is no significant difference between the mean achievement scores of male and female students in Chemistry when taught with personalized and group-based Mastery Learning Strategies.

HO 3: There is no significant interaction effect of teaching strategies and gender on the mean achievement scores of students in Chemistry.

Research Methodology

The quasi-experimental research design, specifically, non-equivalent pre-test - post-test control group design was adopted in the study. This implies that intact classes were used for the study. The area of study of this research was Akwa Ibom State which is one of the 36 states in Nigeria. The State has 1,146 public primary schools, 254 public secondary schools, 298 private secondary schools and 791 privately owned nursery/primary schools. The population of the study consisted of 16,786 senior secondary class two (SSII) students from all the 253 public secondary schools in the state. One hundred and forty six senior secondary class two (SS II) students made up of 84 boys and 62 girls constituted the sample for this study. This number represents the students in three intact classes. Multi-stage procedure and purposive sampling technique was used to select the sample for the study. Finally, balloting was used to assign each of the selected three intact classes to the two experimental groups and a control group. Experimental group I (personalized), had 48 students (22 males and 26 females). Experimental group 2 had 49 students (23 males and 26 females) while the control group had 49 students (39 males and 10 females).

Two instruments were used in the study. They were: Mastery Learning Instructional Packages (MLIP) and Chemistry Achievement Test (CAT). The Chemistry Achievement Test was designed by the researcher for assessing students' achievement in chemistry. It comprised 50 multiple choice items on the relevant topics taught to the students with four options lettered A- D with only one correct answer. The test was first used as pre-test to determine the baseline knowledge of the students in the three groups before the experiment. Each question was scored 2 points and the total score was 100 marks. The Chemistry Achievement Test was also used as post-test after being reshuffled after each administration. The instruments used in the study were subjected to face and content validation. The face validation was done by three experts which include two lecturers in Chemistry Education and one in Measurement and Evaluation in Michael Okpara University

of Agriculture, Umudike. The reliability coefficient of the Chemistry Achievement Test (CAT),was 0.84 obtained using test-retest method.

The experiment was conducted in three phases as follows: Pre-treatment phase, Treatment phase and Post treatment phase. The students in the selected intact classes were then randomly assigned by the researcher to the three study groups as follows: Group I (Personalized mastery learning Strategy); Group II (Group based mastery learning and Group III (Control, Lecture method). Six lessons were covered in the six weeks as follows Physical properties of Chlorine (week 1), Chemical properties of Chlorine (week 2), Laboratory preparation of Chlorine (week 3), Industrial preparation of Chlorine (week 4), Compounds of chlorine 1- Hydrogen Chloride (week 5), and Compounds of chlorine 11-Hydrochloric acid (week 6). Data collected from the students were analyzed using mean and standard deviation to answer the research questions raised whereas the hypotheses formulated were tested using Analysis of Covariance (ANCOVA) at 0.05 level of significance. Post hoc pairwise comparison was employed, where necessary, to locate the differential effectiveness of the three groups.

Results

Research Question 1: What is the difference between the mean achievement scores of students in Chemistry when taught with Mastery Learning Strategies (personalized and group-based) and lecture method?

Table 1: Mean Pre-test and Post-test Scores of Students in Chemistry when taught using Mastery Learning Strategies and Lecture Method

S/n	Group	N	Pre Test $\overline{X}$	SD	Post Test $\overline{X}$	SD	Mean Difference/ % gain
1	Personalised Mastery Learning	48	45.29	5.01	62.08	3.64	16.79 (16.79%)
2.	Group-based Mastery Learning	49	46.45	5.72	60.37	1.84	13.92 (13.92%)
3.	Lecture Method	49	45.51	3.48	53.53	3.31	8.02 (8.02%)

The result presented in Table 1 shows the mean pre-test and post-test scores of students in the three groups with their standard deviations. Students in experimental group one who were taught using personalized mastery learning had mean pre-test and post-test scores of 45.29 and 62.08 respectively with standard deviations of 5.01 and 3.64 making a mean difference of 16.79 representing a gain of 16.79%. It could be observed that students who were taught using personalized mastery learning strategy obtained the highest mean difference of 16.79 representing a gain of 16.79% as against 13.92 (13.92%) and 8.02 (8.02%) obtained by those who were taught using group-based mastery learning strategy and lecture method respectively. This result suggests that teaching chemistry using personalized mastery learning strategy enhances students' achievement in the subject than using the group-based mastery learning strategy and lecture method.

Research Question 2: What is the difference between the mean achievement scores of male and female students in Chemistry when taught with Mastery Learning Strategies.

Table 2: Mean Pre-test and Post-test scores of Male and Female Students in Chemistry when taught using Mastery Learning Strategies

Group	Gender	N	Pre Test		Post Test		Mean Difference/
			$\overline{X}$	SD	$\overline{X}$	SD	% gain
Personalized	Male	22	43.18	2.87	62.64	4.29	19.46%
	Female	26	47.07	5.74	61.64	2.99	14.57%
Group based	Male	25	45.30	5.31	64.35	9.08	19.05%
	Female	24	47.46	5.97	56.84	1.22	9.39%

The result in Table 2 shows the mean pre-test and post-test scores of male and female students in the two experimental groups (personalized and group-based mastery learning). Male students in experimental group one who were taught with personalized mastery learning strategy scored 43.18 and 62.64 respectively in the pre-test and post-test with standard deviations of 2.87 and 4.29. It could be observed that male students in experimental group 1 obtained a higher mean difference of 19.46 representing mean gain of 19.46% as against 14.57% obtained by their female colleagues. Also, male students in experimental group 2 obtained a higher mean difference of 19.05 (or gain of 19.05%) as against 9.39% obtained by their female colleagues. This result suggests that teaching chemistry using mastery learning strategies enhances male students' achievement in the subject more than the female students.

Hypothesis 1 (HO 1): There is no significant difference between the mean achievement scores of students in Chemistry when taught with Mastery Learning Strategies and lecture method

Table 3: Analysis of Covariance Test for Significant Difference in the Mean Post-test Scores of Students in Chemistry when Taught with Mastery Learning Strategies and Lecture Method

Source	Sum of Squares	Df	Mean Square	F	Sig.	Decision
Corrected Model	1998.37[a]	3	666.12	13.93	0.00	
Intercept	5131.91	1	5131.91	107.30	0.00	
PRE_TEST	3.87	1	3.87	0.08	0.78	
GROUP	1991.06	2	995.53	20.82	0.00	S
Error	6791.39	142	47.83			
Total	510781.00	146				
Corrected Total	8789.76	145				

*S = Significant at 0.05 level of significance

The data in Table 3 shows that the f -value for group or teaching method is 20.82 with p-value (probability value) being 0.00. Since the obtained p- value is less than the stipulated probability level of 0.05, it implies that the value of f is significant at 0.05 level of significance. On this basis, the null hypothesis is rejected implying that there is significant difference between the mean test scores of students in Chemistry when taught with Mastery Learning Strategies and lecture method. Turkey's post hoc test was conducted to determine where the significant difference comes from as presented in Table 4.

Table 4: Summary of Turkeys' Post-hoc Pairwise Comparison of the Mean Post Test Scores of the Three Groups

Dependent Variable: Post-Test Score

Groups	Mean Difference*	Standard Error	Sig	Remarks
1 Vs 2	1.7160	1.3999	0.44	NS
1 Vs 3	8.5527**	1.3999	0.00	S
2 Vs 1	-1.7160	1.3999	0.44	NS
2 Vs 3	6.8367**	1.3926	0.00	S
3 Vs 1	-8.5527**	1.3999	0.00	S
3 Vs 2	-6.8367**	1.3926	0.00	S

*Based on observed means (raw scores). The error term is Mean Square(Error) = 47.519.

 **. The mean difference is significant at the .05 level.

The result in Table 4 shows that the mean difference between groups 1 (personalized) and 2 (group-based) was not significant at 0.05 level of significance. Likewise, the mean difference between groups 2 and 1 was not significant at 0.05 level of significance. However, the mean difference between groups 1 (personalized) and 3 (lecture method) was found to be significant. Significant difference was also found in the mean difference between groups 2 and 3, 3 and 1 as well as between groups 3 and 2. This result implies that the mean post test scores of students in two experimental groups 1 (personalized) and 2 (group based) was significantly better than those in the control group. The significant difference is in favour of experimental group 1 students who obtained a higher post-test score than those in the other two groups as seen in Table 1.

HO 2: There is no significant difference between the mean achievement scores of male and female students in Chemistry when taught with Mastery Learning Strategies (personalized and group-based).

HO 3: There is no significant interaction effect of teaching method and gender on the mean achievement scores of students in Chemistry.

Data relating to hypothesis 2 and 3 are presented in Table 5.

Table 5: Analysis of Covariance Test for Significant Difference in the Mean Post-test Scores of Male and Female Students in Chemistry when Taught with Mastery Learning Strategies and Lecture Method

Source	Sum of Squares	Df	Mean Square	F	Sig.	Decision
Corrected Model	770.61[a]	3	256.87	4.29	0.07	
Intercept	363228.63	1	363228.63	6064.85	0.00	
GROUP	56.37	1	56.37	0.94	0.33	
GENDER	437.94	1	437.94	7.31	0.08	NS
GROUP * GENDER	253.23	1	253.23	4.23	0.04	S
Error	5569.85	93	59.89			
Total	369844.00	97				
Corrected Total	6340.45	96				

*S = Significant at 0.05 level of significance

The data in Table 5 shows that the f -value for gender is 7.31 with p- value (probability value) being 0.08. Since the obtained p- value is greater than the stipulated probability level of 0.05, it implies that the value of f is not significant at 0.05 level of significance. On this basis, the

null hypothesis is accepted or upheld implying that there is no significant difference in the mean achievement scores of male and female students in Chemistry when exposed to Mastery Learning Strategies. Table 5 also revealed that the F-value for interaction effect of teaching method and gender on the mean interest scores of students in Chemistry is 4.23 with p-value being 0.04. Since the obtained p- value is less than the stipulated probability level of 0.05, it implies that the value of f is significant at 0.05 level of significance. On this basis, the null hypothesis is rejected implying that there is significant interaction effect of teaching method and gender on the mean interest of students in Chemistry when exposed to Mastery Learning Strategies.

Findings of the Study
It was found that students taught chemistry using personalized Mastery Learning strategy performed better than those taught with group-based Mastery Learning strategy and lecture method. There was a significant difference between the mean test scores of students in Chemistry when taught with personalized and group-based Mastery Learning Strategies and lecture method. There was no significant difference in the mean achievement scores of male and female students in Chemistry when exposed to Mastery Learning Strategies. Moreover, there is a significant interaction effect of teaching strategy and gender on students' academic achievement in Chemistry when taught using Mastery Learning strategies ((personalized and group-based).

Discussion of Findings
In the study, it was found that students taught chemistry using personalized Mastery Learning strategy performed better than those taught with group-based Mastery Learning strategy and lecture method. Testing of the corresponding hypothesis confirmed that there was significant difference between the mean test scores of students in Chemistry when taught with Mastery Learning Strategies (personalized and group-based) and lecture method. The difference was in favour of those in experimental group 1 who were taught with personalised mastery learning strategy. This result could be attributed to the fact that personalised mastery learning strategy enables students to understand a unit of instruction very well before proceeding to the next unit. This finding agrees with that of Ogini, *et al* (2021) and Amos and Mkpa (2023) who in their separate studies found that mastery learning strategy enhance students' academic achievement in more than the lecture method.

It was also found in the study that there is no significant difference in students' mean achievement scores in Chemistry when taught using personalised Mastery Learning strategy and group-based and Mastery Learning strategy. This difference was in favour of the male students. This finding support that of Amos and Mkpa (2023) who reported that male students performed better than their female counterparts in Chemistry when taught with the mastery learning strategy. This finding however contradicts that of Ogini, *et al* (2021) who found that there is no significant difference in students' achievement in Mathematics when taught using Mastery Learning and lecture method based on their gender. It was further found in the study that there is significant interaction effect of teaching strategy and gender on students' academic achievement in Chemistry. This implies that the combination of both teaching strategy and gender have significant influence on students' achievement in Chemistry. This finding supports that of Iserameiya and Ibeneme (2018) who found that there was significant interaction effect of gender and teaching methods on students' achievement in Basic technology.

Conclusion

Based on the findings of the study, it is concluded that teaching Chemistry using personalized and group-based mastery learning strategies enhances students' academic achievement than using the lecture method. Also, the personalized Mastery Learning strategy favours male students more than the females. Moreover, the combined effect of teaching strategy and students' gender have significant influence on students' achievement in chemistry when taught using Mastery Learning strategies.

Recommendations

The following recommendations are made based on the findings of the study.

i.   Chemistry teachers in Akwa Ibom state secondary schools should henceforth adopt the personalised mastery learning strategy in teaching important topics in Chemistry

ii. Chemistry teachers should de-emphasize the use of the traditional methods of teaching.

iii. Curriculum developers in Chemistry should include personalized and group-based Mastery learning strategies among the recommended teaching strategies in order to improve students' achievement in the subject.

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