EFFECT OF LABORATORY INSTRUCTIONAL STRATEGY ON SECONDARY SCHOOL STUDENTS' ACADEMIC PERFORMANCE IN CHEMISTRY IN JIGAWA STATE

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Abstract
The study investigated the Effect of Laboratory Instructional Strategy on Secondary School Students' Academic Performance in Chemistry in Jigawa State, Nigeria. Two objectives, two research questions and two hypotheses were formulated to guide the study. The study employed pre-test, post-test quasi experimental and control group design that involved intact science classes of SSS I level. The population of the study was constituted of 1248 Senior Secondary School I (SS1) science students in 2023/2024 academic session. Two (2) schools were randomly selected and placed as experimental and control groups. One hundred and eleven (111) students served as sample for the study. The instrument used for data collection was the Acids, Bases and Salts Performance Test (ABSPT) which yielded a reliability coefficient of 0.83. The data collected were analyzed statistically using mean and standard deviations to answer the research questions while Analysis of Covariance (ANCOVA) was used to test the hypotheses at 0.5 level of significance. The findings of the study revealed that, there was significant difference between the mean performance score ($p=0.017 < 0.05$) of students taught acids , bases and salts using laboratory instructional strategy and those taught using conventional method in favor of laboratory instructional strategy group. Based on the findings it was recommended that all the chemistry topics which are practically oriented should be taught in the laboratory, using all the necessary equipment, apparatus and reagents.
Keywords: Laboratory Instructional Strategy; Academic Performance; and Chemistry.

Introduction

The criticism of several science educators and the general public concerning the persistent low performance of students in science cannot be over emphasized. This under performance becomes eminent when one considers the performance of students in SSCE examinations. Over the years, various report has brought to lime light the fluctuation under performance of students in Chemistry in the SSCE examination conducted in Nigeria. However, situation in the Nigerian senior secondary schools is such that practical work or topic that need to be taught practically is hardly conducted or at most times ignored. In some schools, practicals are conducted only once or twice just for the purpose of external examinations. These trend does not encourage the acquisition of science process skills. What appears cloudy is whether the use of laboratory instructional strategy could narrow the persistent poor performance and gender gap in performance.

Studies have highlighted the persistent reliance on traditional teaching methods, which prioritize rote memorization over experiential learning (Ogunleye et al., 2023). This approach has been criticized for its inability to address students' diverse learning needs, leading to disengagement and poor academic outcomes in subjects like chemistry (Pramesthi et al., 2022). Addressing this gap requires targeted interventions, including professional development for teachers and investment in laboratory infrastructure, to enable the effective implementation of laboratory-based learning strategies (Ajayi & Olatunji, 2020).

Laboratory instructional strategy have emerged as a powerful pedagogical tool for enhancing students' understanding of challenging chemistry concepts. By integrating hands-on experimentation with theoretical learning, laboratory methods encourage active participation and critical thinking, which are essential for deep learning. Research has shown that students who engage in laboratory-based learning not only achieve higher academic outcomes but also retain knowledge for longer periods, compared to those taught using traditional lecture methods (Osman & Lay, 2020). Despite its potential, the implementation of laboratory strategies in secondary schools faces significant barriers, such as inadequate resources, lack of teacher training, and overcrowded classrooms (Pramesthi et al., 2022).

Furthermore, laboratory instructional strategy has the potential to transform the learning experience in chemistry education. These strategies provide students with hands-on opportunities to explore and understand scientific concepts through experimentation and observation. By engaging students in active learning, laboratory instruction helps bridge the gap between theory and practice, fostering deeper understanding and long-term retention (Osman & Lay, 2020). Research has shown that students exposed to laboratory-based teaching outperform their peers taught using traditional methods, particularly in topics like acids, bases, and salts (Miranda & Smaka, 2021).

The teaching of chemistry, particularly in secondary schools, is essential for equipping students with the knowledge and skills necessary for careers in science, technology, engineering, and mathematics (STEM). Acids, bases, and salts are fundamental concepts in chemistry, and mastery of these topics is critical for students' academic and professional development. However, consistent poor achievement and retention in these topics highlight the need for innovative teaching strategies to address these challenges (Aina & Ayodele, 2020). Laboratory instructional strategies have been identified as a promising approach to improving student achievement and retention in science education.

The teaching and learning of chemistry concepts, particularly acids, bases, and salts, have long been recognized as a cornerstone of science education. Performance in these areas is critical for students' progression in science, technology, engineering, and mathematics (STEM) fields, which are pivotal for national development. However, traditional teaching methods often fail to adequately engage students, resulting in poor achievement and retention of key scientific concepts (Ajayi & Olatunji, 2020).

Omiko (2015) was of the same opinion where he observed that laboratory teaching is sometimes used in conjunction with large lecture courses so that students may acquire technical skills and apply concepts and theories presented in the lecture. Omiko (2015) stated that

"hands-on experience encourages students to develop a spirit of inquiry and allows them to acquire scientific skills and the right attitude to handle scientific tools and materials. Science laboratory provides students with the richest experiences which they will transfer to the society and their various places of work. It helps in providing the students the opportunities to practice science as the scientist do. In order for the laboratory to be effective, students need to understand not only how to do the experiment, but why the experiment is worth doing, and what purpose it serves for better understanding of a concept, relation, or process.

Shulman and Tamir in Omiko (2007), listed five groups of educational objectives that may be achieved through the use of the laboratory in science teaching. Firstly, manipulative skills, inquiry skills, investigative skills, organizational skills and communicative skills. Secondly, concept of mastery: For example, hypothesis, theoretical model, taxonomic category. Thirdly, development of cognitive abilities: critical thinking, problem solving, application, analysis and synthesis. Fourthly, understanding the nature of science, scientific enterprises, scientists and how they work, existence of a multiplicity of scientific methods, inter-relationships between science and technology and among the various disciplines of science. Lastly, development of scientific attitudes: For example, curiosity, interest, risk taking, objectivity, precision, confidence, perseverance, satisfaction, responsibility, consensus, collaboration, and liking science.

Based on the roles of the science laboratory in science teaching and learning, it implies that schools without laboratories, where students can carry out biology, chemistry and physics practical would end up graduating with no knowledge of science practical's required by the West African Examination Council (WAEC) and the National Examination Council (NECO) to pass the senior school certificate examination. Consequently, these students would lack the requisite requirement qualification for courses like medicine, engineering, agricultural science and any of the science related careers.

Statement of the Problem

The persistent poor performance in chemistry among students makes it imperative to search for effective teaching strategies for effective teaching and learning of chemistry concepts. Over the years research studies have shown that Chemistry students performed poorly and they have blamed the poor performance on many factors including lack of use of effective methodology for teaching science in secondary schools according to Ajewole and Ivowi cited in Goje (2014). Also, the issue of gender disparity in Chemistry performance is still being debated among the researchers. Considering the relevance of chemistry in everyday life, there is the need to revisit the methods in use for teaching senior secondary school students. This poor performance in chemistry should be taken as a wakeup call to re-examine the methodologies in use, to prevent it from constituting a clog to the wheel of many Nigerian students offering Chemistry.

The laboratory has been identified as the heart of a good scientific programme which allows students in the school to have experience which are consistent with the goals of scientific literacy. Practical chemistry constitutes a major part in chemistry education, if it is not taught properly the education of the students in the other science courses will be affected negatively. Therefore, secondary schools require properly equipped and functional laboratories. The

effectiveness of laboratory-based instructional strategies in promoting deeper understanding and retention of chemistry concepts remains an area of concern (Smith & Johnson, 2018). When the students are taught chemistry theoretically, without the practical aspects done in the laboratory, the students will not learn properly. The implication of this means that the role of the laboratory on the academic performance of students in chemistry is being ignored.

Although laboratory instruction is often praised for its potential to enhance students' engagement and retention in science subjects, its specific impact on chemistry education, particularly in understanding acids, bases, and salts has not been thoroughly investigated (Williams & Thompson, 2016). This study aims to explore whether laboratory-based instructional strategy leads to better student performance compared to conventional lecture methods in the context of these fundamental chemistry concepts (acids, bases and salts).

Objectives of the Study

This study aimed at investigating the effect of laboratory instructional strategy on academic performance of students in chemistry in Jigawa State, Nigeria. Specifically, the study tends to:

1. Determine the difference between the academic performance scores of students' taught acids, bases and salts concepts using laboratory instructional strategy and those taught using lecture method.
2. Investigate the difference between the academic performance scores of male and female students taught acid, base and salt concepts using laboratory instructional strategy.

Research Questions

In order to guide this study, the following research questions were raised:

1. What is the difference between the mean academic performance scores of students' taught acids, bases and salts concept using laboratory instructional strategy and those taught using conventional lecture method?
2. What is the difference between the mean academic performance scores of male and female students taught acids, bases and salts concept using laboratory instructional strategy?

Hypotheses

The following hypotheses were tested at 0.05 level of significance:

Ho_1: There is no significant difference in the mean academic performance scores of students taught acids, bases and salts concept using laboratory instructional strategy and those taught using conventional lecture method.

Ho_2: There is no significant difference between the mean academic performance scores of male and female students taught acids, bases and salts concept using laboratory instructional strategy.

Methodology

The research design that was adopted for this study is quasi-experimental design. It is non-randomized pre-test, post-test, post post-test control group design involving intact chemistry classes at SS1 level. The sample selected was categorized into two groups namely; Experimental Group (EG) and Control Group (CG). The experimental group was exposed to laboratory instructional strategy as the treatment while the control group was exposed to lecture

method as the treatment. The finding from the sample of the population was generalized to the entire population.

The population of the study consisted all the chemistry students in secondary schools in the thirteen (13) public co-educational secondary schools in Kazaure zonal education. However, there are about 1248 chemistry student as at 2023/2024 academic session in Kazaure zonal education area of Jigawa state. One hundred and eleven (111) chemistry students served as sample for this study, which were selected using purposive and simple random sampling technique. In addition, from the thirteen (13) public co-educational schools, ten (10) schools were purposively selected because they have chemistry laboratory, among the ten schools, two (2) of them were randomly selected and sampled.

Two instruments were used for data collection in this research. They are:

1. Stimulus Instrument; Instructional Guide (lesson plan) for Laboratory Strategy and conventional method.
2. Respondents Instrument; Acids, Bases and Salts Performance Test (ABSPT).

The ABSPT consisted of two sections, section (1) sought information on personal data while the second section contains twenty (20) items structured to provide answers to the major research questions. The instrument (ABSPT) consists of 30 multiple choice items; each item is followed by four (4) response options A—D. Students were asked to circle or tick the correct option, the items were based on the concepts of acids, bases and salts. The instruments were validated by three experts; one expert from the department of science education validated the lesson plan while the second expert from the department of chemistry validated the performance test while the last expert validated the grammar.

The reliability of an instrument is the consistency of the instrument in measuring whatever it is designed to measure. The ABSPT instrument is made up of 30 items which were subjected to a test of reliability using test-retest method and the two test were correlated using Pearson Product Moment Correlation Coefficient (PPMC). A reliability co-efficient of 0.85 was obtained. This high value shows that the instrument was reliable and suitable for the study. The data collected from the administration of the instruments was analyzed statistically using Statistical Package for Social Sciences (SPSS), version 20. At descriptive level, the research questions 1 and 2 were answered by using descriptive statistics of mean scores and standard deviation of the performance score of students in acids, bases and salts concept. While at inferential level, hypothesis 1 and 2 were analyzed using ANCOVA. Based on this premise, the hypotheses formulated for this study is either retained or rejected at an alpha of 0.05 level of significance.

Results

Research Question 1: What is the difference in the mean performance scores between students' taught acids, bases and salts concept using laboratory instructional strategy and those taught using lecture method?

Table 1: Mean Performance Scores and Standard Deviation of Students in the Experimental and Control Group

Group	N	Post-test		Mean difference
		$\bar{X}$	SD	
Experimental	55	18.73	3.02	1.27
Control	56	17.46	2.43	

The result in table 1 shows that the mean score of 18.73 and standard deviation of 3.02 for students who were exposed to laboratory instructional strategy was higher than the mean scores of 17.46 and standard deviation of 2.43 for students who were exposed to the conventional lecture method with the mean difference of 1.27 in favor of the experimental group. The result indicated that students taught the concept of acids, bases and salts using laboratory instructional strategy have a better mean performance score than those taught the same concept using conventional (lecture) method.

Research Question 2: What is the difference between the mean performance scores of male and female students taught acids, bases and salts concept using laboratory instructional strategy?

Table 2: Mean Performance Scores and Standard Deviations of male and female Students in the Experimental Group

Gender	N	Post-Test		Mean Diff
		$\bar{X}$	SD	
Male	32	19.31	2.93	1.40
Female	23	17.91	3.01	

Table 2 shows that the mean performance scores of the two groups that are male and female were 19.31 and 17.91 respectively with standard deviation of 2.93 and 3.01 and mean difference of 1.40 in favor of male students. These mean scores revealed the existence of difference in the performance of the two groups. It is clear from the figures above that the male students in the experimental group performed better than their female counterpart. The significance of this difference in the performance between the two sub-groups is tested in the related hypothesis.

H_{O1}: There is no significant difference in the mean performance scores of students taught acids, bases and salts using laboratory instructional strategy and those taught using the conventional lecture method.

Table 3: ANCOVA of Post-test Mean Scores of both Experimental and Control Groups

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	44.329[a]	2	22.165	2.931	.058
Intercept	2214.661	1	2214.661	292.841	.000
Pretest	.068	1	.068	.009	.925
Treatment	44.191	1	44.191	5.843	.017
Error	816.770	108	7.563		
Total	37186.000	111			
Corrected Total	861.099	110			

R Squared = .051 (Adjusted R Squared = .034)

The result of ANCOVA in table 3 shows that the F-value obtained was 5.843, the Adjusted R Squared was 0.034 and the p-value obtained is 0.0170, hence less than the alpha value of 0.05. The hypothesis is therefore rejected which means there is a significant difference in the academic performance between the two groups in favor of experimental group.

H_{O2}: There is no significant difference between the mean performance scores of male and female students taught acids, bases and salts concept using laboratory instructional strategy.

Table 4: ANCOVA of Post-test Mean Scores of Male and female Students in the Experimental Group

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	11.151[a]	2	5.575	.792	.458
Intercept	138.560	1	138.560	19.674	.000
PrExp	.422	1	.422	.060	.807
Gender	11.136	1	11.136	1.581	.214
Error	366.231	52	7.043		
Total	5640.000	55			
Corrected Total	377.382	54			

R Squared = .030 (Adjusted R Squared = -.008)

The result of ANCOVA in table 4 shows that the F-value obtained was 1.581, the Adjusted R Squared was -0.008 and the p-value obtained is 0.214, hence higher than the alpha value of 0.05. The hypothesis is therefore retained which means that there is no significant difference in the performance scores between male and female students in the experimental group. Therefore, laboratory strategy is gender friendly.

Discussion of Findings

The findings of this study shows that students taught using laboratory instructional strategy performed better those taught using conventional lecture method with a p value of 0.017 which

is less than the alpha level of 0.05. This finding is in agreement with the findings of Goje (2014), where he revealed that students taught using laboratory method performed better that those taught using conventional lecture method. Moreover, this finding is also in agreement with the findings of John & Williams (2019), Edwards & White (2019) and Jackson & Morgan (2020) where they found out that students who engaged in laboratory activities showed significant improvement in their understanding and performance of chemistry concepts compared to those taught using traditional lecture-based instruction.

Furthermore, the findings of this study shows that there was no statistically significant difference between performance of male and female students taught chemistry using laboratory instructional strategy with a p-value of is 0.214, higher than the alpha value of 0.05. Hence, laboratory strategy is gender friendly and this in disagreement with the findings of Alake (2015) who also found out that laboratory method is suitable for both male and female students in teaching and learning in secondary schools. While the findings of Fatoba and Joseph (2015) is in disagreement with the current findings where they revealed that male students prefer conventional method than laboratory method because when they are taught using conventional method, they performed better than their female counter-part of the same group. The researcher also found out that the lack of significant difference between male and female students, can be attributed to; equal learning opportunities, because laboratory strategies provide hands-on experiential learning that is equal.

Conclusion

Based on the findings of the study the researcher concluded that the use of laboratory instructional strategy enhances students' performance in Chemistry more than the conventional lecture method. There is no gender disparity in the performance of Chemistry students when taught using laboratory strategy. This implies that laboratory strategy is very rewarding to students in terms of performance and regardless of gender and could therefore be a means of narrowing the gender gap in performance.

Recommendations

Based on the findings the following recommendations are hereby made:

1. Chemistry teachers should intensively employ the use of laboratory strategy which provides students opportunity to interact with materials and apparatus and enhances their performance.
2. School proprietors should provide laboratory facilities to enable chemistry teachers use laboratory strategy effectively in teaching.

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