A LEGACY OF LEADERSHIP: A SPECIAL ISSUE HONOURING THE TENURE OF OUR VICE CHANCELLOR, PROFESSOR ARMAYA'U HAMISU BICHI, *OON, FASN, FFS, FNSAP*

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EVALUATING THE EFFECTIVENESS OF LABORATORY-BASED INSTRUCTION ON FEMALE STUDENTS' ATTITUDE AND ACADEMIC PERFORMANCE IN CHEMISTRY IN KONTAGORA, NIGER STATE, NIGERIA

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ABSTRACT

This study examines the impact of laboratory-based teaching methods on female students' attitudes and academic performance in Chemistry in Kontagora, Niger State, Nigeria. Utilizing a quasi-experimental design, the study involved two groups: an experimental group receiving laboratory-based instruction and a control group taught via traditional methods. Data were collected through pre- and post-tests on academic performance and attitude surveys. Instruments used included the Chemistry Performance Test (CPT) and the Students' Attitude to Chemistry Laboratory Scale (SACLS). Data were analyzed using SPSS with Multivariate Analysis of Covariance (MANCOVA) and independent t-tests. Results indicated significant improvements in both performance and attitudes among students taught with laboratory methods. The study concludes that the laboratory method is an effective instructional strategy and recommends its broader adoption in Chemistry classrooms across Niger State.

Keywords: Laboratory Instruction, Chemistry Education, Female Students, Academic Performance, Attitude, Kontogora

INTRODUCTION

Education is a critical tool for individual and societal development, and science education, in particular, plays a vital role in fostering technological and economic progress. Chemistry, as one of the core science subjects, is fundamental in shaping students' understanding of the physical and chemical processes that govern the natural world. Despite its importance, the teaching and learning of chemistry in many Nigerian secondary schools face significant challenges, particularly among female students. (Kipnis and Hofstein, 2024).Study conducted by Ajanaku., Oluwaseun., Kuburat & Alabi (2024) posit that Chemistry education is central for scientific literacy and national development. However, female students in Nigeria continue to struggle with the topic, largely due to ineffective educational techniques. Laboratory instruction, which includes hands-on and inquiry-based activities, is regarded as a cornerstone of good science education and has been shown to boost conceptual knowledge as well as student motivation. Despite this, there is little empirical study on how laboratory practices affect female students' academic achievements and attitudes in Chemistry, especially in rural places like Kontagora. This study aims to address this gap by examining the impact of laboratory-based instruction on female students' engagement and achievement.
Science laboratories have been a unique place for instruction, and laboratory activities have played distinctive and vital roles in secondary school science curricula. Science educators have agreed that these activities have proven very beneficial to students (Kotuľáková, and Janošcová, 2024). One objective of science laboratories has been to afford students with a chance to engage in scientific investigations and inquiry, potentially leading to enhanced acquisition of scientific content and processes. Substantial learning and comprehension of scientific knowledge in the laboratory have taken place when students raised queries and received clarification for their uncertainties (Gericke, and Högström 2023). As a complementary to science education, with laboratory practices, students develop their skills of creative and scientific thinking, problem solving, and observing and interpreting the events, collecting, and analyzing data, thus they can improve their scientific knowledge Thus, laboratory activities must also help students develop the right attitudes and interests in learning chemistry (Çıbık, 2021.).
According to Asamoah, (2024), laboratory work is the core of science education. While performing laboratory work, the students get an opportunity to develop their own abilities to design, conduct, interpret and report scientific investigations. On the same vein, Masime, (2016). States that the primary goals of practical chemistry work are manly observation and description of chemical occurrences, the learning of certain manipulative abilities, and the identification of chemistry-related problems and strategies for solving them. Cultivate a logical reasoning approach to thinking increase self-reliance, confirm previously learned concepts and facts, and cultivate certain disciplined approaches to acquire a critical mindset and the ability to understand and stick to instructions. Practical work is seen as an essential part of teaching and learning science at school level (Sharpe,2012). Students seem to enjoy practical work and it is thus generally regarded as adding to the students' motivation to study science at school level. In most countries, practical approach is either considered a central part of science classes or its status is wished to be lifted to such a position (Hodson, 2005).
According to Festile, (2017) Practical work may be considered as engaging the learner in observing or manipulating real or virtual objects and materials Likewise Okwoduba, and Okigbo,(2018). Practical work induces scientific attitudes, develops problem solving skills, collaboration and improves conceptual understanding in students Practical work puts the students at the center of science learning where they can participate in, rather be told about science (Abrahams, and Saglam,2010). Kapici, Akcay, & de Jong, (2020). Conducted a study by comparing the effects of hands-on, virtual, and combined laboratory environments on middle school students' attitudes toward science courses. Findings revealed that all forms of laboratory

experiences positively influenced students' attitudes, with virtual labs showing a slightly higher impact. Alnaser, & Forawi, (2024). Investigating virtual laboratories' effects, this research found that such labs significantly boosted students' motivation and attitudes toward science. Key factors included increased self-efficacy and perceived usefulness, leading to greater effort and engagement in science learning. According to Oyelowo, (2023). Focusing on Nigerian secondary schools, this study highlighted that the availability and utilization of functional physics laboratories positively affect students' attitudes toward physics. The research emphasized that practical laboratory experiences are essential for fostering positive attitudes and improving academic performance.

Also, Uche & Eze, (2020) conducted an experimental study in Kaduna State, Nigeria, the finding showed that students exposed to laboratory activities exhibited significantly better attitudes and academic performance in science compared to those taught through traditional lecture methods. Furthermore, Ntawuhiganayo & Nsanganwimana,. (2023) carried out an experimental study in Rwanda, this research assessed the impact of laboratory practical activities on students' academic achievement and attitudes toward biology. Findings indicated that students engaged in laboratory activities achieved higher academic scores, although the effect on attitudes was not statistically significant. These studies collectively affirm that laboratory activities are instrumental in enhancing students' attitudes, engagement, and motivation in science education. According to Alshehri, (2022), there is not one unique approach that is best for teaching science, like laboratory-based, interactive method. Furthermore, Kyakuwa, (2017) believe that a laboratory is where science teachers conduct scientific exercises for the benefit of their students. Experiments and other activities that support the students' acquisition of scientific knowledge are included in laboratory exercises. Also, Akani, (2015) observed a science laboratory as a workshop where science is done or where scientific activities are carried out.

Theoretical Framework

The Expectancy-Value Theory of Achievement Motivation and Constructivist Learning Theory serve as the theoretical foundations for this investigation. Particularly for female students studying chemistry, these theories shed light on how laboratory-based instruction might improve learning outcomes and affect students' attitudes.

Constructivist Learning Theory

According to constructivist theory, which was developed by Lev Vygotsky after Jean Piaget, students actively construct knowledge through social collaboration and interaction with their surroundings (Piaget, 1952; Vygotsky, 1978). This perspective holds that knowledge is actively created rather than passively acquired. The laboratory approach in this study is an example of constructivism in action. Students practice experimentation, observation, data collection, and critical analysis through practical exercises. By connecting theoretical ideas with actual occurrences, these interactive exercises help students better comprehend and remember the material covered in Chemistry.

Vygotsky also highlighted the value of social interaction and the zone of proximal development (ZPD), arguing that learning happens best when students collaborate with one another while being guided by a more experienced individual. This process is supported in lab settings by peer interactions and teacher facilitation, which foster meaningful learning opportunities and the growth of favorable attitudes toward chemistry.

Expectancy-Value Theory of Achievement Motivation

The Expectancy-Value Theory, developed by Eccles and Wigfield (2002), explains how students' motivation and academic choices are influenced by their expectations for success and the value they place on the learning task. This theory is highly relevant to the present study, as it provides a framework for understanding how laboratory experiences affect female students' motivation and engagement in Chemistry. When students perceive laboratory tasks as enjoyable and meaningful (high task value) and believe they can succeed (high expectancy), they are more likely to develop a positive attitude and perform better academically. Laboratory instruction, by making Chemistry more tangible and relatable, increases students' perceived utility and interest in the subject. Success in laboratory tasks builds confidence and self-efficacy, which are critical components of expectancy beliefs. Together, these elements contribute to improved academic outcomes and foster a sustained interest in Chemistry among female students.

Integration of these theories into the Study

By applying Constructivist Learning Theory and the Expectancy-Value Theory of Achievement Motivation, this study establishes a robust conceptual foundation for investigating the impact of laboratory-based instruction. These theories support the notion that hands-on, student-centered learning environments can lead to both cognitive and affective gains, especially in underrepresented groups such as female learners in science disciplines.

Objective of the Study

This study set to achieve the following objectives:

To assess the impact of laboratory-based teaching versus traditional methods on female students' academic performance in

To examine how laboratory method influence female student attitude toward learning chemistry in Kontagora Niger state

Research Questions

The study was guided by the following research questions;

What differences exist in the academic performance of students taught Chemistry using laboratory instruction compared to those taught using the lecture method?

How does laboratory-based teaching influence female students' attitudes toward Chemistry

Null Hypotheses

The following null hypotheses were tested at 5% level of significance to further answer the research questions.

There is no significant difference in academic performance between students taught using laboratory instruction and those taught with traditional methods.

Laboratory-based teaching does not significantly influence female students' attitudes toward learning Chemistry.

Scope of the Study

This study examined the effectiveness of laboratory method of instruction on female students attitude and academic performance in chemistry in Kontagora. There are 18 secondary schools in Kontagora local government of Niger state; 3 are pure female secondary schools among the schools This study was carried out in women day senior secondary schools and government girls secondary school in Kontagora local government area of Niger state Female Senior Secondary class two (SSII) would be used for the study, the subject matter content falls into SSII chemistry curriculum, the areas includes, acid base titration , and simple calculations using mole concept formula

MATERIALS AND METHODS

The study used a quasi-experimental approach with non-equivalent control groups. We chose intact SSII Chemistry courses from two female high schools in Kontagora. One class received laboratory-based training (experimental group), and the other received standard lecture-based education (control group). The study included 130 students (64 experimental and 66 controls). Pre- and post-tests were used to assess knowledge and attitudes prior to and following the intervention. There are two instruments for this study. (1). Chemistry Performance Test (CPT). (2) Student attitude to chemistry laboratory Scale (SACLS). Informed permission and confidentiality of the data collected were among the ethical issues observed. Data were examined using SPSS, which included descriptive statistics, t-tests, and Pearson correlation.

Data Analysis

The main objective of the present study was to an investigation into the effectiveness of laboratory method on Female students attitude and academic performance in chemistry Quantitative data collected through pre-posttest in quasi experimental design was analyzed via descriptive statistics and independent sample t-test with Statistical Package for Social Sciences (SPSS) at 0.05 significant level. Likert scales attitude questions test was ranked from strongly agree to strongly disagree. The negative statement was scored in revised order to positive statement. Strong agree (five marks) agree (four marks), neutral (three marks), disagree (two marks) and strongly disagree (one mark). After scoring each item, the average mean-scores, standard deviation and t-test among experimental and control groups were computed before and after intervention.

RESULTS AND DISCUSSION

Research Question One: What are the differences in the mean academic performance scores of students taught chemistry using laboratory work and those taught with Lecture Method?

Table 1: Means and Standard Deviations of Academic performance of Posttest Scores of Students taught chemistry using laboratory work and those taught with Lecture Method

Treatment	N	Mean	SD	Std Error
Experimental	62	49.11	8.171	
Control	66	44.53	9.093	

The Table 1 above showed the descriptive mean academic achievement scores of those taught with lecture methods in chemistry. The experimental group (exposed to a laboratory work) scored higher on average (Mean=49.11) than the control group (Mean=44.53). This showed that participants taught using laboratory method have the highest mean gain academic achievement of 49.11 followed by participants taught with lecture method who had the least mean gain achievement scores of 44.53. This implies that those taught with laboratory method have the highest mean gain academic achievement scores than participants in the control groups.

Hypothesis One: There is no significant difference in the mean academic performance scores of students taught chemistry using laboratory work and those taught using the lecture method.

Table 2: Results of Posttest Analysis of Independent sample t-test on Academic performance Scores

GroupTreatment Group	Mean	SD	T	Df	p-value	Effect size
Experimental	49.11	8.171	3.017	128	.003	0.529
ControControl	44.53	9.093				

The Experimental group outperformed the control group in chemistry performance, with a statistically significant difference in their mean scores. (49.11) and the (P<0.05) The medium effect size (Cohen's d = 0.529) indicates that the intervention applied to the experimental group had a meaningful positive impact. This suggests that the teaching method or strategy implemented in the experimental group was effective in enhancing their chemistry achievement compared to the traditional approach used with the control group. Therefore, the null hypothesis which states that there is no significant difference in the mean academic achievement scores of students taught chemistry with laboratory method and those taught with Lecture method (CG), is hereby rejected. This implies that laboratory method of instruction has produced significant difference in performance between experimental group. This is evident from the performance of posttest mean scores of the experimental groups having the highest mean value of 49.11and the least value of 44.53 recorded by the Control Group (CG).

Research Hypothesis two: The use of the laboratory method does not significantly influence female students' attitudes toward learning chemistry in Kontagora, Niger State.

A Pearson correlation coefficient was computed to assess the linear relationship between Chemistry Female Student Attitude and performance

Table 3: Pearson Correlation for Chemistry Female Student Attitude and performance

Correlation		Chemistry achievement	Attitude
Chemistry achievement Attitude	Pearson Correlation (r)	1	.377**
	Sig. (2-tailed)		.000

**. Correlation is significant at the 0.01 level (2-tailed).

There was a Pearson correlation coefficient of 0.377 between the two variables r=0.377, n=130, p=0.000 indicating a moderate positive correlation between laboratory work and chemistry performance. This means that increased engagement in laboratory work is moderately associated with higher academic performance in chemistry. The p-value of

0.000 is less than the commonly used significance threshold of 0.01, suggesting that the correlation is statistically significant. This indicates that the relationship observed is not likely due to random chance. The results suggest that laboratory work contributes meaningfully to improving chemistry achievement. Practical, hands-on activities likely help reinforce theoretical concepts, which enhances understanding and application in academic assessments and the null hypothesis that "Laboratory work does have a significant and positive effect on female students' attitude on chemistry performance" was rejected.

Discussion

The results of this study reveal that laboratory-based instruction significantly enhances the academic performance of female students in Chemistry compared to the traditional lecture method. The post-test mean scores indicate a noticeable advantage for the experimental group (M = 49.11, SD = 8.17) over the control group (M = 44.53, SD = 9.09), with a statistically significant difference (t(128) = 3.017, p = 0.003). This finding is in line with earlier studies such as those by Uche & Eze (2020) and Kapici et al. (2020), who emphasized the efficacy of hands-on laboratory activities in boosting students' understanding and retention of scientific concepts. The moderate effect size (Cohen's d = 0.529) further reinforces the practical significance of the intervention, suggesting that active engagement with experimental tasks allows students to better conceptualize abstract Chemistry topics, thereby improving their performance.

Additionally, the study found a moderate positive correlation (r = 0.377, p < 0.01) between students' attitudes toward Chemistry and their academic performance, indicating that laboratory instruction not only improves achievement but also fosters a more positive disposition toward the subject. This supports the theoretical framework grounded in Expectancy-Value Theory, which posits that students are more likely to succeed when they perceive a task as valuable and believe in their ability to complete it successfully. Laboratory experiences, by making learning more interactive and meaningful, appear to elevate students' confidence and motivation. These findings affirm that fostering positive attitudes through laboratory-based learning can have a lasting impact on students' engagement and academic success in science education, especially among underrepresented groups like female learners in rural settings.

CONCLUSION

From these findings, the following conclusions are drawn:

Academic Performance: The experimental group showed a higher mean post-test score (M = 49.11, SD = 8.17) than the control group (M = 44.53, SD = 9.09). The difference was statistically significant (t(128) = 3.017, p = 0.003), with a moderate effect size (Cohen's d = 0.529), indicating that laboratory instruction positively affected academic performance.

Attitude toward Chemistry: A moderate positive correlation (r = 0.377, p < 0.01) was found between laboratory engagement and improved attitude, confirming that laboratory methods significantly influence students' interest, motivation, and confidence in Chemistry.

RECOMMENDATIONS

On the basis of the findings emanating from this study, the following recommendations are made:

Policy Implementation: The Ministry of Education should prioritize equipping schools with functional laboratories and promote laboratory-based instruction in science curricula.

Teacher Training: Regular workshops and professional development programs should be organized to train Chemistry teachers in effective laboratory teaching strategies.

Further Research: Additional studies should investigate other variables influencing learning, such as socio-economic factors and classroom interactions, to develop holistic STEM education strategies.

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