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Empirical Paper

Effect of Practical Work on Senior Secondary Students' Achievement in Physics in Katsina Metropolis, Nigeria

Attahir Tukur[1*], Abbas Sulaiman[2], Sulaiman Ahmad[3]

Affiliations

[1]Department of Physics, Isa Kaita College of Education, Dutsin-Ma, Katsina State, Nigeria
[2]Department of Chemistry, Isa Kaita College of Education, Dutsin-Ma, Katsina State, Nigeria
[3]Department of General Studies Education, Isa Kaita College of Education, Dutsin-Ma, Katsina State, Nigeria

ORCID Identifiers

Attahir Tukur
0009-0002-7071-7632

Abbas Sulaiman
0009-0002-2134-1333

Sulaiman Ahmad
0009-0002-8310-1578

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Abstract

Purpose: This study examined the effect of practical-based instruction on senior secondary school students' academic achievement in physics in Katsina metropolis, Nigeria. It also investigated whether gender differences exist in students' performance when exposed to practical-based instruction.

Methodology: The study adopted a quasi-experimental design with 100 SS2 students randomly assigned to an experimental group (practical-based instruction) and a control group (lecture method). Data were collected using a 20-item Physics Achievement Test (PhysAT), administered as both pre-test and post-test. The instrument had a reliability coefficient of 0.70. Data were analysed using means, standard deviations, and an independent-samples t-test.

Results: Findings revealed a statistically significant difference in the academic achievement of students taught using practical-based instruction and those taught using lecture methods, with the experimental group performing better. However, no significant difference was found between male and female students exposed to practical-based instruction.

Novelty and Contribution: This study provides empirical evidence from Katsina metropolis on the effectiveness of practical-based instruction in improving physics achievement. It contributes to the growing body of knowledge supporting learner-centred approaches and offers context-specific data relevant for curriculum implementation in Nigerian secondary schools.

Practical and Social Implications: The findings highlight the importance of integrating structured practical activities into physics teaching to enhance students' understanding and performance. The study also supports gender-inclusive instructional practices, suggesting that practical-based instruction promotes equal learning opportunities for both male and female students. Policymakers, educators, and curriculum planners are therefore encouraged to strengthen laboratory-based teaching to improve science education outcomes.

Keywords: Practical-based instruction, Physics achievement, Secondary school students, Gender differences

*Corresponding author
E-mail address: tahirtukur82@gmail.com

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1 Introduction

Education is universally regarded as the most strategic instrument for national development because it equips individuals with the knowledge, skills, values, and competencies required for economic productivity and social transformation. Modern economies depend largely on a well-educated citizenry capable of innovation, critical thinking, and problem-solving (UNESCO, 2021; World Bank, 2020). Consequently, nations invest heavily in education to enhance human capital development and global competitiveness. However, the effectiveness of any educational system depends largely on the quality of instruction delivered within specific disciplines, particularly science-related subjects that drive technological advancement.

Within the broader educational framework, science education plays a vital role in preparing learners for participation in a technology-driven world. It promotes inquiry, logical reasoning, creativity, and evidence-based decision-making necessary for solving contemporary societal problems (OECD, 2019; National Research Council, 2018). In developing countries such as Nigeria, science education is particularly crucial for achieving sustainable development goals and industrial growth. Despite its recognised importance, students' engagement and performance in science subjects remain relatively low, raising concerns about instructional approaches and learning environments. Among the science disciplines, physics presents the greatest challenge to learners, necessitating focused attention on its teaching and learning processes.

Physics education is fundamental because physics explains natural phenomena and underpins innovations in engineering, medicine, communication technology, transportation systems, and environmental management (Redish & Hammer, 2009). However, persistent reports indicate poor academic achievement and declining interest in physics among secondary school students in many countries, including Nigeria (WAEC Chief Examiners' Reports, 2020–2024; Ibrahim, 2023). Researchers attribute this trend largely to abstract content presentation and over-dependence on teacher-centred instructional strategies. These challenges highlight the need for learner-centred approaches capable of improving conceptual understanding and engagement, one of which is practical work.

Practical work involves structured laboratory or activity-based experiences where students interact directly with materials, equipment, and observable phenomena to construct knowledge through investigation (Abrahams & Millar, 2011; Hodson, 2018). Unlike the traditional lecture method, it encourages active participation, inquiry, experimentation, and collaborative learning. Studies show that practical activities enhance conceptual understanding, retention, and scientific reasoning by linking theory to real-life applications (Hofstein & Kind, 2019; Kibirige & Tsamago, 2019). Furthermore, practical instruction provides inclusive learning opportunities that reduce gender gaps in science participation because students learn by doing rather than memorising abstract ideas. These benefits suggest that practical work may significantly influence students' learning outcomes, especially academic achievement.

Academic achievement in physics reflects the extent to which students understand concepts, apply principles, and solve real-world problems successfully. Evidence indicates that instructional methods strongly determine achievement levels, with activity-based approaches consistently producing better outcomes than passive learning strategies (Freeman et al., 2019; Lazonder & Harmsen, 2016). Therefore, investigating how practical work influences students' academic performance compared with conventional lecture teaching becomes essential.

Despite the recognised importance of practical work in science education, many secondary schools in Katsina metropolis still rely heavily on lecture-based teaching methods, with limited emphasis on hands-on laboratory activities. Previous studies have examined practical work in different contexts; however, there is limited empirical evidence on its specific impact on students' academic achievement in physics within Katsina metropolis. Furthermore, the issue of gender differences in performance under practical-based instruction remains underexplored in this context. This gap necessitates the present study.

Research Questions:

The study was guided by the following main research question;

i. What is the difference in the mean of the academic achievement scores of students taught physics concepts using the practical method and those taught using the lecture method in Senior Secondary Schools, Katsina metropolis?

ii. What is the difference in the mean academic achievement scores of male and female students when taught physics concepts using the practical method in Senior Secondary Schools, Katsina metropolis?

Research Hypotheses:

The following null hypotheses are formulated and were tested at $p < 0.05$ levels of significance.

H_{01}: There is no significant difference between the mean academic achievement scores of students taught physics concepts using the practical method and those taught using the lecture method in Senior Secondary School, Katsina metropolis.

H_{02}: There is no significant difference between the mean academic achievement scores of male and female students taught Physics concept using practical method in Senior Secondary Schools, Katsina metropolis.

2 Research Methodology

2.1 Research Design

This study employed a quasi-experimental design involving random assignment of students to experimental and control groups, with pre- and post-tests administered.

2.2 Sample and Sampling Techniques

A total of 100 SS2 students (50 males, 50 females) were randomly selected from two public secondary schools in Katsina metropolis. The two schools were purposively selected based on their comparable characteristics and accessibility. Stratified random sampling was used to ensure gender balance.

School	Number of male students	Number of female students
G.S.S.S Kofar Kaura	25	25
G.D.S.S.S Kofar Yandaka	25	25
Total	50	50

2.3 Instrumentation

The Physics Achievement Test (PhysAT), developed and validated by subject matter experts, consisted of 20 multiple-choice questions adapted from past WAEC examinations. A pilot test with a similar population yielded a reliability coefficient of 0.70 using the test-retest method.

2.4 Data Analysis

Data were analysed using SPSS software. Descriptive statistics (mean and standard deviation) and inferential statistics (independent samples t-test) were applied at a significance level of 0.05.

3 Results

The data collected in the course of the study were analysed using statistical techniques of mean and standard deviation and T-test at 0.05 level of significance using Statistical Packages for the Social Sciences (SPSS).

Research Question 1: What is the difference in the mean of the academic achievement scores of students taught physics concepts using the practical method and those taught using the lecture method in Senior Secondary Schools in Katsina metropolis?

Table 3.1 Mean and Standard Deviation of Academic Achievement Scores of students taught physics concepts using the practical method and those taught using the lecture method.

Groups	N	Mean	S.D	M.D
Experimental	50	18.06	1.20	4.68
Control	50	13.36	1.36	

The result in Table 3.1 presents the post-test mean score of students taught using the experimental method and those taught using lecture methods. The result revealed that the students taught using the experimental method recorded a mean score of 18.06 and a standard deviation of 1.20, and the students taught using the lecture method recorded a mean score of 13.36 and a standard deviation of 1.36. The result shows a mean difference of 4.68 in favour of the experimental group. The higher mean score of the experimental group shows that students taught physics using practical work performed better than those taught using the lecture method.

Research Question 2: What is the difference in mean academic achievement scores of male and female students when taught physics concepts using the practical method in Senior Secondary Schools in Katsina metropolis?

Table 3.2 Mean and Standard Deviation of practical method on male and female students' academic achievement when taught concept of Physics in Senior Secondary Schools.

Group	N	Mean	S.D.	M.D.
Male	25	17.96	1.21	0.20
Female	25	18.16	1.21	

The result in Table 3.2 presents the post-test mean score of students taught using the experimental method and those taught using lecture methods. The result revealed that the Male students taught using the practical method recorded a mean score of 17.96 and a standard deviation of 1.21, and the Female students recorded a mean score of 18.16 and a standard deviation of 1.21. This shows a mean difference of 0.20. The mean difference indicates no significant difference between the male and female students taught physics using practical work.

Research Hypothesis 1

There is no significant difference between the mean academic achievement scores of students taught Physics concepts using the practical method, and those taught the same concepts using the lecture method in senior secondary schools.

Table 3.3 t-test Analysis of academic achievement of student scores taught physics concepts using practical method and those taught using lecture method.

Group	N	Mean	S.D.	D.F.	t	p	Remark
Experimental	50	18.06	1.20	98	16.78	0.000	Rejected
Control	50	13.38	1.56				

The result in Table 3.3 shows that the mean score of students in the experimental group (18.06) is higher than that of the control group (13.38), with a mean difference of 4.68 in favour of the experimental group. The calculated t-value of 16.78 with a p-value of 0.000 is less than the alpha level of 0.05. Therefore, the null hypothesis is rejected. This indicates that there is a statistically significant difference in the academic achievement scores of students taught Physics using the practical method and those taught using the lecture method.

Research Hypothesis 2

There is no significant difference between the mean academic achievement scores of male and female students taught Physics concepts using the practical method in senior secondary schools.

Table 3.4 t-test Analysis of the mean academic achievement scores of male and female students taught concept of Physics using practical method.

Group	N	Mean	S.D.	D.F.	t	p	Remark
Male	25	17.96	1.21	48	0.58	0.562	Accepted
Female	25	18.16	1.21				

The result in Table 3.4 shows that the mean score of male students (17.96) and female students (18.16) differs slightly by 0.20. The calculated t-value of 0.58 with a p-value of 0.562 is greater than the alpha level of 0.05. Therefore, the null hypothesis is not rejected. This indicates that there is no statistically significant difference in the academic achievement scores of male and female students taught Physics using the practical method.

4 Discussion of Findings

Physics remains a core science subject in the Nigerian secondary school curriculum due to its critical role in scientific innovation, technological advancement, and national development. In recognition of this importance, the Federal Republic of Nigeria emphasised activity-based and practical-oriented science teaching in the National Policy on Education (FRN, 2014) to enhance meaningful learning and skill acquisition. Practical engagement enables students to translate theoretical knowledge into functional understanding required in contemporary society.

The result of Research Hypothesis H_{01} (Table 3.3) revealed that there is a statistically significant difference in the mean academic achievement scores of students taught Physics concepts using the practical method and those taught using the lecture method. This is evident from the p-value (0.000), which is less than the alpha level of 0.05, leading to the rejection of the null hypothesis. The experimental group performed significantly better than the control group, indicating that the practical method is more effective in enhancing students' academic achievement in Physics. This finding supports the view that activity-based learning promotes deeper understanding and improved performance. It is consistent with constructivist learning theory, which posits that learners achieve better outcomes when they actively engage in the learning process (Abrahams & Millar, 2011).

This finding is also in agreement with previous empirical studies which reported that practical and inquiry-based teaching methods significantly improve students' achievement, attitude, and participation in Physics (Freeman et al., 2019; Kibirige & Tsamago, 2019). Similarly, research has shown that students exposed to experimental learning environments demonstrate superior conceptual understanding compared to those taught using traditional lecture methods (Hofstein & Kind, 2019; Lazonder & Harmsen, 2016). Therefore, the significant difference observed in this study confirms the effectiveness of the experimental method over the lecture method in teaching Physics concepts.

The result of Research Hypothesis H_{02} (Table 3.4) indicated that there is no statistically significant difference in the mean academic achievement scores of male and female students taught Physics using the experimental method. This is based on the p-value (0.562), which is greater than the alpha level of 0.05, leading to the decision not to reject the null hypothesis. This finding implies that gender does not significantly influence students' academic achievement when exposed to practical work and activity-based instructional strategies.

This result supports existing literature which suggests that participatory and hands-on learning environments help to minimise gender disparities in science education by providing equal opportunities for engagement (UNESCO, 2021; Kibirige & Tsamago, 2019). Furthermore, studies have shown that collaborative and practical teaching approaches enhance learning outcomes for both male and female students without bias (Hofstein & Kind, 2019; OECD, 2019). The implication is that students' achievement in Physics is more strongly influenced by instructional methods than by gender differences.

Overall, the findings of this study demonstrate that the use of experimental teaching methods significantly improves students' academic achievement in Physics, while also promoting gender equity in learning outcomes. This underscores the importance of adopting learner-centred and activity-based instructional approaches in Physics education to enhance both performance and inclusivity.

5 Conclusions of the study

The study made the following conclusions: The first objective of the study was to establish the effects of practical work in Physics on students' academic achievement in Physics. The study concluded that the students exposed to practical work in Physics performed better than those taught through the conventional method. The second objective of the study was to establish the effects of practical work in Physics on students' attitude change towards Physics. The study concluded that there was a significant difference in attitude change towards Physics for students taught Physics through practical work and those taught through conventional methods. The third objective was to determine the effect of practical work in Physics on students' acquisition of science process skills. The experimental groups had higher scores than the control groups in the science process skills. The study concluded that the students taught Physics through practical work acquired more science process skills than those taught Physics through the conventional method.

Recommendations

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

Adoption of Experimental Teaching Method: Physics teachers should adopt the practical work (activity-based) method in teaching Physics concepts, as it has been shown to significantly improve students' academic achievement compared to the conventional lecture method.

Teacher Training and Professional Development: Educational authorities and school administrators should organise regular workshops, seminars, and training programmes to equip Physics teachers with the skills required to effectively implement experimental and learner-centred instructional strategies.

Provision of Laboratory Facilities and Materials: Government and school management should ensure adequate provision of well-equipped laboratories, instructional materials, and practical resources to facilitate effective teaching and learning of Physics through experimentation.

Practical and Social Implications

The findings revealed that the Practical-Based Instruction method enhances students' academic achievement in Physics more effectively than the lecture method, indicating the need for more learner-centred and hands-on teaching approaches. The study also found no significant gender difference in students' performance, suggesting that equal learning opportunities promote balanced achievement in Physics. Practically, schools should improve laboratory facilities and provide adequate instructional materials, while socially, the findings support gender equality and equal participation in science education.

Limitations and Future Research Directions

This study was limited to selected secondary schools, a small sample size, and only one Physics topic, which may affect the generalisation of the findings. The study duration and differences in school facilities and teaching resources also influenced the results. For further research, future studies should employ larger samples and broader study areas, examine other Physics topics, investigate long-term retention effects, and explore the influence of school resources, teacher experience, and classroom environment on the effectiveness of experimental teaching methods.

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Availability Statement

Data will be made available on request.

Conflict of Interest

The author declares no conflicts of interest.

Declaration of generative AI usage

Generative AI tools were used solely for language editing (grammar, clarity, and formatting) and did not contribute to the study's design, data collection, analysis, interpretation, or conclusions.

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