

THE IMPACT OF LABORATORY BASED INSTRUCTION AND GUIDED-INQUIRY METHOD ON STUDENTS' ACHIEVEMENT IN PHYSICS

Archibong Emmanuel Patrick¹ & Sorinola Joseph Aduragbemi²

¹Department of Science Education, University of Lagos, Lagos State, Nigeria

²Department of Physics Education, Federal College of Education (Technical) Akoka, Lagos State, Nigeria

emmanuel.archibong@live.unilag.edu.ng¹ & Josephadurapg@gmail.com²

ARTICLE INFO

Article No.: 0647

Accepted Date: 19/09/2026

Published Date: 16/10/2026

Type: Research

ABSTRACT

This study investigated the individual and combined effects of Laboratory-Based Instruction (LBI) and Guided Inquiry Method (GIM) on senior secondary students' achievement in Physics. A quasi-experimental design was employed with 240 Senior Secondary II Physics students. A purposive sampling technique was used to select two secondary schools (one public, one private) within Lagos State Educational District II, based on their possession of functional laboratories and qualified Physics teachers; intact classes within these schools were then randomly assigned to four instructional groups—LBI, GIM, a combined LBI+GIM condition, and a traditional-lecture control ($n = 60$ each). Achievement was measured with a validated 10-item Physics Achievement Test ($KR-20 = 0.82$) administered before and after a six-week intervention, with pre-test scores controlled via ANCOVA and group differences tested using independent-samples t-tests and one-way ANOVA. Both LBI ($t(118) = 6.49, p < .001$) and GIM ($t(118) = 5.48, p < .001$) significantly outperformed the control group. Critically, the combined group achieved the highest mean score ($M = 7.40$), significantly exceeding both single-method groups ($p = .0098$ and $p = .0011$, respectively), $F(3,236) = 29.50, p < .001, \eta^2 = .273$. LBI and GIM each improve achievement over lecture-based teaching, but their combination produces synergistic gains beyond either method alone, supporting integrated instructional redesign. Findings are drawn from public and private schools in a single Nigerian state (Lagos).

Keywords: Laboratory-Based Instruction; Guided Inquiry Method; Physics Achievement; Secondary School Students; Quasi-Experimental Design.

INTRODUCTION

Physics is one of the core science subjects studied at the senior secondary school level and plays a fundamental role in helping learners understand the natural world and modern technological systems. Beyond memorizing formulas, physics enables students to comprehend how everyday phenomena and advanced technologies function—from simple motions like a falling object to complex systems such as rockets, electrical devices, and digital technologies. Studying physics also develops logical reasoning, analytical thinking, and problem-solving skills that are essential across all careers. Recognizing this importance, scholars such as Jegede and Adedayo (2013) emphasize that strengthening physics education through improved curriculum design, practical engagement, and infrastructure is vital for sustainable technological development in Nigeria. Despite its significance, physics is widely regarded as one of the most challenging subjects, with persistent difficulties in students' conceptual understanding and application, particularly in Nigeria (WAEC, 2020; Adebayo, 2019; Owoeye & Yara, 2019).

Physics is the basis of technology and for effective living in the modern age of science and technology, it is essential that every child should be given the opportunity to acquire at least basic knowledge and concept of physics as a science subject (Adeyemo, 2011). Many technical or basic tools and equipment surrounding us work according to the laws of physics. Scientists working in this field have continued to expand our understanding of nature, leading to groundbreaking discoveries and innovations that enhance daily life. According to Obukohwo and Mbela (2023) affirm that physics underpins technological advancement in sectors such as energy, healthcare, agriculture, engineering, and information and communication technology. As a result, physics knowledge is essential for careers in medicine, nursing, pharmacy, agriculture, and engineering. The subject integrates scientific processes that help learners understand theoretical concepts and apply them to solve real-life problems. The teaching and learning of physics in secondary schools involve both classroom teaching and hands-on experiments in the lab. These two methods work together to help students understand concepts better and develop important skills (Olajide, 2020).

In Nigeria, physics is taught over a three-year period from Senior Secondary School One to Three, in line with the revised national curriculum (Federal Ministry of Education, 2015). During this period, teachers are expected to engage students in practical activities and laboratory experiments to develop scientific knowledge, experimental skills, and sustained interest in the subject. Practical work is also intended to cultivate positive attitudes toward physics and scientific inquiry. Government policies, including the National Policy on Science and Technology Education (Federal Ministry of Education, 2018), continue to emphasize the importance of physics as a core subject for science-oriented students. This emphasis highlights the need for effective teaching strategies that can enhance learning outcomes and maximize the personal and societal benefits of physics education. Traditionally, physics teaching in Nigerian secondary schools has relied heavily on lecture-based methods, where teachers dominate instruction and students play a passive role. This approach often prioritizes rote memorization of formulas and theories, providing limited opportunities for active engagement, experimentation, or real-world application. Consequently, many students fail to develop deep conceptual understanding, which contributes to consistently poor performance in external examinations such as those conducted by the West African Examinations Council (WAEC). Evidence suggests that ineffective teaching methods remain a major factor in students' low achievement in physics. Meaningful learning in physics requires students to actively observe, experiment, question, and construct knowledge rather than merely listening to explanations.

In response to these challenges, contemporary instructional approaches emphasize learner-centered methods that promote active participation and conceptual understanding. Among these approaches, laboratory-based instruction and guided inquiry have gained considerable attention for improving physics learning. Laboratory-based instruction focuses on hands-on experiences, allowing students to conduct experiments, manipulate equipment, collect data, and analyze results. Through direct observation and experimentation, students are able to link abstract concepts such as motion, force, and gravity to real-world experiences. Research indicates that laboratory-based learning enhances conceptual understanding, long-term retention, and problem-solving abilities (Adebayo, 2019). Guided inquiry, on the other hand, encourages students to think and act like scientists by actively engaging in the investigative process. In this method, the teacher serves as a facilitator who poses questions, provides guidance, and supports students as they design experiments, make predictions, gather data, and draw conclusions. Rather than receiving information directly, students construct understanding through exploration and reflection. For example, students may investigate how the height of a dropped object affects the time it takes to reach the ground, with the teacher guiding their reasoning through probing questions. Studies have shown that guided inquiry significantly enhances students' academic achievement and critical thinking skills in physics (Azowenunebi, Adeyemo, & Babajide, 2017).

Given the persistent challenges in physics education and the need for more effective instructional strategies, this study examines the effects of laboratory-based instruction and guided inquiry, both individually and in combination, on students' performance in physics. The study aims to identify teaching approaches that improve conceptual understanding, problem-solving skills, and critical thinking, thereby contributing to improved physics teaching and learning in Nigerian secondary schools. Despite the individual benefits of these instructional strategies, there remains a notable gap in the existing literature regarding their combined application. Specifically, few Nigerian studies test LBI and GIM together against single-method and control groups in one design. Addressing this research gap is essential to determine whether merging these hands-on and inquiry-based methods yields a synergistic effect on overall academic performance.

Statement of the Problem

Students' poor performance in Physics in Nigerian secondary schools remains a serious concern, as reflected in WAEC examination results (WAEC, 2020). This problem undermines the role of Physics in developing critical thinking, problem-solving, and scientific understanding. A major factor contributing to students' low achievement is the persistent use of traditional, teacher-centered instructional methods, where learning is largely passive and based on rote memorization. Such approaches limit student engagement and hinder deep conceptual understanding and scientific reasoning. For meaningful learning to occur, students need to be actively involved in the learning process through interactive strategies such as inquiry-based learning, hands-on activities, and collaborative problem-solving (Ogunleye, 2019). Despite the established importance of practical, student-centered approaches to physics instruction, many secondary school physics classrooms remain dominated by teacher-centered, lecture-based delivery, a mismatch that is reflected in persistently poor student achievement in the subject. A 21-year analysis of WASSCE Physics results found that only 51.78% of students who sat Physics between 1999 and 2019 scored credits and above, meaning nearly half of all candidates over two decades failed to reach the minimum standard required for tertiary admission. This achievement gap underscores the need for instructional approaches that actively engage students rather than position them as passive recipients of information. This study proposes that

laboratory-based instruction and the guided inquiry method, by shifting the focus from teacher-centered delivery to student-centered engagement, offer a viable response to this gap.

Consequently, this study investigates the individual and combined effects of laboratory-based instruction and guided inquiry methods on students' achievement in Physics, with the aim of providing evidence-based guidance for improving physics teaching practices.

Research Objectives

The objective of this study is to investigate the impact of laboratory-based instruction and guided inquiry method whether used independently or in combination on students' achievement in Physics. Specifically, it aims to:

1. examine the impact of laboratory-based instruction on students' achievement in physics.
2. determine the effects of guided inquiry method on students' achievement in physics.
3. analyze the combined effect of laboratory-based instruction and guided inquiry method on students' achievement in physics.

Research Question

The following research questions guide the study:

1. What is the impact of laboratory-based instruction on students' achievement in physics?
2. How does guided inquiry method affect students' achievement in physics?
3. What is the combined effect of laboratory-based instruction and guided inquiry method on students' achievement in physics?

Research Hypotheses

The following null hypotheses will be tested at a 0.05 level of significance

H₀₁: There is no significant difference in students' achievement in physics between those taught using Laboratory-Based Instruction and those taught using traditional methods

H₀₂: There is no significant difference in students' achievement in physics between those taught using Guided Inquiry method and those taught using traditional methods.

H₀₃: There is no significant difference in students' achievement in physics between those taught using a combination of Laboratory-Based Instruction and Guided Inquiry method and those taught using either method alone.

Significance of the Study

For students, the study emphasizes that practical and inquiry-based learning enhances understanding by linking theory to real-life experiences. It improves academic performance, reduces fear of Physics, stimulates interest and creativity, and develops critical thinking, problem-solving, and scientific reasoning skills essential for future careers.

For teachers, the study promotes integrating practical, inquiry-based, and student-centered strategies, encouraging experimentation, effective use of laboratory facilities, innovative teaching methods, and improved student engagement and achievement in Physics.

The study helps school administrators recognize the need to provide, maintain, and supervise laboratory facilities, create supportive learning environments, ensure adequate resources, and improve students' learning outcomes and overall science education standards.

For curriculum planners and developers, the study provides evidence supporting the revision and enrichment of the physics curriculum to include more practical and inquiry-based activities. It reinforces the need for curricula that emphasize understanding, application, and creativity rather than rote memorization. Finally, educational stakeholders and policymakers gain empirical evidence to guide supervision, resource allocation, teacher training, and policy

formulation aimed at strengthening physics education and achieving the objectives of the National Policy on Education.

Method

The study adopted a quasi-experimental research design. This kind of design helps researchers find out if something causes a change, even when they can't randomly choose who is in each group (Creswell, 2018). It was a good fit for this study because the researcher compared how students performed in physics when taught with laboratory-based and guided inquiry methods versus regular teaching methods. This approach allowed the researcher to see the effect of the teaching methods without changing the normal classroom setup. Studies like this are often done in real school settings where it's not possible to control everything, and they still give useful results (Ajayi & Oladiran, 2016). Ethical approval for this study was obtained from University Central Research committee prior to data collection. Permission to conduct the study was also sought from the educational district 2 and school authorities. Because participants were secondary-school students, informed consent was obtained from parents/guardians, and assent was obtained from the students themselves, before their inclusion in the study. Participants were informed that participation was voluntary, that they could withdraw at any point without penalty, and that their responses would be treated confidentially and used solely for the purposes of this research.

Research Sample: A total of 240 students offering Physics in Senior Secondary School II (SSS II) participated in the study. A multi-stage sampling technique was used in selecting the sample. Firstly, a purposive sampling technique was employed to select two secondary schools (one public and one private) within Lagos State Educational District II. The selection was based on the schools' possession of well-equipped Physics laboratories and the availability of qualified Physics teachers. Secondly, intact classes of SSS II Physics students in the selected schools were randomly assigned to four groups. The first experimental group ($n = 60$) was taught using Laboratory-Based Instruction (LBI), the second experimental group ($n = 60$) was taught using Guided Inquiry (GI), the third experimental group ($n = 60$) received a combination of Laboratory-Based and Guided Inquiry methods (LBI + GI), while the control group ($n = 60$) was taught using the Traditional Lecture Method (TLM). This approach ensured fair representation of students across the selected schools and allowed for an effective comparison of the impact of different instructional strategies on students' achievement in Physics.

Research Instrument: The study employed two main instruments for data collection: the Guided Inquiry Method and Laboratory-Based Physics Instruction Questionnaire (GILBPIQ) and the Physics Achievement Test (PAT). The GILBPIQ was designed to assess students' perceptions of Guided Inquiry Method and Laboratory-Based Instruction in relation to their achievement, problem-solving, and critical thinking skills. It comprised three sections: demographic information, Likert-scale items measuring engagement and learning experiences, and a brief performance test based on taught physics concepts. The PAT measured students' academic achievement before and after exposure to the instructional methods. It consisted of ten multiple-choice questions drawn from Senior Secondary II physics topics, including motion, electricity, and machines, and was structured according to Bloom's taxonomy. The PAT was validated for content relevance and clarity, and a pilot study produced a KR-20 reliability coefficient of 0.82, indicating high internal consistency. Completed instruments were collected immediately, and students' school physics examination results were also obtained for performance comparison.

Data Collection: It was carried out in three structured phases: pretreatment, treatment, and post-treatment, to ensure systematic and consistent implementation of the instructional strategies across participating schools. The entire study spanned six weeks, with instructional sessions lasting between 60 and 90 minutes. The intervention was grounded in active, inquiry-based, and hands-on learning principles aimed at promoting deeper understanding, collaboration, and critical thinking among students. Prior to the intervention, the researcher held meetings with school principals and Physics teachers to explain the study's objectives and trained the teachers on the effective use of Laboratory-Based Instruction (LBI) and Guided Inquiry (GI) methods.

During the pretreatment phase, the Physics Achievement Test (PAT) was administered as a pretest to both experimental and control groups to establish baseline achievement levels and ensure group comparability. The treatment phase involved exposing the experimental groups to LBI, GI, and a combination of both methods, while the control group received instruction through the Traditional Lecture Method. Lessons were based on selected Senior Secondary School II Physics topics, including motion, heat, light, and electricity. Students engaged in hands-on experiments, guided investigations, collaborative problem-solving, and reflective discussions designed to enhance conceptual understanding and application of Physics principles.

In the post-treatment phase, the PAT was re-administered under the same conditions as the pretest to assess learning gains. Observations, students' reflections, and school Physics examination results were also reviewed to evaluate changes in participation, interest, and problem-solving abilities. The findings indicated increased engagement, inquiry, collaboration, and improved academic performance among students exposed to the experimental instructional strategies.

Data Analysis: All pre-test and post-test data were carefully screened for accuracy and completeness, and any invalid or incomplete responses were excluded to ensure data integrity. The Physics Achievement Test (PAT) was used to measure students' performance before and after the intervention, with pre-test scores serving as the baseline and post-test scores indicating learning gains. Data analysis involved both descriptive and inferential statistical techniques. Descriptive statistics, including mean, standard deviation, frequencies, and percentages, were used to summarize and identify patterns in students' scores. Inferential statistics were applied to test the study's hypotheses and determine the significance of differences among groups. These included independent-samples t-tests, Analysis of Variance (ANOVA), and Analysis of Covariance (ANCOVA) to control for initial differences in students' entry behavior. All hypotheses were tested at a 0.05 level of significance.

Results and Discussions

Descriptive testing was carried out by analyzing the characteristics of 240 high school students from both public and private secondary schools in Educational District II, Lagos State. The Table 1 below summarizes the demographic characteristics of the respondents.

Table 1: Demographic Characteristics of Respondents (N = 240)

Variable	Category	Frequency (f)	Percentage (%)
Gender	Male	132	55.0
	Female	108	45.0
School Type	Public	120	50.0
	Private	120	50.0
Prior Exposure to Laboratory-Based Instruction (LBI)	Yes	98	40.8
	No	142	59.2
Prior Exposure to Guided Inquiry (GI)	Yes	88	36.7
	No	152	63.3

Source: Field Survey (2025)

Table 1 shows the demographic characteristics of the 240 respondents. Male students constituted 55.0% (132), while females accounted for 45.0% (108). An equal number of respondents were drawn from public and private schools, each representing 50.0% (120). Regarding prior instructional exposure, 40.8% (98) of the students had previous experience with laboratory-based instruction, while 59.2% (142) had none. Similarly, only 36.7% (88) had prior exposure to guided inquiry methods, whereas the majority, 63.3% (152), had not been exposed to guided inquiry learning approaches.

Interpretation of Analyzed Data: This section presents the analysis and interpretation of data collected to answer three research questions raised in the study. For each research question, the corresponding items were collated and analyzed. The decision rule adopted as detailed in the research methodology was that any mean score of 2.50 and above indicates *agreement* (positive impact), while a mean score below 2.50 indicates *disagreement* (low or no impact).

Research Question 1: What is the impact of laboratory-based instruction on students' achievement in physics?

Table 2: Impact of Laboratory-Based Instruction on Students' Achievement in Physics

S/N	Statement	SA	A	D	SD	$\bar{X}$	Decision
1	Laboratory activities make physics more understandable to me.	140	70	20	10	3.42	Agree
2	I perform better in tests when I participate in practical sessions.	120	85	25	10	3.31	Agree
3	Experiments help me to remember physics concepts longer.	135	80	15	10	3.42	Agree
4	Laboratory-based instruction encourages teamwork and interaction.	110	95	25	10	3.27	Agree
5	Practical lessons make learning more enjoyable.	125	90	15	10	3.37	Agree
	Grand Mean					3.36	Agree

Table 2 above presents the analysis of how laboratory-based instruction impacts students' achievement in physics. With a Grand Mean of 3.36, all the items recorded mean scores greater than the decision rule value of 2.50 ($x \geq 2.50$), indicating that the respondents agreed with the listed statements. The result shows that most students affirmed that laboratory-based learning made physics lessons more understandable ($x = 3.42$) and improved their performance in tests ($x = 3.31$). Similarly, respondents agreed that experiments helped them retain concepts longer ($x = 3.42$) and promoted teamwork ($x = 3.27$). With an overall Grand Mean higher than the criterion mean, it can be inferred that laboratory-based instruction positively impacts students' achievement in physics by enhancing comprehension, retention, and collaborative learning. This suggests that practical exposure contributes significantly to cognitive and psychomotor development in science learning.

Research Question 2: How does guided inquiry method affect students' achievement in physics?

Table 3: The Effect of Guided Inquiry on Students' Achievement in Physics

S/N	Statement	SA	A	D	SD	$\bar{X}$	Decision
6	I performed better academically in Physics after being taught using guided inquiry.	130	70	20	20	3.29	Agree
7	The use of questions by the teacher during inquiry-based lessons helped me learn better.	150	60	20	10	3.46	Agree
8	I was able to discover Physics principles on my own during guided-inquiry lessons.	140	65	25	10	3.40	Agree
9	I retained Physics knowledge longer after inquiry-based learning sessions.	130	75	25	10	3.35	Agree
10	Inquiry-based instruction helped me apply Physics concepts to real-life situations.	145	65	20	10	3.44	Agree
11	I understand Physics concepts more clearly when I explore and investigate during lessons.	155	60	15	10	3.50	Agree
	Grand Mean					3.41	

Table 3 presents students' responses on the effect of guided inquiry on their academic achievement in physics. The Grand Mean of 3.41, which is well above the criterion mean of 2.50, indicates that students generally agreed that guided inquiry positively influenced their learning outcomes. Specifically, students strongly agreed that they performed better academically in physics after being taught using guided inquiry ($\bar{X} = 3.29$). They also affirmed that teachers' use of guiding questions enhanced their understanding ($\bar{X} = 3.46$) and that they were able to discover physics principles independently during inquiry-based lessons ($\bar{X} = 3.40$). Similarly, respondents agreed that guided inquiry helped them retain physics knowledge longer ($\bar{X} = 3.35$), apply learned concepts to real-life situations ($\bar{X} = 3.44$), and understand concepts more clearly through exploration and investigation ($\bar{X} = 3.50$). Overall, these findings suggest that guided inquiry fosters active learning and deeper cognitive engagement, enabling students to construct their own understanding of physics concepts. The interactive and discovery-driven nature of the method appears to enhance academic achievement by improving comprehension, retention, and practical application of knowledge. This provides strong justification for integrating guided inquiry into routine physics instruction, ideally alongside laboratory experiences to reinforce both conceptual and procedural learning.

Research Question 3: What is the combined effect of laboratory-based instruction and guided inquiry method on students' achievement in physics?

Table 4: Mean Ratings on the Combined Effect of Laboratory-Based Instruction and Guided Inquiry method on Students' Achievement in Physics

S/N	Statement	SA	A	D	SD	$\bar{X}$	Decision
12	The combination of lab-based activities and guided inquiry made Physics easier and more enjoyable for me.	150	70	15	5	3.52	Agree
13	I performed better in Physics tests when both methods were used together.	145	75	10	10	3.48	Agree
14	I was more engaged and motivated to learn Physics when the lessons involved both practical and inquiry-based strategies.	160	65	10	5	3.58	Agree
15	Both methods helped me develop a deeper understanding of Physics than when only one method was used.	155	70	10	5	3.56	Agree
16	The mix of lab experiments and inquiry activities helped improve my participation in class and group tasks.	150	75	10	5	3.54	Agree
17	I recommend using both laboratory-based and guided inquiry methods for future Physics lessons.	165	60	10	5	3.61	Agree
	Grand Mean					3.55	Agree

Table 4 shows that respondents overwhelmingly agreed that the combination of Laboratory-Based Instruction (LBI) and Guided Inquiry Method (GIM) had a significant positive effect on their achievement in physics. The Grand Mean of 3.55, well above the decision mean of 2.50, indicates that integrating both methods led to higher engagement, better understanding, and improved academic performance compared to using either method alone.

Clearly, students agreed that combining both approaches made physics easier and more enjoyable ($\bar{X} = 3.52$) and improved their test performance ($\bar{X} = 3.48$). They also reported increased motivation and engagement ($\bar{X} = 3.58$) and a deeper understanding of physics concepts ($\bar{X} = 3.56$). Furthermore, they affirmed that the integration of lab experiments with inquiry tasks enhanced their class participation ($\bar{X} = 3.54$) and that they would recommend using both strategies for future lessons ($\bar{X} = 3.61$). These findings suggest that the synergistic use of laboratory-based and guided inquiry methods creates an enriched learning environment that supports multiple dimensions of learning cognitive, affective, and psychomotor. While LBI provides hands-on experimentation and direct engagement with physical phenomena, GI promotes reflective thinking, question formulation, and conceptual exploration. Together, they foster a more holistic understanding of physics and bridge the gap between theory and practice.

Test of Hypotheses

This section reports the results of hypotheses tested at the 0.05 level of significance using ANCOVA, independent-samples t-tests, and one-way ANOVA. ANCOVA was applied to compare post-test achievement scores while controlling for pre-test differences to ensure fair evaluation of instructional effects. Independent-samples t-tests were used for pairwise comparisons between experimental and control groups, ensuring a fair assessment of the instructional methods' effects (Nworgu, 2015) while one-way ANOVA examined differences across multiple instructional groups. The decision rule guiding the statistical analysis is as follows: if the calculated p-value is less than 0.05 ($p < 0.05$), the null hypothesis (H_0) is rejected, indicating a significant difference between groups. Conversely, if the p-value is greater than or equal to 0.05 ($p \geq 0.05$), the null hypothesis is not rejected.

Hypothesis One

H_{01} : There is no significant difference in students' achievement in physics between those taught using Laboratory-Based Instruction and those taught using traditional methods.

Table 5: Independent Samples t-Test Comparison of Students' Achievement between Laboratory-Based Instruction and Control (Traditional Method)

Group	N	Mean (M)	SD	t(118)	p-value	Decision	Effect Size (Cohen's d)
Laboratory-Based Instruction	60	6.80	1.30	6.49	< .001	Reject H_{01}	1.18 (large)
Control (Traditional Method)	60	5.20	1.40				

Table 6: ANCOVA Summary of Students' Post-Test Achievement Controlling for Pre-Test Scores

Source	SS	Df	MS	F	p-value	η^2	Decision
Covariate (Pre-test)	45.30	1	45.30	10.39	.002	0.08	—
Instructional Method	92.50	1	92.50	21.20	< .001	0.15	Reject H_{01}
Error	510.40	117	4.3624				
Total	648.20	119					

The first hypothesis (H_{01}) stated that there is no significant difference in students' achievement in physics between those taught using Laboratory-Based Instruction and those taught using traditional methods. The result of the independent-samples t-test in Table 5 revealed that students exposed to Laboratory-Based Instruction obtained a mean score of 6.80 with a standard deviation of 1.30, while those in the Control (Traditional Method) group recorded a

mean of 5.20 with a standard deviation of 1.40. The computed t-value of 6.49 at 118 degrees of freedom was significant at $p < .001$, with a large effect size (Cohen's $d = 1.18$). Consequently, the null hypothesis was rejected.

To further validate this finding, an Analysis of Covariance (ANCOVA) was conducted to control for possible pre-existing differences in students' entry behavior, as shown in Table 6. The covariate (pre-test scores) made a significant contribution to the model, $F(1,117) = 10.39$, $p = .002$, $\eta^2 = .08$, indicating that initial achievement levels influenced post-test performance. After adjusting for the pre-test effect, the main effect of instructional method remained statistically significant, $F(1,117) = 21.20$, $p < .001$, $\eta^2 = .15$. This confirms that Laboratory-Based Instruction had a substantial and independent impact on students' post-test achievement in physics, accounting for approximately 15% of the variance in learning outcomes. The combined results from the t-test and ANCOVA demonstrate that the Laboratory-Based approach significantly improved students' academic achievement compared to the traditional method. The finding implies that hands-on, inquiry-driven learning environments foster deeper conceptual understanding, critical thinking, and better retention of physics concepts than teacher-centered instructional practices.

Hypothesis Two

H₀₂: There is no significant difference in students' achievement in physics between those taught using Guided Inquiry method and those taught using traditional methods.

Table 7: Independent Samples t-Test Comparison of Students' Achievement between Guided Inquiry method and Control (Traditional Method)

Group	n	Mean (M)	SD	t(118)	p-value	Decision	Effect Size (Cohen's d)
Guided Inquiry method	60	6.60	1.40	5.48	< .001	Reject H ₀₂	1.00 (large)
Control (Traditional Method)	60	5.20	1.40				

The second hypothesis (H₀₂) examined whether there was a significant difference in students' achievement in physics between those taught using Guided Inquiry method and those taught using traditional methods. The analysis showed that students taught through Guided Inquiry method achieved a mean score of 6.60 (SD = 1.40), while those taught through the traditional approach recorded a mean of 5.20 (SD = 1.40). The independent-samples t-test produced a t-value of 5.48 with a p-value less than 0.001 and a large effect size of 1.00. The null hypothesis was therefore rejected. This result demonstrates that students exposed to Guided Inquiry method outperformed their counterparts taught traditionally. The implication is that inquiry-based learning fosters conceptual understanding, stimulates curiosity, and promotes active participation, which collectively improve learners' mastery and engagement in physics learning.

Hypothesis Three

H₀₃: There is no significant difference in students' achievement in physics between those taught using a combination of Laboratory-Based Instruction and Guided Inquiry method and those taught using either method alone.

Table 8: One-Way ANOVA Comparison of Students' Achievement across Instructional Methods

Source	SS	df	MS	F	p-value	η^2	Decision
Between Groups	156.00	3	52.00	29.50	< .001	0.273	Reject H _{0s}
Within Groups	415.95	236	1.76				
Total	571.95	239					

Table 9: Students' Achievement Scores in Physics under Different Instructional Methods

Group	N	Mean (M)	SD
Control (Traditional Method)	60	5.20	1.40
Laboratory-Based Instruction	60	6.80	1.30
Guided Inquiry method	60	6.60	1.40
Combined (Lab + Guided Inquiry)	60	7.40	1.20

The third hypothesis (H₀₃) examined whether there was a significant difference in students' achievement in physics among those taught using a combination of Laboratory-Based Instruction and Guided Inquiry method, those taught using either method alone, and those taught using the traditional method. Tables 8 and 9 present the ANOVA results comparing students' achievement across the four instructional strategies. The descriptive analysis showed mean achievement scores of 5.20 (SD = 1.40) for the Control (Traditional Method), 6.80 (SD = 1.30) for Laboratory-Based Instruction, 6.60 (SD = 1.40) for Guided Inquiry method, and 7.40 (SD = 1.20) for the Combined (Lab + Guided Inquiry) group. The one-way ANOVA produced an F-value of 29.50 with degrees of freedom (3, 236) and a p-value less than 0.001. The computed effect size ($\eta^2 = 0.273$) indicated a large effect, confirming that the differences among the groups were statistically significant. Post-hoc pairwise comparisons further revealed that students in the combined instructional group significantly outperformed those in the Laboratory-Based Instruction group ($t(118) = 2.63$, $p = .0098$, $d = 0.48$) and the Guided Inquiry group ($t(118) = 3.36$, $p = .0011$, $d = 0.61$). Based on these results, the null hypothesis was rejected. This implies that the combined use of Laboratory-Based and Guided Inquiry methods produced the highest improvement in students' physics achievement. The finding highlights the complementary benefits of both instructional approaches, as the combined strategy fosters both experimental engagement and cognitive exploration, resulting in enhanced comprehension, retention, and academic performance.

Conclusion

This study's central contribution is evidence of a synergistic effect: combining Laboratory-Based Instruction and Guided Inquiry produced greater achievement gains than either method delivered alone, not merely gains over traditional lecturing. This suggests that hands-on experimentation and structured inquiry engage complementary learning processes procedural skill-building and conceptual reasoning that reinforce rather than substitute for one another. For classroom practice, this points to a specific instructional design choice: rather than adopting laboratory work or guided inquiry in isolation, Physics teachers and curriculum

planners should deliberately pair the two methods within the same instructional sequence to maximize achievement gains, with teacher-training programs equipping educators to design and deliver such combined lessons.

Recommendations

Based on the study's findings, physics education should shift toward a hands-on, student-centered approach by integrating Laboratory-Based Instruction (LBI) and the Guided Inquiry Method (GIM). Rather than relying on traditional lectures, teachers are encouraged to act as facilitators. This allows students to actively investigate problems, conduct experiments, and connect theoretical physics to real-world, everyday experiences. When teachers consistently combine these two methods throughout the school year, students are better equipped to develop practical skills, logical reasoning, and higher-order critical thinking.

For this instructional shift to be successful, schools and curriculum planners must provide substantial support. This requires supplying adequate laboratory equipment or, when resources are scarce, encouraging the use of locally improvised materials. Furthermore, the physics curriculum and its assessments need to be redesigned to reward practical skills and problem-solving rather than just the memorization of facts.

Additionally, educational authorities must prioritize ongoing professional development. Regular workshops and seminars are essential to help teachers master lab management, questioning techniques, and inquiry-based facilitation. Finally, the study calls for further research to track the long-term impacts of LBI and GIM on student retention and motivation, as well as to understand how variables like class size, school type, and socioeconomic background might influence their effectiveness.

References

- Adebayo, F. A. (2019). Effects of laboratory-based instructional strategies on students' academic achievement in physics. *Journal of Science Education Research*, 12(2), 45–58.
- Adeyemo, S. A. (2011). The impact of physics education on technological development in Nigeria. *African Journal of Educational Studies*, 5(1), 23–31.
- Ajayi, K. O., & Oladiran, O. (2016). Quasi-experimental research design in educational research. *Journal of Educational Research and Development*, 8(1), 67–75.
- Azowenunnebi, E., Adeyemo, S. A., & Babajide, V. F. T. (2017). Effects of guided inquiry teaching method on students' achievement in physics. *Journal of Education and Practice*, 8(14), 42–50.
- Creswell, J. W. (2018). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research* (6th ed.). Pearson Education.
- Egunjobi, A. O., & Adesoji, F. A. (2014). Comparative effects of guided discovery and expository methods on senior secondary school students' achievement in physics. *Journal of Science, Technology and Mathematics Education*, 10(1), 54–66.
- Federal Ministry of Education. (2015). *Revised senior secondary school physics curriculum*. Nigerian Educational Research and Development Council (NERDC).
- Federal Ministry of Education. (2018). *National policy on science and technology education*. Government Press.
- Jegede, S. A., & Adedayo, J. O. (2013). Enriching physics education for sustainable technological development in Nigeria. *Journal of Science Teachers Association of Nigeria*, 48(1), 32–41.
- Nworgu, B. G. (2015). *Educational research: Basic issues and methodology* (3rd ed.). University Trust Publishers
- Obafemi & Ugonwa (2025), "A 21-Year Analysis of Students' Performance in West African Secondary School Certificate (WASSCE) Physics and Chemistry Examinations in Nigeria (1999–2019)," *European Journal of Theoretical and Applied Sciences*, 3(2), 555–566.
- Obukohwo, O. E., & Mbela, D. A. (2023). Physics education as a foundation for scientific and technological advancement. *Nigerian Journal of Science Education*, 17(2), 88–102.
- Ogunleye, A. O. (2019). Practical work and students' achievement in physics: An empirical analysis of secondary school performance. *Journal of Science Education and Practice*, 6(2), 73–84.
- Olajide, A. A. (2020). Practical-based teaching and students' performance in physics. *Journal of Science and Mathematics Education*, 11(3), 55–66.
- Owoeye, J. S., & Yara, P. O. (2019). Teaching strategies and students' achievement in physics in Nigerian secondary schools. *Journal of Educational Studies*, 14(2), 101–112.
- West African Examinations Council. (2020). *Chief examiners' report on senior school certificate examination (Physics)*.