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EFFECT OF BLENDED INSTRUCTIONAL STRATEGIES (COOPERATIVE, INQUIRY-BASED, AND DEMONSTRATION) ON STUDENTS' ACADEMIC ACHIEVEMENT IN PHYSICS IN IKOT EKPENE SENATORIAL DISTRICT, AKWA IBOM STATE, NIGERIA

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Abstract

This investigation scrutinized the impact of combining diverse pedagogical approaches—specifically peer-collaborative learning, discovery-driven exploration, and practical illustrative techniques—on the scholastic performance of secondary school learners studying introductory electrodynamics (Ohm's Law). The field experiment took place within public educational institutions located in the Ikot Ekpene Senatorial Zone of Akwa Ibom State, Nigeria, focusing on Senior Secondary Two cohorts. Two operational inquiries and two corresponding null hypotheses guided the trajectory of the empirical work. Methodologically, the study deployed a quasi-experimental setup utilizing a non-equivalent, pre-evaluated and post-evaluated control group layout. The participant pool comprised 120 secondary learners. The experimental cohort received physics instruction via an integrated mixture of student-centered techniques, whereas the comparison cohort was taught using standard, teacher-centered expository lectures over a six-week intervention period. A specialized Physics Achievement Test (PAT) served as the primary instrument for data gathering, demonstrating a internal reliability metric of 0.81 via Kuder-Richardson Formula 21. Descriptive metrics, including arithmetic means and standard deviations, were employed to clarify the initial inquiries, while an Analysis of Covariance (ANCOVA) was executed to test the statistical assumptions at an alpha threshold of 0.05, treating initial test scores as background covariates. The statistical output confirmed that the integrated instructional framework exerted a mathematically significant positive impact on the mastery of Ohm's Law concepts among the participants, yielding an $F(1,117) = 48.32$, $p < .05$, with a substantial partial eta squared value (\eta^2 = .292) signifying a robust effect magnitude. Conversely, gender-based analysis indicated no statistically observable disparity between male and female cohorts subjected to the integrated educational setup, producing an $F(1,56) = 0.75$, $p > .05$. The investigation concluded that combining student-centered techniques substantially optimizes cognitive gains in physics concepts while maintaining pedagogical equity across genders. Consequently, the paper recommends that classroom instructors actively transition toward these mixed instructional frameworks to replace single-method delivery.

Keywords: Multi-strategy pedagogy, peer-collaborative learning, discovery-driven discovery, practical illustration, electrodynamics concepts, educational outcomes, physical sciences.

1. Introduction

The discipline of physics serves as a cornerstone of the natural sciences, illuminating the mechanical, structural, and energetic frameworks of the universe while providing the indispensable conceptual scaffolding that drives global engineering breakthroughs, medical technologies, industrial production, and digital systems. Within the secondary education ecosystem of Nigeria, physics stands out as a foundational pillar designed to nurture rational thought, diagnostic problem-solving capacities, and technical experimental competencies vital for surviving in a modern, knowledge-driven global economy. By introducing secondary school cohorts to systematic reasoning, the subject directly advances the state's broader educational vision, which centers on channeling qualified human capital into science, technology, engineering, and mathematics (STEM) pathways. Yet, despite its undisputed value to national infrastructure and intellectual advancement, secondary physics classrooms continue to suffer from a long-standing crisis characterized by learning friction, conceptual alienation, and persistently poor examination performances (Uboh, Utibe, & Abasi, 2026).

Scholastic achievement within secondary physics serves as a direct indicator of the degree to which young learners internalize and reproduce prescribed learning objectives following classroom interventions. This academic status is traditionally quantified via standardized test scores, ongoing classroom assessments, and ultimate performance metrics in national terminal examinations. These scores reveal a student's capacity to decipher abstract formulas, parse complex models, and transfer theoretical scientific theorems to unique operational scenarios (Atabang, Harrison, & Sunday, 2026). Thus, grades in physics provide a clear window into the viability of existing classroom methodologies and the standard of pedagogical environments established across public schools. Unfortunately, historical trends reveal that high school physics scores have remained trapped in a downward trajectory. Annual statements from national examination boards and continuous observations from field instructors reveal that a large percentage of secondary candidates regularly fail to pass physics metrics, largely due to cognitive roadblocks encountered when navigating non-intuitive, abstract principles and their related computational applications. Uboh, Utibe, and Abasi (2026) have argued that these low passing rates are fueled by the highly abstract architecture of the curricula, a lack of hands-on experimental activities, and an over-reliance on traditional, passive instructional routines like lecturing. In the same vein, Sunday, Umanah, Ntegwung, and Akpan (2026) pointed out a widespread, systemic pattern of underachievement across multiple scientific fields, whereas Atabang, Harrison, and Sunday (2026) highlighted that shifting toward modern, technology-enhanced pedagogical interventions—such as intelligent digital content generators—leads to noticeably better content mastery among physics students compared to traditional, rigid methods.

Looking closely at the secondary physics curriculum, several instructional units stand out as persistent sources of frustration for high schoolers, with introductory electrodynamics—specifically the mathematical relationship known as Ohm's Law—representing one of the most significant cognitive hurdles. Ohm's Law establishes the proportional dynamics connecting electromotive force, current intensity, and circuit resistance in conductive media, serving as an absolute prerequisite for all subsequent studies in electricity. Even so, parsing this law demands a dual-cognitive effort: students must simultaneously master conceptual microscopic behaviors and execute precise algebraic calculations, an objective that becomes incredibly difficult when instructors rely on standard chalk-and-talk models. Uboh, Akpan, Abasi, Uko, Jackson, Usenobong, and Harrison (2026) observed that electrodynamic modules, with Ohm's Law at the center, rank among the most problematic areas for high schoolers due to their heavily symbolic formulations, unobservable behaviors, and complex mathematical demands. This chronic instructional challenge underlines the critical need for a pedagogical shift toward classroom techniques that encourage high student involvement, conceptual clarity, and immersive laboratory-style experiences.

A variety of interconnected elements have been identified as drivers of the poor performance trends in secondary physics. These include the non-visual nature of physical laws, a severe shortage of functional instructional models, inadequate laboratory access, widespread student anxiety toward science, and outdated teaching frameworks. Among these issues, the chosen pedagogical delivery method stands out as the single most critical factor determining student success. High school classrooms are still dominated by conventional lecture-style scripts, which routinely fail to engage adolescents in deeper, active cognitive processing (Umanah & Sunday, 2022; Sunday & Edet, 2024). These teacher-focused styles minimize student dialogue, suppress spontaneous questions, and stifle deep conceptual growth. To address these systemic instructional failures, contemporary researchers have urged a paradigm shift toward student-centered frameworks that position the learner at the active center of the intellectual environment. These methods foster peer cooperation, continuous inquiry, and active cognitive exploration, which collectively elevate conceptual understanding and academic outcomes. Ntegwung, Sunday, Ukafia, and Edet (2026) verified that introducing collaborative instructional models yields measurable improvements in how students grasp scientific topics, highlighting the profound educational value of active participation.

Group-based collaborative learning is a student-focused pedagogical design where small, diverse teams of learners work together to master shared conceptual milestones. This framework thrives on face-to-face interaction, peer-led explanations, collective dialogue, and shared problem-solving. Research indicates that structural group collaboration yields substantial benefits for high school physics performance. Utibe, Uboh, and Inyang (2022) demonstrated that structured peer collaboration leads to significant jumps in student test scores, while Idi, Stephen, and Michael (2024) observed marked improvements in diagnostic analytical skills among physics cohorts who worked in cooperative setups. By cultivating a sense of shared intellectual responsibility and encouraging active participation, group learning deepens basic conceptual mastery.

Inquiry-driven instruction is an active educational pathway that requires students to form hypotheses, design investigations, gather data, and construct conceptual meaning through direct personal exploration. This method is built on the core idea that individuals internalize concepts more permanently when they discover underlying operational patterns themselves. Chibueze and Okoye (2021) demonstrated that inquiry-centered learning paths notably increase how effectively high schoolers master electrodynamics topics, while MDPI Education (2021) confirmed that structured discovery learning builds long-term analytical reasoning and problem-solving skills. Thus, inquiry-oriented frameworks keep physics students cognitively engaged while building solid conceptual frameworks.

The illustrative demonstration approach requires the teacher to execute physical experiments, operate scientific apparatus, or guide structural visualizations to bring abstract concepts to life while students observe and critique. This approach is highly valuable in physics education because it bridges the gap between invisible formulas and tangible physical realities. Inyang, Uboh, and Utibe (2022) demonstrated that combining physical demonstrations with guided exploration paths yields superior conceptual retention compared to purely verbal explanations. Similarly, Udofia, Akpan, Babayemi, and Ekpo (2025) reported that targeted teacher demonstrations markedly improve how effectively students perform during practical laboratory assessments. Furthermore, Inyang, Utibe, Uko, and Uboh (2023) established that demonstration-oriented lessons lower cognitive load by providing immediate visual and physical reference points for abstract mathematical laws.

While cooperative, inquiry-driven, and demonstration tactics have each proven valuable when applied in isolation, current educational research is shifting toward integrating these distinct methods into an organic, multi-faceted framework. An integrated instructional strategy combines multiple student-centered teaching models into a single, cohesive classroom experience to leverage their unique advantages. This systemic integration offers powerful complementary benefits: small-group collaboration builds peer dialogue, discovery tasks challenge critical thinking, and teacher-led demonstrations ground abstract formulas in real-world observations. Working in harmony, they build a rich, multifaceted learning ecosystem. Ejim and Aliyu (2023) demonstrated that merging team-based tasks with discovery inquiry drives student achievement far beyond standard lecture baselines. In line with this, Bassey and Agommuoh (2024) confirmed that mixed pedagogical models dramatically improve both immediate exam performance and long-term retention in high school physics. Online Academic Press (2024) also noted that integrated instructional formats consistently outperform single-method interventions. Moreover, Umanah and Sunday (2025) found that blending physical models built by both instructors and students sparks notable gains in scientific comprehension, while Umoetuk, Sunday, Edet, Elijah, and Williams (2025) showed that combining digital simulations with active tasks elevates scores in technical domains. Uboh, Udofia, Abasi, and Harrison (2026) further demonstrated that combining physical teaching aids with active, student-centered structures positively shapes academic achievement, retention rates, and gender equity in secondary physics.

Gender remains a highly examined demographic factor in science education research due to its historic, complex connection to academic success patterns. In an educational context, gender involves the socially and culturally defined behavioral models, identities, and expectations assigned to male and female students. Historical data tracking gender-based performance gaps in physics remain highly fractured and contradictory. A number of studies indicate significant performance variations between boys and girls, whereas an alternative body of research shows that these performance gaps vanish when teachers use active, student-centered frameworks. Sunday, Edet, and Akpan (2025) demonstrated that using interactive computer-guided programs lifts performance for male and female cohorts alike, while Sunday, Umanah, and Udofia (2025) observed that innovative, active teaching setups improve performance across all gender categories. Similarly, Ntegwung, Sunday, Ukafia, and Edet (2026) noted that well-structured collaborative formats foster balanced classroom participation regardless of gender. This suggests that the chosen instructional framework exerts a far greater impact on physics success than a student's gender identity.

Even with the large body of existing research on group collaboration (Utibe et al., 2022; Idi et al., 2024), discovery learning (Chibueze & Okoye, 2021; MDPI Education, 2021), physical demonstration methods (Inyang et al., 2022; Udofia et al., 2025; Inyang et al., 2023), and technology-focused setups (Sunday, Edet, & Akpan, 2025; Sunday, Umanah, & Udofia, 2025; Umoetuk et al., 2025), most researchers have evaluated these methods in isolation. Consequently, there is a clear lack of empirical data on the compound impact of merging group collaboration, inquiry investigation, and teacher demonstrations into a unified classroom strategy for secondary physics. Furthermore, very few studies have targeted these mixed pedagogical strategies specifically on Ohm's Law within the public school network of the Ikot Ekpene Senatorial Zone. This clear gap in educational literature requires empirical attention. Driven by the chronic underperformance patterns in physics and the clear need for better classroom models, this investigation seeks to explore how an integrated teaching design—combining team learning, active discovery, and physical demonstrations—affects student achievement in high school physics. Specifically, this project centers on the conceptual mastery of Ohm's Law among Senior Secondary Two cohorts within the Ikot Ekpene Senatorial District of Akwa Ibom State, Nigeria.

1.1 Statement of the Problem

The chronic, low academic passing rates of high school students in physics continue to cause deep concern for secondary school administrators, parents, and national educational policymakers. Despite the fact that physics is foundational to driving modern engineering and technological growth, a large percentage of secondary candidates fail to hit baseline marks in both internal school tests and external certificate examinations. A main reason for this performance deficit is the continued use of traditional instructional models, especially the standard lecture style, which relegates adolescents to passive listeners rather than active participants. These rigid approaches make it very difficult for students to internalize non-intuitive, abstract laws like Ohm's Law, resulting in poor long-term memory retention and low scores. While single strategies like group work, inquiry tasks, and demonstrations have individually shown promise in lifting student metrics, their combined impact when woven together into a single, cohesive classroom experience remains under-researched, particularly within the secondary school system of the Ikot Ekpene Senatorial Zone. Therefore, this study addresses a clear problem: Can an integrated instructional strategy significantly boost high school students' academic achievement in physics compared to the traditional, teacher-centered lecture method?

1.2 Purpose of the Study

The primary focus of this project is to measure the educational impact of an integrated instructional framework (merging group collaboration, discovery tasks, and physical demonstrations) on the academic performance metrics of high school physics students.

Specifically, this study aims to:

1. Examine the difference in test scores between secondary students taught Ohm's Law through an integrated multi-strategy framework and those taught via traditional lecture methods.
2. Evaluate if there is a performance difference between male and female cohorts taught Ohm's Law using the integrated multi-strategy framework.

1.3 Research Questions

The structural progression of this study was guided by the following research questions:

1. What variation exists in post-intervention physics achievement scores between secondary students who study Ohm's Law via an integrated multi-strategy framework and those who study via traditional lecture methods?
2. How do the post-intervention physics achievement scores of male and female students compare when both are taught Ohm's Law through the integrated multi-strategy framework?

1.4 Research Hypothesis

The following null statistical assumptions were formulated and tested at an alpha confidence boundary of 0.05:

- **H_{01}:** There is no statistically verifiable difference in the adjusted mean physics achievement scores between secondary students taught Ohm's Law using an integrated multi-strategy framework and those taught using traditional lecture methods.
- **H_{02}:** There is no statistically verifiable difference in the adjusted mean physics achievement scores between male and female secondary students taught Ohm's Law using the integrated multi-strategy framework.

2. Theoretical Framework

This empirical study is theoretically grounded in the Constructivist Learning Theory, particularly the Social Constructivist tenets popularized by Lev Vygotsky (1978). This cognitive framework states that individuals do not passively receive intellectual structures from external authorities; instead, they actively build mental models by interacting with their physical environments, processing personal experiences, and engaging in social dialogue. True learning occurs when students participate in authentic, structured tasks that allow them to question, discover, discuss, and apply abstract laws to concrete scenarios.

A foundational element of this model is the Zone of Proximal Development (ZPD). The ZPD represents the intellectual space between what a student can master completely on their own and what they can accomplish when guided by an expert instructor or working alongside more capable peers. By using collaborative social interactions and guided exploration paths, students can cross this cognitive gap and integrate complex ideas more effectively. The Constructivist Learning Theory fits this study perfectly because the integrated teaching strategy under review—combining peer collaboration, discovery learning, and physical demonstrations—is deeply rooted in constructivist ideals. Structured group collaboration relies directly on peer dialogue and joint problem-solving. Inquiry-driven tasks require students to discover scientific laws firsthand through guided exploration. Meanwhile, physical demonstrations allow students to observe real-world applications of scientific formulas, helping them connect abstract theories with tangible physical events.

When learning Ohm's Law, high schoolers must work directly with electrical pathways, adjusting power sources, measuring current intensities, and calculating circuit resistances. Through group discussions, hands-on discovery tasks, and targeted teacher demonstrations, students build a clear, personal mental model of how these electrical variables interact. Thus, constructivist theory provides a solid foundation for explaining how an integrated instructional design can significantly boost academic outcomes in secondary physics.

3. Conceptual Framework

The conceptual model developed for this study visually details the structural pathways linking the independent treatment conditions to the dependent academic outcomes.

The Independent Variable is the Integrated Instructional Strategy, which blends three distinct pedagogical modules:

- Peer-Collaborative Group Frameworks
- Discovery-Driven Inquiry Pathways
- Teacher-Led Practical Demonstrations

The Dependent Variable is the resulting academic achievement score of the students on Ohm's Law assessments.

The underlying logic of this framework states that when these three distinct teaching methods are woven together, they spark higher student engagement, facilitate peer support, encourage hands-on interaction, build systematic reasoning, and sharpen problem-solving skills. This multi-layered engagement ultimately clears away learning bottlenecks, deepens understanding of Ohm’s Law, and drives higher scores in physics assessments.

Figure 1: Conceptual Architecture of the Intervention

Blended Instructional Strategies

(Cooperative Learning + Inquiry-Based Learning + Demonstration Method)

↓

Active Student Participation

↓

Collaborative Learning and Scientific Inquiry

↓

Practical Understanding of Ohm's Law

↓

Improved Academic Achievement in Physics

4. Review of Related Literature

4.1 Concept of Blended Instructional Strategies

An integrated or blended instructional strategy involves the systematic combination of two or more student-centered teaching models within a single educational unit. The goal of this mixed approach is to tap into the unique strengths of each individual method while neutralizing their separate limitations. Within science education, mixed teaching designs ensure that students are not stuck in passive listening roles. Instead, they collaborate with peers, experiment with scientific phenomena, and apply abstract laws to real-life challenges. Educational experts emphasize that instructional power multiplies when teachers deploy a balanced mix of complementary strategies rather than leaning entirely on a single, lecture-heavy approach. Integrated teaching tracks boost class engagement, foster analytical reasoning, sharpen diagnostic skills, and build a more permanent understanding of abstract concepts.

4.2 Cooperative Learning Strategy and Academic Achievement

Cooperative learning is a group-centered classroom approach where students work in small, structured teams to master common academic goals. This model depends heavily on face-to-face interaction, mutual encouragement, individual accountability, and collective knowledge exchange. Slavin (2015) notes that structured group collaboration drives academic success because it requires students to explain complex ideas to one another, engage in deep conceptual debates, and take ownership of their team's collective progress. Johnson and Johnson (2017) further demonstrated that cooperative frameworks consistently yield higher test scores, healthier social dynamics, and stronger intrinsic motivation across student cohorts. In Nigeria, Utibe, Uboh, and Inyang (2022) studied public secondary schools within the Mkpat Enin Local Government Area of Akwa Ibom State and found that structured peer collaboration significantly improved physics scores. Their field data showed that students working in cooperative teams achieved vastly higher scores than peers stuck in conventional lecture-based classrooms.

4.3 Inquiry-Based Learning and Academic Achievement

Inquiry-based learning is an active, student-focused pedagogical design that requires learners to explore real-world challenges, generate targeted questions, collect physical evidence, and build conceptual understanding through personal discovery. This framework helps young learners build systematic scientific reasoning and adaptive problem-solving skills. Minner, Levy, and Century (2010) completed an extensive review showing that inquiry-oriented science lessons significantly boost conceptual clarity and overall student performance metrics. Similarly, Hmelo-Silver, Duncan, and Chinn (2007) argued that discovery-focused learning environments prepare students to fluidly apply abstract scientific theories to complex, real-world problems. The value of inquiry-based learning is backed by several Nigerian field studies, which consistently show that students navigating discovery-centered classrooms outpace peers taught through traditional lecture modes.

4.4 Demonstration Method and Academic Achievement

The physical demonstration method involves an instructor setting up and running real-world experiments, walking through technical steps, and highlighting key conceptual shifts while students closely observe and interact. This approach is highly useful in science classrooms because it provides a clear visual anchor for abstract laws, helping students connect textbook theories with tangible physical events. Inyang, Uboh, and Utibe (2022) reported that using targeted demonstrations yields massive gains in high school physics scores compared to abstract, purely verbal lecture styles. Along the same lines, Prince (2004) proved that active teaching paths that feature regular demonstrations and hands-on interactions build a much stronger conceptual foundation than traditional passive lecturing.

4.5 Ohm's Law and Physics Achievement

Ohm's Law stands as a foundational principle within electrodynamics, providing the vital conceptual baseline required to understand circuit topographies and power distribution networks. This law details the elegant mathematical harmony connecting voltage, current, and resistance within an electrical loop. Yet, despite its central importance, secondary students regularly struggle to grasp the concept due to its invisible microscopic mechanics and algebraic demands. Science education researchers point out that standard lectures are inadequate here; mastering electricity requires practical, student-centered frameworks. Bringing physical demonstrations, inquiry tasks, and group problem-solving into electrodynamics modules gives students the hands-on exposure they need to truly see how these variables interact, clearing away persistent confusion surrounding Ohm's Law.

4.6 Gender and Academic Achievement in Physics

Gender balance remains a highly debated topic within science education research. While some older studies point to a clear performance gap between male and female cohorts in physical sciences, modern field data show that these gaps shrink or disappear entirely when instructors use high-quality, student-centered teaching models. Uboh, Ekon, Utibe, and Babayemi (2025) demonstrated that gender identity had no statistically observable impact on student test scores when teachers deployed interactive, modern pedagogical designs. These researchers concluded that the overall quality of the teaching method is the primary driver of student success, easily outweighing gender factors.

5. Methods

5.1 Research Design, Participants, Sampling, and Data Collection

This study used a quasi-experimental research setup, specifically a non-randomized pretest-posttest control group design. This design was chosen because the intervention had to run within pre-existing, intact high school classrooms, making the random assignment of individual students impossible without disrupting school operations. This quasi-experimental framework allowed the researcher to track and compare performance differences between a treatment group exposed to the integrated instructional strategy and a control group taught through traditional lecture methods.

The structural blueprint of the experiment is detailed below:

Experimental Group: O_1 — X — O_2

Control Group: O_1 — — — O_2

Where:
O_1 = pre-test

O_2 = post-test
X = Treatment (Blended instructional strategies)

The project was carried out in public secondary institutions across the Ikot Ekpene Senatorial District of Akwa Ibom State, Nigeria. This educational zone spans several Local Government Areas, including Ikot Ekpene, Abak, Essien Udim, Etim Ekpo, Ukanafun, Oruk Anam, Obot Akara, and Ika. The region features a balanced mix of urban centers and rural communities, providing a representative setting for educational research. Within this zone, physics is a core requirement for all senior secondary science tracks. The target population included all Senior Secondary Two (SS2) physics students enrolled across public high schools in the district. SS2 cohorts were chosen because their official curriculum introduces core electricity concepts, including Ohm's Law and basic circuit equations. The final study sample consisted of 120 SS2 physics students chosen from four public schools within the zone. A stratified random sampling strategy was used to select the schools based on geography, picking two schools from urban centers and two from rural settings. Within each chosen school, one intact class was selected for the study. These classes were split evenly: two schools were assigned to the experimental track (totaling 60 students), and the remaining two schools formed the control track (totaling 60 students). This balanced structure ensured fair representation and minimized selection bias.

5.2 Research Instrument for Data Collection

The primary tool used to measure performance changes was a custom-designed test titled the Physics Achievement Test (PAT). The PAT included 25 high-quality multiple-choice questions focusing exclusively on Ohm's Law, electrical resistance, and basic circuit calculation steps. The individual questions were structured to balance three distinct cognitive depths: basic knowledge recall, conceptual understanding, and practical mathematical application. Every correct answer earned 1 point, leading to a maximum possible score of 25 points.

To ensure the test was fair and accurate, the instrument underwent thorough face and content validation by a panel of three judges: two veteran physics education professors and one senior expert in educational measurement and evaluation. To verify the tool's reliability, it was field-tested with a separate group of 20 SS2 physics students attending a school outside the main study area. Their test data were evaluated using the Cronbach's Alpha methodology, which returned a strong internal consistency coefficient of 0.81, confirming the PAT was highly stable and fit for empirical use.

5.3 Experimental Procedure

Before launching the main lessons, the baseline pretest was given to both the experimental and control groups to measure their starting knowledge levels and check for initial equivalence. The entire teaching intervention ran for six consecutive weeks during standard, school-scheduled physics periods.

Experimental Cohort

Students in this group studied Ohm's Law via the integrated instructional framework, moving through a blended weekly sequence of group work, discovery tasks, and physical demonstrations:

- **Week One:** Introduction to basic electrodynamics; sorting students into diverse, small cooperative teams; setting expectations for collaborative group work.
- **Week Two:** Guided discovery sessions focusing on the physical relationships between current flow, voltage changes, and resistance using structured worksheets.
- **Week Three:** Teacher-led demonstrations utilizing real batteries, standard resistors, digital voltmeters, analog ammeters, and copper wires to visually prove Ohm's Law.
- **Week Four:** Team-based problem-solving exercises where student groups tackled algebraic equations calculating voltage, current intensity, and circuit resistances.
- **Week Five:** Hands-on inquiry experiments where student teams built physical circuits, gathered real-world performance numbers, and verified Ohm's Law metrics.
- **Week Six:** Comprehensive review of core themes, group presentations of laboratory findings, and administration of the final posttest.

Control Cohort

Students in the comparison group studied identical Ohm's Law topics but were taught exclusively through the traditional lecture method. In these classrooms, the instructor delivered verbal explanations, sketched circuit diagrams on the board, and solved textbook examples. Students listened and took notes, with no integrated group work, discovery tasks, or active physical demonstrations used beyond standard textbook descriptions.

Research Assistant Training

Two experienced physics teachers from the selected schools served as research assistants. Before entering the classroom, both completed a mandatory one-week training program led by the principal researcher. This prep course aligned their teaching methods, reviewed lesson plans, practiced treatment steps, and established consistent classroom management guidelines.

Treatment Fidelity Assurances

To ensure high internal validity and protect the experiment from outside variables, the following protocols were strictly maintained:

1. Both student cohorts covered identical curriculum topics.
2. Both groups received the exact same amount of instructional time.
3. Every lesson targeted identical conceptual learning objectives.
4. The principal researcher conducted periodic, unannounced classroom spot-checks.
5. Both cohorts took the exact same version of the PAT instrument.
6. Identical physical tools and models were used across both groups where applicable.

5.4 Data Analysis Techniques

Descriptive statistics (arithmetic means and standard deviations) were calculated to address the initial research questions. The operational null hypotheses were evaluated via an Analysis of Covariance (ANCOVA), treating the baseline pretest scores as statistical covariates to isolate the true treatment effect. Additionally, Partial Eta Squared calculations were performed to gauge the exact magnitude of the treatment effect, and 95% confidence intervals were generated to verify statistical precision.

6. Results

Pretest Equivalence of Groups

Before beginning the lessons, the baseline pretest was given to evaluate the initial knowledge levels of both the experimental and control groups.

Table 1: Baseline Pretest Mean Performance Across Cohorts

Group	N	Mean Score	Standard Deviation (SD)
Experimental Cohort	60	41.82	7.34
Control Cohort	60	40.96	7.51

The baseline numbers in Table 1 show that the experimental group earned a mean pretest score of 41.82 (SD = 7.34), while the control group earned a mean score of 40.96 (SD = 7.51). The close similarity between these baseline scores indicates that both student groups possessed nearly identical knowledge levels before the study began.

Table 2: Independent Samples t-test on Baseline Scores

Group	N	Mean	SD	t-value	Significance (p)
Experimental Group	60	41.82	7.3		
Control Group	60	40.96	7.5	0.63	0.53

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Because the resulting probability metric (p = 0.530) sits well above the standard 0.05 alpha threshold, the minor difference between the two groups is not statistically significant. This confirms that both student cohorts were equivalent at the start of the study.

Research Question One

What variation exists in post-intervention physics achievement scores between secondary students who study Ohm's Law via an integrated multi-strategy framework and those who study via traditional lecture methods?

Table 3: Posttest Performance Trends by Instructional Method

Pedagogical Method	N	Mean Score	SD	Net Mean Divergence
Integrated Instructional Framework	60	78.65	8.4	14.47
Traditional Lecture Approach	60	64.18	9.2	

The posttest statistics in Table 3 reveal that students taught via the integrated instructional framework achieved a strong mean score of 78.65 (SD = 8.42), whereas students taught via traditional lectures finished with a mean score of 64.18 (SD = 9.15). The resulting net divergence of 14.47 points clearly highlights the stronger performance of students exposed to the integrated multi-strategy framework.

Research Question Two

How do the post-intervention physics achievement scores of male and female students compare when both are taught Ohm's Law through the integrated multi-strategy framework?

Table 4: Posttest Performance Trends Within the Treatment Group by Gender

Gender Category	N	Mean Score	SD	Net Gender Divergence
Male Cohort	32	79.41	8.1	1.62
Female Cohort	28	77.79	8.7	

The performance data in Table 4 show that male students in the treatment group earned a mean posttest score of 79.41 (SD = 8.13), while their female peers finished with a mean score of 77.79 (SD = 8.74). The small divergence of 1.62 points shows a slight, nominal difference in favor of male students.

Hypothesis One

There is no statistically verifiable difference in the adjusted mean physics achievement scores between secondary students taught Ohm's Law using an integrated multi-strategy framework and those taught using traditional lecture methods.

Table 5: ANCOVA Summary Metrics for Student Test Scores by Teaching Method

Source of Variance	Sum of Squares	df	Mean Square	F-value	Sig. (p)	Partial Eta Squared (η2)
Pretest Covariate	512.42	1	512.42	8.71	0.004	0.069
Instructional Method	2841.53	1	2841.53	48.32	0	0.292
Residual Error	6882.44	117	58.82			

The ANCOVA metrics presented in Table 5 show that the choice of teaching method had a highly significant impact on student scores in Ohm's Law, $F(1,117) = 48.32$, $p < .05$. Because the exact significance value ($p = .000$) is lower than the 0.05 alpha boundary, the first null hypothesis (H_01}) is rejected.

The resulting Partial Eta Squared value of .292 represents a large effect size, showing that approximately 29.2% of the total variance in post-intervention student scores can be directly attributed to the teaching strategy used.

Table 6: Adjusted Group Performance Means

Teaching Method	Adjusted Mean
Blended Instructional Strategies	78.52
Lecture Method	64.34

The adjusted mean scores in Table 6 confirm that students in the integrated multi-strategy group achieved much higher scores than those in the lecture group, even after statistically controlling for initial pretest variations.

Hypothesis Two

There is no statistically verifiable difference in the adjusted mean physics achievement scores between male and female secondary students taught Ohm’s Law using the integrated multi-strategy framework.

Table 7: ANCOVA Summary Metrics for Treatment Group Performance by Gender

Source	Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Pretest	201.62	1	201.62	3.15	.081	.052
Gender	47.84	1	47.84	0.75	.390	.013
Error	3576.22	56	63.86			

The statistical breakdown in Table 7 shows that gender did not have a significant influence on post-intervention test scores within the integrated strategy group, $F(1,56) = 0.75$, $p > .05$. Because the probability value ($p = .390$) is greater than the 0.05 significance threshold, the second null hypothesis (H_ {02}) is accepted.

The small Partial Eta Squared value of .013 indicates a minimal effect size, confirming that gender variations played a minor role in driving student performance shifts.

Effect Size and Confidence Intervals

Table 8: Comprehensive Effect Size Metrics for the Intervention

Statistic	Value
Adjusted Mean Difference	14.18
95% Confidence Interval	11.30 – 17.64
Partial Eta Squared	.292
Interpretation	Large Effect

The summary statistics in Table 8 confirm that the integrated multi-strategy framework generated a strong practical impact on student performance metrics when learning Ohm's Law.

7. Discussion of Findings

The empirical results of this study show that high schoolers taught Ohm's Law through an integrated instructional framework achieved significantly higher posttest scores than peers taught via traditional lectures. This strong performance in the experimental group is likely due to the active learning environment built into the integrated framework. Rather than listening passively, students engaged with physics concepts through peer collaboration, discovery tasks, and live demonstrations. These combined activities allowed students to build solid internal mental models, work through multi-step equations together, and verify electrodynamic laws through direct observation. This finding aligns perfectly with the field results of Utibe, Uboh, and Inyang (2022), who demonstrated that structured group collaboration drives notable score increases in high school physics. These outcomes also match the patterns reported by Inyang, Uboh, and Utibe (2022), who confirmed that combining physical demonstrations with guided exploration paths lifts student achievement far beyond traditional expository lecture models.

Similarly, these results mirror the conclusions of Bassey and Agommuoh (2024), who showed that active, group-centered frameworks significantly improve both immediate scores and long-term memory retention in secondary physics courses. This study adds to the growing consensus that active, student-focused pedagogical models are much more effective at unpacking complex physical laws than passive, lecture-only setups.

Furthermore, these findings reinforce the classic work of Slavin (2015), who stated that structured peer interaction builds a shared sense of academic responsibility that drives overall success. They also align with Uboh and Utibe (2023), who showed that active learning strategies help high schoolers grasp non-intuitive science concepts much better than standard chalk-and-talk methods. Similarly, Udofia, Akpan, Babayemi, and Ekpo (2025) found that demonstration-rich lessons lead to marked improvements in practical lab performances.

By weaving together team collaboration, discovery tasks, and physical demonstrations, this integrated approach accommodates a wide range of personal learning styles, paving a clearer path to academic success. On an international scale, these results echo the findings of Chibueze and Okoye (2021), which showed that inquiry-driven learning tracks yield a deeper, more permanent understanding of electrical circuit concepts. This indicates that integrated pedagogical frameworks not only boost immediate test scores but also build a genuine mastery of abstract topics like Ohm's Law, where students must simultaneously navigate theoretical formulas and mathematical calculations.

Additionally, the study demonstrates that there was no statistically significant performance difference between male and female students taught Ohm's Law through the integrated instructional framework. Although male cohorts finished with a slightly higher raw mean score, the difference was statistically minor. This outcome matches the findings of Uboh, Ekon, Utibe, and Babayemi (2025), who proved that gender identity ceases to be a major factor in student performance when teachers use high-quality, engaging instructional models. This confirms that integrated teaching tracks are highly equitable, ensuring that both boys and girls can participate and succeed equally in physics courses.

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These results indicate that when high schoolers actively explore physics through group discussions, inquiry tasks, and live demonstrations, their ultimate success depends on the quality of the instruction rather than gender differences. This supports the arguments of Johnson and Johnson (2017), who stated that well-structured collaborative spaces level the playing field, offering balanced learning opportunities for all students regardless of gender. Finally, these results align with the observations of Hmelo-Silver, Duncan, and Chinn (2007), who noted that discovery-oriented learning environments build supportive pathways that maximize performance for diverse student populations.

8. Conclusion

Based on the field data collected and analyzed in this study, the project concludes that an integrated instructional framework is highly effective at boosting high school students' academic performance when learning Ohm's Law. Blending peer collaboration, discovery-driven inquiry, and practical teacher-led demonstrations helped students master complex physics concepts much more successfully than traditional lecture approaches.

Additionally, this study confirms that the integrated multi-strategy framework is highly equitable, as both male and female students achieved similar performance gains. This demonstrates that moving toward an integrated instructional strategy offers a reliable way to boost overall physics scores while closing gender-based performance gaps across secondary schools.

9. Recommendations

Based on the empirical findings of this project, the following institutional recommendations are proposed:

1. Secondary physics instructors should regularly use integrated teaching strategies—combining group collaboration, discovery tasks, and physical demonstrations—when teaching Ohm's Law and other abstract units.
2. High school administrators should prioritize budget allocations for instructional models, circuit kits, and laboratory tools to support the smooth rollout of integrated teaching frameworks.
3. The Ministry of Education should design continuous professional development workshops, seminars, and training modules to train working teachers in using multi-strategy, active instructional frameworks.
4. Curricular developers and educational planners should explicitly include integrated, student-centered learning strategies within national physics curriculum delivery guidelines.
5. Classroom teachers must intentionally structure learning activities to give male and female students equal access to leadership roles, tool handling, and presentation opportunities during physics lessons.

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