



## Effect of Group and Individual Laboratory Activities on Senior Secondary School Students' Achievement and Retention in Practical Physics

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### Abstract

This quasi-experimental study examined the impact of group and individual laboratory activities on senior secondary school students' academic achievement and retention in practical physics within Orlu Education Zone I, Imo State. Guided by three research questions and hypotheses, the study sampled 65 students from 2 selected schools through multistage sampling from the entire population of 3,285 SSII students in 65 public secondary schools. The validated "Practical Physics Performance Test" (PPPT) instrument, with a reliability coefficient of 0.72, measured student performance. Following the pretest, a six-week experimental intervention was implemented, culminating in the administration of the posttest, which comprised reordered pretest items. Subsequently, a retention test was conducted two days later. Data for this study were derived from the scores obtained from these three assessments. Descriptive statistics and ANCOVA analyzed the data. Results showed that students engaging in group laboratory activities significantly outperformed and retained more information than those in individual laboratory activities. Recommendations include principals organizing teacher training seminars and workshops to effectively integrate group laboratory activities into practical physics instruction, enhancing student performance.

**Keywords:** Gender, Group laboratory activities, Individual laboratory activities, Lecture method, Practical physics, Retention and Students' performance

### Introduction

Physics is a fundamental component of the Nigerian senior secondary school curriculum, falling under the umbrella of natural sciences. This discipline explores the intricate relationships between matter and energy, encompassing various manifestations such as motion, light, electricity, radiation, and gravity. Through a blend of experimentation and theoretical frameworks, physics employs the scientific method to develop and validate hypotheses grounded in observations of the natural world. Physics encompasses the study of matter across an expansive range of scales, from the minute subatomic particles that comprise atoms and their constituent components, to celestial bodies such as stars and galaxies (Adolphus T et al, 2021). A fundamental aspect of physics involves formulating and refining scientific laws, which serve as a foundation for making predictions about unexplored

phenomena. These predictions, in turn, generate new inquiries that experimental physicists investigate through meticulously designed experiments (Andrew P.U, 2019). The dynamic interplay between theoretical and experimental aspects of physics drives the advancement of scientific knowledge. As theory and experimentation continually inform and refine each other, new areas of understanding emerge. To achieve the discipline's objectives, student-centered approaches become essential. Notably, laboratory activities serve as a crucial component of this paradigm, fostering hands-on exploration and discovery.

Laboratory activities involve hands-on investigations that equip students with essential practical skills in science, encompassing a range of key competencies. These activities enable students to conduct detailed observations, recognize and categorize



phenomena, formulate informed hypotheses, make educated predictions, accurately measure variables, and design and execute experiments. A laboratory is a specialized facility where scientific research and experimentation are conducted to explore and understand natural phenomena through hands-on investigation. A laboratory is a designated space for conducting scientific research, varying in scope and setup, from advanced facilities to basic, makeshift areas, and can be situated in diverse locations, such as a dedicated room, outdoor areas, or even temporary settings (Ali A, 2018). A laboratory serves as a pivotal workspace where scientists conduct research, often yielding groundbreaking discoveries that significantly impact human lives. In an educational context, laboratory activities facilitate hands-on learning, with science teachers guiding students to achieve specific learning objectives. These activities can be categorized into two distinct approaches: collaborative group work and individualized experimentation (Bajon R.H, 2015).

Group laboratory activities involve collaborative learning, where a small team of students works together to achieve a shared objective and finalize instructional task in the course of conducting practical laboratory lessons. The approach embodies the principles of cooperative learning, leveraging structured interactions and strategic organization to foster effective teamwork, critical thinking, and knowledge sharing among students (Prince M, 2014). Cooperative group learning involves instructing students to collaborate in small groups of four to five, fostering an environment where peers mutually support and enhance each other's learning. Through dynamic interactions, students engage in discussions, debates, and constructive feedback, identifying knowledge gaps and collectively addressing them (Aladejana F et al, 2017). Group laboratory activities involve collaborative teamwork among a small group of students, who collectively tackle problems, complete tasks, or achieve shared objectives during hands-on experiments. This group-based approach offers the added advantage of enabling students to witness and learn from their peers' skill development processes. However, can laboratory activities truly facilitate effective group learning and enhance students' physics achievement? Empirically, a research examining the impact of laboratory approaches on students' achievement in Biology revealed that learners who were engaged in group laboratory activities outperformed those participating in individual laboratory work. (Ugwu C.B.A et al, 2020). Another research conducted in Enugu State, Nigeria, explored

the impact of laboratory teaching methods on senior secondary school students' academic achievement in inorganic chemistry, specifically acid-base titration. The findings revealed that there is a positive and significant correlation that exists between laboratory teaching and students' chemistry achievement (Ezeano C.A et al, 2019).

Individual laboratory activities entail students working independently to investigate an instruction during practical lessons, with the option to seek guidance from peers, classmates, or instructors when needed. Individualized instruction tailors teaching to meet the unique abilities, interests, and learning pace of each student, utilizing personalized content, materials, and media to foster self-directed growth. Empirically, a research examining the impact of laboratory activity modes on biology achievement revealed that students participating in group laboratory work outperformed those engaging in individual laboratory activities. Also, the study revealed a significant gender difference in achievement scores, with males outperforming females. (Bajon R.H, 2015). Another research conducted in Eket L G A. of Akwa Ibom State revealed that chemistry students participating in laboratory practicals demonstrated significantly improved academic achievement compared to peers using alternative methods (Umoh S.W, 2021). Thus, in this study, this research utilized individual laboratory activities to assess and evaluate students' practical skills and academic achievement in physics.

Student achievement refers to the educational outcomes that result from a student's learning experiences, encompassing acquired knowledge, developed skills, and formed ideas. Students' achievement emerges as the outcome of academic endeavors, whether within the structured environment of a school or through informal learning experiences. Achievement manifests in diverse forms, extending beyond traditional academic settings and encompassing a broader range of skills and competencies (Orji S.O.N, 2019). Consequently, the assessment conducted upon completion of practical physics coursework accurately reflects a student's achievement. Student achievement is commonly measured through various statistical metrics, reflecting a student's mastery of skills and knowledge demonstrated in exams and real-world applications (Omemu F, 2018). The primary objective of performance testing is to facilitate teacher-student evaluation of learning success, and laboratory activities play a crucial role in determining academic proficiency and knowledge retention.



Retention is the capacity of learners to store and recall information over a given period of time (Ajayi O.V et al, 2017). Information storage over a specified duration, known as the retention interval, determines whether learning is retained or lost. When confronted with a stimulating scenario, previously stored mental images are reactivated, facilitating the process of memorization (Ibrahim B et al, 2015). Hence, effective teaching of practical physics requires approaches that resonate with learners' subconscious minds, facilitating rapid recall of concepts. In this study, retention in practical physics has to do with the capacity to maintain and retrieve learned knowledge, ensuring accessibility when needed. Effective retention in practical physics requires more than simple memorization; it demands engaging teaching methods. This research will identify studies on students' gender, their academic performance and retention rates. Within educational settings, a notion exists that one gender outperforms the other in practical physics.

In this study, gender is the distinction between male and female students, encompassing personality traits, self-concept, and social roles that transcend biological differences (Ewumi S.D, 2019). Gender has been identified as a significant personal factor influencing motivational dynamics and academic outcomes. It encompasses societal norms and expectations regarding suitable behavior, traits, and responsibilities for men and women. The concept of gender examines the diverse roles, responsibilities, limitations, opportunities, and requirements of males and females across various contexts (Abdurahaman M et al, 2016). As earlier explained, gender is a significant factor impacting students' academic performance, with notable differences in achievement of students based on gender. Gender encompasses the socially constructed characteristics, behaviors, and attributes associated with being male or female within a particular cultural context (Uwameike R et al, 2015).

The consistently poor performance of senior secondary school students in practical physics, both in internal and external exams, remains a pressing concern for stakeholders, including students, educators, and the broader community. According to the WAEC Chief Examiners' Report (2024) for Imo State, a five-year trend analysis of physics students' performance nationwide reveals a concerning pattern: pass rates fluctuated between 23.28% (2019) and 13.47% (2022), with 19.42% passing in 2023. The WAEC Physics results reveal a concerning trend: a significantly higher number of students fail compared to those who pass.

This persistent poor performance in Physics among senior secondary school students demands urgent attention. The downward trend in previous results mirrors the overall underachievement of Physics students in Imo State, reflecting a nationwide issue. Research suggests that ineffective teaching methods may contribute to this problem. Studies have shown that non-Physics majors teaching Physics curriculum and lack of varied teaching approaches can hinder student understanding. To address this, educators should employ relevant and engaging teaching methods to enhance student learning outcomes. To combat the persistent poor performance in practical physics, innovative teaching strategies are crucial. This study investigates the potential of laboratory activities in enhancing students' academic achievement and retention. Specifically, it explores whether group and individual laboratory engagements can improve senior secondary school students' understanding and retention of practical physics concepts. To address this research gap, this investigation focuses on Orlu Education Zone I in Imo State, examining the impact of collaborative and individual laboratory experiences on students' academic outcomes in practical physics.

### Research Question

The investigation was directed by a set of research questions aligned with the study's specific objectives;

1. What are the pre-test and post-test scores of students participating in the two types of laboratory activities in practical physics?
2. What is the comparative analysis of post-test mean achievement scores for male and female students taught practical physics using group and individual laboratory methods?
3. What are the mean scores for post-test and retention test performance of students participating in group versus individual laboratory activities in practical physics?

The study formulated and examined the hypotheses, with a statistical significance threshold of 5%.

Ho<sub>1</sub>: The pre-test and post-test scores of students participating in the two types of laboratory activities in practical physics do not differ significantly.

Ho<sub>2</sub>: The comparative analysis of post-test scores of students taught practical physics with the two



types of laboratory activities is not significantly different according to gender.

H<sub>03</sub>: The mean scores for post-test and retention test performance of students participating in group versus individual laboratory activities in practical physics are not significantly different.

### Methodology

This study utilized a quasi-experimental approach, incorporating pre-test, intervention, post-test, and retention test phases, with non-equivalent groups serving as experimental units. The study's population comprised 3,285 SSII students, consisting of 2,113 males and 1,174 females, enrolled in 65 public secondary schools within the designated area. This study focused on SSII students, as they possess a foundational understanding of Physics, making them ideal participants, whereas SSIII students are often preoccupied with external examination preparations. A total of 65 SSII students were randomly selected for the study and divided into two experimental groups: Group I (31 students; 17 males, 14 females) and Group II (34 students; 19 males, 15 females). The sample size was determined using a multistage sampling approach. Initially, two co-educational schools were sampled purposively. Subsequently, these schools were randomly selected from a pool of 65 public schools through a draw. The school names were written on folded papers, placed in a container, and thoroughly mixed. Two schools were then randomly selected through a draw-with-replacement method. Finally, streams A and B were purposefully chosen from the selected schools. However, within each selected school, two intact SSII classes (Streams A and B) were utilized as experimental groups, eliminating the need for random subject sampling. Treatment assignments were then determined by flipping a coin three times.

To assess students' practical physics skills, a researcher-designed test, the Practical Physics Performance Test (PPPT), was employed. The test's validity was verified by three specialists from Imo State University's Faculty of Education. The experts received a comprehensive package, including the study title, objectives, research questions, and hypotheses, to evaluate the instrument's alignment with the topic. They provided constructive feedback, refining poorly formulated items, suggesting relevant additions, and eliminating ambiguous statements. The experts verified that the questions spanned the cognitive domain's six levels: knowledge-cognition, comprehension-cognition, application-cognition, analysis-cognition, synthesis-cognition, and evaluation-cognition. This rigorous review guaranteed the instrument's ability to assess its intended objectives.

Utilizing the Kuder-Richardson KR-20 method, a reliability coefficient of 0.72 was established, confirming the instrument's consistency. Given the theoretical nature of the questions, this method proved appropriate. The pretest was initially administered to the sampled students, followed by the post-test, which was created by reordering the pretest items after the treatment. Following the pretest, a six-week experimental intervention was implemented, culminating in the administration of the posttest, which comprised reordered pretest items. Subsequently, a retention test was conducted two days later. Data for this study were derived from the scores obtained from these three assessments. The study's research questions were addressed through descriptive statistics, employing mean and standard deviation. To evaluate the null hypotheses, Analysis of Covariance (ANCOVA) was employed stating the significance threshold of 5%.

### Results

**Table 1:** Achievement scores of students participating in group and individual laboratory activities in practical physics

Test: Achievement Methods	n	Pre-test		Post-test	
		X	S	X	S
Group Laboratory Activities	31	21.48	2.606	38.48	2.827
Individual Laboratory Activities	34	22.18	2.801	26.24	2.016

Table 1 illustrates the outcomes of Research Question 1, highlighting the pre-test and post-test mean achievement scores of students engaged in group versus

individual laboratory activities in practical physics. Notably, students engaged in group laboratory activities achieved pretest and posttest mean scores of 21.48 and



38.48, respectively. 1. Conversely, students taught practical physics through individual laboratory activities achieved pretest and posttest mean scores of 22.18 and 26.24, respectively. Notably, the score distribution exhibited homogeneity, characterized by a distinct gap between the mean scores and standard

deviation. A comparative analysis of the pretest and posttest mean scores reveals that group laboratory activities yield significantly greater improvements in students' practical physics achievement compared to individual laboratory activities.

**Table 2:** ANCOVA Statistics

<b>Tests of Between-Subjects Effects</b>						
Dependent Variable: Post Test						
<b>Source</b>	<b>Type III Sum of Squares</b>	<b>df</b>	<b>Mean Square</b>	<b>F</b>	<b>Sig.</b>	
Corrected Model	2554.493 <sup>a</sup>	2	1277.246	314.090	.000	
Intercept	428.379	1	428.379	105.343	.000	
Pre_Test	121.737	1	121.737	29.937	.000	
Teaching_Methods	2533.335	1	2533.335	<b>622.978</b>	<b>.000</b>	
Error	252.123	62	4.066			
Total	69687.000	65				
Corrected Total	2806.615	64				

a. R Squared = .910 (Adjusted R Squared = .907)

Table 2 presents the findings related to Hypothesis 1, examining the significance of mean achievement score differences between students taught practical physics via group and individual laboratory activities. Notably, the table reveals a substantial F-calculated (F-cal) value of 622.978. With a p-value of 0.000, the results fell below the 0.05 significance

threshold, leading the researcher to reject the null hypothesis in favor of the alternative hypothesis. This conclusion supports the existence of a statistically significant difference between the mean achievement scores of students taught practical physics via group and individual laboratory activities.

**Table 3:** Comparative analysis of post-test mean achievement scores for male and female students taught practical physics using group and individual laboratory methods

<b>Test: Achievement</b>	<b>Posttest</b>		
<b>Group Laboratory Activities</b>	<b>n</b>	<b>X</b>	<b>SD</b>
Gender	31		
Male	17	38.88	2.571
Female	14	38.00	3.138
<b>Individual Laboratory Activities</b>	<b>n</b>	<b>X</b>	<b>SD</b>
Gender	34		
Male	19	27.07	2.052
Female	15	22.13	2.900

Table 3 presents the results for Research Question 2, comparing the post-test mean achievement scores of male and female students participating in group and individual laboratory activities in practical physics. Notably, male students in the group activity group scored 38.88, while their female counterparts scored 38.00. In contrast, male students in the individual activity group achieved 27.07, whereas

female students scored 22.13. The score distribution exhibits homogeneity, characterized by a noticeable gap between mean scores and standard deviation. Moreover, the data suggests that teaching practical physics through group and individual laboratory activities yields slightly greater achievement gains for male students compared to their female counterparts.



**Table 4:** ANCOVA Statistics

<b>Tests of Between-Subjects Effects</b>					
Dependent Variable: Post-Test					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	41.373 <sup>a</sup>	3	13.791	1.658	.186
Intercept	90154.576	1	90154.576	10841.464	.000
Teaching_Methods	14.438	1	14.438	1.736	.193
Gender	24.631	1	24.631	<b>2.962</b>	<b>.090</b>
Teaching_Methods * Gender	2.171	1	2.171	.261	.611
Error	490.627	59	8.316		
Total	91504.000	63			
Corrected Total	532.000	62			

a. R Squared = .078 (Adjusted R Squared = .031)

Table 4 presents the findings related to Hypothesis 2, examining the significance of mean achievement score differences between male and female students taught practical physics via group and individual laboratory activities in the post-test. Notably, the F-calculated (F-cal) value is 2.962, indicating a relatively low effect. The statistical analysis yielded a

p-value of 0.09, which supersedes the 0.05 threshold for significance, thus the null hypothesis remains tenable. Consequently, the analysis concludes that no statistically significant difference exists between the mean achievement scores of male and female students taught practical physics via group and individual laboratory activities in the post-test.

**Table 5:** Comparative analysis of post-test mean achievement scores for male and female students taught practical physics using group and individual laboratory methods

Test: Retention	Post test			Retention test	
	n	X	SD	X	SD
Teaching Methods					
Group Laboratory Activities	31	38.48	2.827	38.58	3.394
Individual Laboratory Activities	34	26.24	2.016	26.41	2.148

Table 5 presents the findings related to Research Question 3, examining the mean retention scores of students taught practical physics through group and individual laboratory activities, as measured in both post-test and retention test. According to the table, students engaging in group laboratory activities for practical physics achieved mean scores of 38.48 on the post-test and 38.58 on the retention test. In contrast, students participating in individual laboratory activities

scored 26.24 on the post-test and 26.41 on the retention test. 1. The score distribution exhibits homogeneity, characterized by a noticeable separation between mean scores and standard deviation. Furthermore, the differences in mean scores between groups from pretest to retention test suggest that group laboratory activities yield greater improvements in practical physics achievement compared to individual laboratory activities.

**Table 6:** ANCOVA Statistics

<b>Tests of Between-Subjects Effects</b>						
Dependent Variable: Retention Test						
Source	Type III Sum of Squares	df	Mean Square	F	Sig.	
Corrected Model	3314.165 <sup>a</sup>	3	1104.722	138.424	.000	
Intercept	546.119	1	546.119	68.430	.000	
Post_Test	6.046	1	6.046	.758	.386	
Teaching_Methods	493.562	2	246.781	<b>30.922</b>	<b>.000</b>	
Error	742.206	93	7.981			
Total	118581.000	97				
Corrected Total	4056.371	96				

a. R Squared = .817 (Adjusted R Squared = .811)

Table 6 presents the findings related to Hypothesis 3, examining the significance of mean achievement score differences between students taught practical physics via group and individual laboratory activities in the post-test and retention test. Notably, the F-calculated (F-cal) value reaches 30.922. The extremely low p-value (0.000) provides compelling evidence to refute the null hypothesis at the 0.05 significance level, lending strong support to the alternative hypothesis. The findings indicate a notable disparity in mean achievement scores, revealing a statistically significant advantage of group laboratory activities over individual ones.

### Discussion of Findings

The study's findings indicate that a group-based laboratory approach to teaching practical physics yields superior outcomes, outperforming individual laboratory activities in terms of student achievement. This suggests that collaborative learning strategies are more effective in promoting student success in practical physics. The effectiveness of group laboratory activities in physics stems from their ability to foster a collaborative and supportive learning environment. With the teacher serving as a facilitator and motivator, students enthusiastically engage in hands-on experimentation, sharing responsibilities and expertise to achieve common goals. Supporting the results, Research by Ugwu et al. (2020) revealed that group laboratory activities yielded superior performance in biology compared to individual laboratory activities, with male students outperforming their female counterparts. Similarly, Ezeano et al. (2019) discovered that laboratory teaching methods significantly impacted Chemistry students' achievement. The similarities between the present study and the formal could be

attributed to the similar research designs and level of students used for the studies.

It was also revealed that male students slightly achieved more than female students in practical physics when both groups were taught using group and individual laboratory activities, but the difference between their achievements is not significant. This finding indicates that the two teaching approaches do not significantly favour one group over another. This also means that the teaching approaches are gender friendly. This study reveals that gender does not determine achievement in practical physics learning through group and individual activities. Instead, societal expectations, roles, and opportunities assigned to women and men, along with underlying power dynamics, influence outcomes, perpetuating unequal divisions between masculinity and femininity. The current study's results align with Abdurahaman et al. (2016), which found no significant gender-based performance differences in two teaching strategies. However, this contrasts with Bonah (2015), who reported statistically significant performance disparities between male and female students engaging in chemistry laboratory exercises. The similarities recorded among the findings could be attributed to the potency of the teaching methods on both genders.

Lastly, the result showed that students that were taught practical physics using group laboratory activities retained significantly more than students that were taught practical physics using individual laboratory activities. The post-experiment evaluation demonstrated that group laboratory activities maintained their efficacy in bolstering students' long-term retention and mastery of practical physics skills. This sustained impact can be attributed to the activities' capacity to cultivate deeper comprehension, enhanced



retention rates, and advanced cognitive abilities, including analytical problem-solving and discerning critical thinking. The current study's results align with Ibrahim et al. (2015), who reported superior performance among treatment group students on post-test assessments. Similarly, Ajayi and Angura (2017) discovered improved retention rates in Physics using innovative methods, suggesting group laboratory activities enhance long-term knowledge retention. The recorded similarities could be linked to the use of similar teaching method.

### Conclusion

This research revealed that laboratory activities are inherently student-centered, with group-based approaches surpassing individual activities in effectiveness. Group work allows students to tap into the collective problem-solving strategies and expertise of their peers. Participating in group settings allows students to observe peers' successes and challenges, fostering self-awareness of their academic strengths and weaknesses. This awareness can motivate students to adjust their approach, leading to improved academic achievement and retention in practical physics.

### Recommendations

The study's outcomes informed the following recommendations for future practice:

1. School administrators should provide professional development opportunities for teachers to enhance their skills in integrating group laboratory activities into practical physics instruction, ultimately improving student performance.
2. Teachers should strive to create an inclusive learning environment for practical physics, ensuring equal opportunities and participation for both genders during laboratory activities, free from bias or discrimination.
3. Textbook writers should always continue to explore the relevance of using group laboratory activities in the teaching of practical physics. This will help to create more awareness to teachers to put more consideration on the usage of the teaching approach.

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