



## Enhancing physics students' academic performance in oscillatory motion concept using laboratory work-based instruction in Bonny Island, Rivers state

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### Abstract

The aim of this study was to investigate the effect of laboratory work-based Instruction on Secondary School Physics students' academic performance in Oscillatory motion in Bonny Island, Rivers State. The research design adopted for the study was pre-test, post-test quasi-experimental design. A sample of ninety-nine SS2 Physics students was selected from two Schools using random sampling. Three research questions were answered and three hypotheses were tested at 0.05 level of significance. The validated, researcher-constructed instrument used to collect data was Oscillatory Motion Performance Test with a reliability coefficient of 0.77, obtained using Kuder-Richardson 21 formula. Mean and standard deviation were used to answer the research questions, while the hypotheses were tested using Analysis of Covariance. Findings revealed that laboratory work-based Instruction significantly enhanced students' academic performance in the concept of Oscillatory motion. Furthermore, though the male students performed better than the female students, the difference in their performance was not found to be statistically significant. The findings also revealed that the male students taught oscillatory motion using laboratory work had the best academic performance, while the female students taught using lecture method had the least performance. The interaction of instructional method and gender on students' academic performance in oscillatory motion was however not statistically significant. Recommendations include integrating more laboratory work into the teaching of secondary school physics concepts to foster a deeper understanding of physics concepts and in turn enhance students' academic performance.

**Keywords:** Laboratory work, Oscillatory motion, Academic performance, Gender, Physics.

### Introduction

Physics is the study of matter in relation to energy. It is a subject that has a very important place among the science subjects. Its knowledge is required in applied sciences, medicine, engineering, technology, ICT, many other professions. Physics is classified into branches namely Classical Mechanics, Thermodynamics, Electromagnetics, Optics, Waves and Sound, Electricity and Magnetism, and Modern Physics. Oscillatory motion (Simple Harmonic Motion) is an important concept under the Waves branch of Physics. Oscillatory motion has its application in many equipment and devices and gadgets used in various professions and endeavours of life, even in recreation.

The laboratory is a space or facility where natural phenomena, and physical laws, theories, and scientific concepts are investigated, explored, and explained. Laboratory work involves the use of apparatus, equipment, gadgets, and learning materials that enable effective teaching and learning of Physics. In the laboratory, students use learning materials to explore natural phenomena and scientific laws, theories, and concepts. Laboratory work enables the students to participate and interact, thus making them active participants in the lesson. This promotes the learner-centered classroom being advocated in the science lessons. Laboratory work in Physics equips students with scientific attitudes, science process skills, and a deeper understanding of scientific concepts. Lecture method is one of the conventional methods used in teaching Physics. It is a teacher-centered method, also called the talk and chalk method in which the teacher instructs while the students listen and take notes, making the students passive participants of the lesson.

Much research has been done comparing the effect of laboratory and conventional methods which include lecture method in the teaching of science subjects. Kibirige *et al.* (2014) <sup>[11]</sup> found that practical work improves learners' performance in Science more than the traditional method. Antwi *et al.* (2021) <sup>[15]</sup> also found that practical work enabled students' acquisition of scientific process skills, and was effective in enhancing the learning of Physics. In the same vein, El-Rabadi (2013) <sup>[8]</sup> found that students taught Physics using practical work scored significantly higher than students taught using the traditional method. Ojediran *et al.* (2014) <sup>[20]</sup> found that laboratory-based instructional intervention significantly enhanced the learning outcomes of low-performing Senior Secondary students in Physics more than the conventional teaching method. Musasia *et al.* (2016) <sup>[13]</sup> found that practical work significantly enhanced academic achievement in Physics more than the conventional teaching method. Usman and Sabo (2018) <sup>[26]</sup> found that laboratory practical skills significantly enhanced students' achievement in Physics more than the conventional method. Ugwuanyi *et al.* (2019) <sup>[25]</sup> found that the achievement of students taught Physics using practical activities was significantly enhanced more than students taught without practical activities. Twahirwa and Twizeyimana (2020) <sup>[23]</sup> found that students taught using practical work outperformed those taught using the expository method in Physics.

In other science subjects, Chibabi *et al.* (2018) <sup>[7]</sup> found that the laboratory method of teaching significantly enhanced students' achievement more than the traditional method of teaching in Biology. Ezra and Agah (2019) <sup>[9]</sup> discovered that the practical teaching method significantly enhanced

students' academic achievement in Biology more than the lecture method. Ntawuhiganayo and Nsanganwimana (2022) <sup>[15]</sup> found that the achievement of students taught Biology using laboratory practical activities was significantly higher than the students taught using the "talk and chalk" method. Afyusisye and Gakuba (2022) <sup>[3]</sup> found a significant difference in performance between the students taught Volumetric Analysis concept in Chemistry using practicals and those taught without practicals. Okwara *et al.* (2019) <sup>[21]</sup> found that laboratory teaching method significantly enhanced students' achievement in Basic Science.

Investigating the influence of gender on students' academic performance, Musasia *et al.* (2016) <sup>[13]</sup> found that male students performed better than female students in Physics, and Obafemi and Aderonmu (2020) found a significant difference in the effect of gender in favour of male students in Physics. Ndukwe and Obafemi (2023) <sup>[14]</sup> found that though the male students performed better than the female students in Redox reaction, the difference in their performance was not significant, while Ezra and Agah (2019) <sup>[9]</sup> discovered a significant difference in the effect of gender in favour of the male students in Biology. On the contrary, Ojediran *et al.* (2014) <sup>[20]</sup> found that the learning outcomes of female students in Physics were significantly better than their male counterparts, Usman and Sabo (2018) <sup>[26]</sup> found that female students had better achievement in Physics than male students, though the difference in their performance was not statistically significant. Chibabi *et al.* (2018) <sup>[7]</sup> found that female students significantly achieved better than male students in Biology. Okwara *et al.* (2019) <sup>[21]</sup> found that female students had better achievement in Basic Science than male students, though the difference in their performance was not statistically significant, while Akpan and Obafemi (2023) <sup>[4]</sup> discovered that though female students performed better than male students in quadratic graphs, there was no significant difference between the performance of male and female students.

Considering the joint effect of instructional method/instructional and gender on students' academic performance, Ugwu (2014) <sup>[24]</sup> found a significant interaction of instructional strategy and gender on students' performance in Basic science, Obafemi (2015) <sup>[15]</sup> discovered a significant joint effect of instructional strategy and gender on students' performance at the application level of the concept of Light waves, while Ibeneme and Akinlabi (2021) <sup>[10]</sup> discovered a significant interaction of instructional strategy and gender on the performance of students in Instruction on Block laying. On the contrary, Abumchukwu *et al.* (2021) <sup>[1]</sup> found no significant interaction of instructional strategy and gender on students' performance in Chemistry. Macaulay and Obafemi (2022) <sup>[12]</sup> found no significant interaction of instructional strategy and gender on students' performance in Electrolysis. Obafemi and Rowland (2022) found no significant joint effect of instructional strategy and gender on the performance of students in Basic science. Akpan and Obafemi (2023) <sup>[4]</sup> found no significant joint effect of instructional strategy and gender on the performance of students in Quadratic graphs, while Ndukwe and Obafemi (2023) <sup>[14]</sup> discovered no significant interaction of instructional strategy and gender on students' performance in Redox reaction.

In the studies conducted by Obafemi and Onwioduokit (2013), Bello *et al.* (2018) <sup>[6]</sup>, Adebisi *et al.* (2020) <sup>[2]</sup>, and Taangahar and Okwori (2022) <sup>[22]</sup>, students indicated that Simple harmonic motion (Oscillatory motion) is a difficult Physics concept. As a proof of the difficulty expressed by the students, WAEC Chief Examiner's Report for 2023 in WASSCE Physics Examination revealed that students were not able to correctly answer questions on Simple harmonic motion due to the lack of understanding of the concept. Could the use of laboratory work-based Instruction enable better performance of students in the concept? This study therefore investigated the effect of laboratory work-based Instruction on Secondary School Physics students' academic performance in the concept of Oscillatory motion in Bonny Island, Rivers State.

### Aim and objectives of the study

The aim of this study was to investigate the effect of instructional strategy (laboratory work-based Instruction and lecture method) on Secondary School Physics students' academic performance in the concept of oscillatory motion in Bonny Island, Rivers State.

The following are the specific objectives:

1. to investigate the effect of instructional strategy (laboratory work-based Instruction and lecture method) on students' academic performance in oscillatory motion.
2. to determine the influence of gender on students' academic performance in oscillatory motion.
3. to determine the joint effect of instructional strategy and gender on students' academic performance in oscillatory motion.

### Research Questions

This study was guided by the following questions:

1. What is the effect of instructional strategy (laboratory work-based Instruction and lecture method) on students' academic performance in oscillatory motion?
2. How does gender influence students' academic performance in oscillatory motion?
3. What is the joint effect of instructional strategy and gender on students' academic performance in oscillatory motion?

### Hypotheses

The following hypotheses were tested at 0.05 level of significance:

**H<sub>01</sub>:** There is no significant difference between the academic performance of students taught oscillatory motion using laboratory work-based Instruction and those taught using lecture method.

**H<sub>02</sub>:** There is no significant difference between the academic performance of male and female students in oscillatory motion.

**H<sub>03</sub>:** There is no significant joint effect of instructional strategy and gender on students' academic performance in oscillatory motion.

### Materials and Methods

This study investigated the effect of laboratory work-based Instruction on Secondary School Physics students' academic performance in oscillatory motion in Bonny Island, Rivers State. The research design used for the study was pre-test, post-test quasi-experimental design. The population of the

study was 1046 Senior Secondary School 2 (SS2) Physics students. Out of the population, two schools were selected using random sampling. One intact class was selected from each of the two Schools for the study. From the two intact classes, a sample of ninety-nine (99) SS2 Physics students comprising 38 males and 61 females was obtained. The first intact class was the Experimental group while the second intact class was the Control group. The instrument used for data collection was a validated instrument titled ‘Oscillatory Motion Performance Test’ (OMPT). The researcher-constructed instrument was intended to obtain the performance of students in the concept of Oscillatory motion. The instrument consisted of two sections A and B. Section A was used to obtain the students’ bio-data, while section B contained 20 multiple choice questions on Oscillatory Motion with four options A to D. Each question was scored 1 mark totalling up to 20 marks. OMPT was validated and its reliability coefficient was obtained to be

0.77 using Kuder-Richardson 21 formula. Copies of the research instrument OMPT were administered as pre-test to students in each group. Thereafter, the experimental group was taught the concept of Oscillatory motion using Laboratory work-based Instruction, while the control group was taught the same concept of Oscillatory motion using Lecture method. The instrument OMPT was then re-administered to each of the two groups as post-test. The scores from the graded students’ responses for pre-test and post-test constituted the data for this study. The research questions were answered using mean and standard deviation while Analysis of Covariance (ANCOVA) was used to test the hypotheses at 0.05 level of significance.

**Results and Findings**

**Research Question 1:** What is the effect of instructional strategy (laboratory work-based Instruction, lecture method) on students’ academic performance in oscillatory motion?

**Table 1:** Mean and Standard deviation values of students’ academic performance classified by instructional strategy.

Instructional strategy		Pre-test	Post-test	Gain
Laboratory work-based Instruction	Mean	4.7755	14.1224	9.3469
	Std. Deviation	1.72319	2.15670	2.15591
	N	49	49	49
Lecture Method	Mean	5.2800	9.1000	3.8200
	Std. Deviation	1.93823	1.24949	2.10626
	N	50	50	50

Table 1 shows that the students taught using laboratory work-based Instruction had a mean gain of 9.35 while the students taught using lecture method had a mean gain of 3.82. This indicates that students taught using laboratory work-based Instruction gained more than students taught using lecture method. In other words, laboratory work-based

Instruction was more effective than the lecture method in enhancing the academic performance of students in oscillatory motion.

**Research Question 2:** How does gender influence students’ academic performance in oscillatory motion?

**Table 2:** Mean values and Standard deviation of students’ academic performance classified by gender.

Gender		Pre-test	Post-test	Gain
Male	Mean	5.0263	12.0000	6.9737
	Std. Deviation	1.6844	3.2798	3.2172
	N	38	38	38
Female	Mean	5.0328	11.3279	6.2951
	Std. Deviation	1.9491	2.9310	3.6576
	N	61	61	61

Table 2 shows that the male students had a mean gain of 6.97 while the female students had a mean gain of 6.30. This indicates that the male students performed better than the female students in the concept of Oscillatory motion.

**Research Question 3:** What is the joint effect of instructional strategy and gender on students’ academic performance in Oscillatory motion?

**Table 3:** Mean values and Standard deviation of students’ academic performance classified by instructional strategy and gender.

Instructional Strategy	Gender		Pre-test	Post-test	Gain
Laboratory work-based Instruction	Male	Mean	5.5294	15.1176	9.5882
		Std. Deviation	1.58578	2.11785	2.42536
		N	17	17	17
	Female	Mean	4.3750	13.5938	9.2188
		Std. Deviation	1.68005	2.01381	2.02778
		N	32	32	32
Lecture Method	Male	Mean	4.6190	9.4762	4.8571
		Std. Deviation	1.68749	1.16701	1.98206
		N	21	21	21
	Female	Mean	5.7586	8.8276	3.0690
		Std. Deviation	1.99383	1.25553	1.88852
		N	29	29	29

Table 3 reveals that in the group of students taught using laboratory work-based Instruction, the male students had a mean gain of 9.59 while the female students had mean gain of 9.22, showing that the male students gained more than their female counterparts. Furthermore, in the group of students taught using lecture method, the male students had a mean gain of 4.86 while the female students had a mean gain of 3.07, showing that the male students gained more than their female counterparts. These results indicate that in the two groups, the male students gained more than their female counterparts. Overall, the male students taught using laboratory work-based Instruction gained the most, followed

by female students taught using Laboratory work-based Instruction, while the female students taught using lecture method gained the least. In other words, the academic performance of male students taught using laboratory work-based Instruction in Oscillatory motion had the best performance.

**Hypothesis 1:** There is no significant difference between the academic performance of students taught oscillatory motion using laboratory work-based Instruction and those taught using lecture method.

**Table 4:** Summary of Analysis of Covariance of students’ academic performance classified by instructional strategy.

Tests of Between-Subjects Effects					
Dependent Variable: Post-test					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	650.706 <sup>a</sup>	2	325.353	114.278	0.000
Intercept	1184.497	1	1184.497	416.047	0.000
Pre-test	26.451	1	26.451	9.291	0.003
Instructional strategy	647.958	1	647.958	227.591	0.000
Error	273.314	96	2.847		
Total	14213.000	99			
Corrected Total	924.020	98			

a. R Squared = 0.704 (Adjusted R Squared = 0.698)

Table 4 shows a value of  $F_{(1,96)} = 227.591$ ,  $p = 0.00$  ( $p < 0.05$ ) for the effect of instructional strategy on students’ academic performance in oscillatory motion. Therefore, the null hypothesis is therefore rejected. This indicates that

there is a significant difference between the academic performance of students taught oscillatory motion using laboratory work-based Instruction and those taught using lecture method.

**Table 5:** Post Hoc analysis of students’ academic performance classified by instructional strategy

Pairwise Comparisons						
Dependent Variable: Post-test						
(I) Instructional strategy	(J) Instructional strategy	Mean Difference (I-J)	Std. Error	Sig. <sup>b</sup>	95% Confidence Interval for Difference <sup>b</sup>	
					Lower Bound	Upper Bound
Laboratory work-based Instruction	Lecture Method	5.166*	0.342	0.000	4.486	5.846
Lecture Method	Laboratory work-based Instruction	-5.166*	0.342	0.000	-5.846	-4.486

Based on estimated marginal means  
 \*. The mean difference is significant at the 0.05 level.  
 b. Adjustment for multiple comparisons: Least Significant Difference (equivalent to no adjustments).

The post hoc analysis in Table 5 shows a mean difference of 5.166,  $p = 0.000$  ( $p < 0.05$ ) between laboratory work-based Instruction and lecture method. This indicates that students taught using laboratory work-based Instruction contributed more to the significant difference in the effects of the

methods on students’ academic performance in oscillatory motion.

**Hypothesis 2:** There is no significant difference between the academic performance of male and female students in oscillatory motion.

**Table 6:** Summary of Analysis of Covariance of students’ academic performance classified by gender.

Tests of Between-Subjects Effects					
Dependent Variable: Post-test					
Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	13.343 <sup>a</sup>	2	6.672	0.703	0.497
Intercept	1448.860	1	1448.860	152.733	0.000
Pre-test	2.766	1	2.766	0.292	0.590
Gender	10.596	1	10.596	1.117	0.293
Error	910.677	96	9.486		
Total	14213.000	99			
Corrected Total	924.020	98			

a. R Squared = 0.014 (Adjusted R Squared = -0.006)

Table 6 shows a value of  $F_{(1,96)} = 1.12$ ,  $p = 0.29$  ( $p > 0.05$ ) for the influence of gender on students' academic performance in oscillatory motion. Therefore, the null hypothesis is therefore retained. This shows that there is no significant difference between the academic performance of

male and female students in oscillatory motion.

**Hypothesis 3:** There is no significant joint effect of instructional strategy and gender on students' academic performance in oscillatory motion.

**Table 7:** Summary of Analysis of Covariance of students' academic performance classified by instructional strategy and gender.

Tests of Between-Subjects Effects					
Dependent Variable: Post-test					
Source	Type III Sum of Squares	df	Mea Square	F	Sig.
Corrected Model	678.110 <sup>a</sup>	4	169.527	64.802	0.000
Intercept	1095.630	1	1095.630	418.808	0.000
Pre-test	22.949	1	22.949	8.772	0.004
Instructional strategy	642.327	1	642.327	245.531	0.000
Gender	27.308	1	27.308	10.439	0.002
Instructional strategy * Gender	0.295	1	0.295	0.113	0.738
Error	245.910	94	2.616		
Total	14213.000	99			
Corrected Total	924.020	98			

a. R Squared = 0.734 (Adjusted R Squared = 0.723)

Table 7 shows a value of  $F_{(1,94)} = 0.113$ ,  $p = 0.738$  ( $p > 0.05$ ) for the interaction of Instructional strategy and gender on students' academic performance in oscillatory motion. Therefore, the null hypothesis is retained. This indicates that there is no significant joint effect of instructional method and gender on students' academic performance in oscillatory motion.

### Discussion of Findings

The findings of this study revealed that laboratory work-based instruction was more effective than the lecture method in enhancing the academic performance of students in oscillatory motion. There was a significant difference between the academic performance of students taught oscillatory motion using laboratory work-based Instruction and those taught using lecture method, in favour of the students taught using laboratory work-based Instruction. This finding may be due to the hands-on nature of laboratory work-based Instruction, in which the students had the opportunity to interact with learning materials and explore the Physics concept, which may have led to a deeper understanding of the concept. This finding is in agreement with the findings of Antwi *et al.* (2021) [5], El-Rabadi (2013) [8], Ojediran *et al.* (2014) [20], Musasia *et al.* (2016) [13], and Usman and Sabo (2018) [26] who found that the students taught Physics using practical work performed significantly better than the students taught using traditional/conventional teaching method. This finding also aligns with the findings of Ugwuanyi *et al.* (2019) [25] who found that the achievement of students taught Physics using practical activities was significantly enhanced more than students taught without practical activities, and Twahirwa and Twizeyimana (2020) [23] who found that students taught using practical work outperformed those taught using the expository method in Physics.

The findings of this study further revealed that the male students performed better than the female students in the concept of oscillatory motion. This finding may be because laboratory work-based Instruction allowed interaction among the students, as well as active participation in the lesson, irrespective of gender. This finding is in agreement with the findings of Musasia *et al.* (2016) [13] and Obafemi and Aderonmu (2020) who found that male students

performed better than female students in Physics, Macaulay and Obafemi (2022) [12] who found that male students performed better than the female students in Electrolysis, Ndukwe and Obafemi (2023) [14] who found that male students performed better than the female students in Redox reaction, and Ezra and Agah (2019) [9] who discovered that male students performed better than the female in Biology. This finding is however at variance with the findings of Ojediran *et al.* (2014) and Usman and Sabo (2018) [26] who found that the learning outcomes of female students in Physics were better than their male counterparts, Chibabi *et al.* (2018) [7] who found that female students achieved better than the male students in Biology, Okwara *et al.* (2019) [21] who found that female students had a better achievement in Basic Science than the male students, as well as Akpan and Obafemi (2023) [4] who discovered that female students performed better than male students in Quadratic graphs.

The findings of this study also revealed that the difference between the academic performance of male and female students in oscillatory motion was not statistically significant. This finding aligns with the findings of Kibirige *et al.* (2014) [11] who found no significant difference between the performance of male and female students in Science, and Usman and Sabo (2018) [26] who found no significant difference between the performance of male and female students in Physics. The findings also agree with the findings of Okwara *et al.* (2019) [21] who found no significant difference between the performance of male and female students in Basic Science, Macaulay and Obafemi (2022) [12] who found no significant difference between the performance of male and female students in Electrolysis, Ndukwe and Obafemi (2023) [14] who found no significant difference between the performance of male and female students in Redox reaction, and Akpan and Obafemi (2023) [4] who discovered no significant difference between the performance of male and female students in Quadratic graphs. The finding is however at variance with the findings of Ojediran *et al.* (2014) [20] who found a significant difference between the learning outcomes of male and female students in Physics, Obafemi and Aderonmu (2020) who found a significant difference in the effect of gender on students' performance in Physics, as well as Chibabi *et al.* (2018) [7] and Ezra and Agah (2019) [9] who found a

significant difference between the performance of male and female students in Biology.

The findings of this study revealed that the male students taught oscillatory motion using laboratory work-based Instruction had the best academic performance, while the female students taught using lecture method had the least performance, although the interaction of instructional strategy and gender on students' academic performance in oscillatory motion was not significant.

This finding is in agreement with the findings of Abumchukwu *et al.* (2021) <sup>[1]</sup> who found no significant interaction of instructional strategy and gender on students' performance in Chemistry, Macaulay and Obafemi (2022) <sup>[12]</sup> who found no significant interaction of instructional strategy and gender on students' performance in Electrolysis, and Obafemi and Rowland (2022) <sup>[19]</sup> who found no significant joint effect of instructional strategy and gender on the performance of students in Basic science. This finding also aligns with the findings of Akpan and Obafemi (2023) <sup>[4]</sup> who found no significant joint effect of instructional strategy and gender on the performance of students in Quadratic graphs, and Ndukwe and Obafemi (2023) <sup>[14]</sup> who discovered no significant interaction of instructional strategy and gender on students' performance in Redox reaction. This finding is however at variance with the findings of Ugwu (2014) who found a significant interaction of strategy and gender on students' performance in Basic science, Obafemi (2015) who discovered a significant joint effect of strategy and gender on students' performance at the application level of students' performance in the concept of Light waves, and Ibeneme and Akinlabi (2021) <sup>[10]</sup> who discovered a significant interaction of strategy and gender on the performance of students in Instruction on Block laying.

### Conclusion

This study investigated the effect of laboratory work on Secondary School Physics students' academic performance in oscillatory motion in Bonny Island, Rivers State. The study has shown that laboratory work-based instruction was more effective than the lecture method in enhancing the academic performance of students in the Physics concept of Oscillatory motion. In the laboratory work-based instruction, the students made use of apparatus, equipment, and learning materials to explore the Physics concept taught. This enabled the students to participate, explore, and interact with one another and with the teacher, making them active participants in the lesson, promoting a learner-centered classroom, resulting in a deeper understanding of scientific concepts and a better performance. If Physics teachers therefore engage the students in laboratory work in the teaching of Physics concepts, the academic performance of students in Physics concepts will surely improve.

### Recommendations

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

1. Physics teachers should integrate laboratory work-based instruction into daily lesson plans, emphasizing hands-on experiments to deepen students' understanding of Physics concepts.
2. Science curriculum planners should create comprehensive resources, including experiment guides

and materials, to support teachers in conducting meaningful laboratory work.

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