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TWO-METHOD INDOOR LABORATORY INSTRUCTION: HOW EFFECTIVE IS IT ON SECONDARY SCHOOL STUDENTS' PERFORMANCE IN PHYSICS?

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ABSTRACT: *This study probed the effectiveness of two-method indoor laboratory instruction on secondary school students' performance in physics in Jos Metropolis, Nigeria. The quasi-experimental research design of the non-equivalent control group pre-test, post-test type was employed. The population for the study comprised 1,112 senior secondary two students offering physics in 18 schools in Jos metropolis, with the schools purposively obtained. The study sample consisted of 80 SSS II students obtained from two intact classes, one class each from two schools selected using simple random sampling technique. Two research questions were raised and two hypotheses were formulated. Physics Performance Test (PPT) was the instrument validated and used to gather data. The test-retest method was used to obtain the reliability of PPT and its coefficient was computed as 0.73 using Kuder-Richardson formula 21 (K-R 21). Mean and standard deviation were used to answer the research questions while independent t-test of difference and Analysis of Covariance (ANCOVA) were the statistical tools used to test the hypotheses at 0.05 levels of significance. The results revealed that students taught concepts of simple harmonic motion and elasticity using group indoor laboratory method performed better than their counterparts taught using individual indoor laboratory method; although male students performed slightly higher than their female counterparts after exposure to the two methods, gender was found to have no interaction effect on their performance; there was a significant interaction effect of treatments and gender on students' performance in the study area, with the methods as source of interaction effect. Based on the findings, recommendations were made, which include that curriculum developers should ensure that laboratory teaching methods are included in physics curriculum in order to enhance students' performance in the subject.*

KEYWORDS: Elasticity, Group Indoor Laboratory Method, Individual Indoor Laboratory Method, Simple Harmonic Motion, Students' Gender, Students' Performance.

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INTRODUCTION

The quality of learning is dependent on the quality of teachers in the education sector of a nation. Teaching is an activity that incorporates purposeful interaction between learners and teachers. One of the goals of education, as posited by the Federal Republic of Nigeria (FRN) in 2014, is to, in part, equip learners with the appropriate skills and competencies towards contributing to the socio-technological growth of Nigeria. The implication is that the teaching of science subjects in secondary schools is expected to encourage and enable students to acquire critical thinking skills and problem-solving skills which will be useful in society. These skills are practical skills which can be acquired in the laboratory. By imparting practical skills to students, physics laboratory activities have played a significant role towards the technological and socio-economic development of nations. Moreover, laboratory activities stimulate creativity, curiosity and critical thinking in the students. Students also engage with the scientific methods and are encouraged to actively learn and solve problems.

Realities on ground reveal that there has been a fluctuating performance of secondary school students in physics in the Senior School Certificate Examinations (SSCE) over the years. The West African Senior School Certificate Examinations (WASSCE) and National Examinations Council (NECO) SSCE results for 2010 to 2018 revealed a fluctuating performance of students in physics over the years (WAEC, 2015; Josiah & Gana, 2019; Josiah, 2020). Although the question on simple harmonic motion in the 2010 SSCE was adjudged popular amongst students by NECO (2012), many students were unable to relate frequency and period of an oscillating pendulum. According to WAEC (2019), WAEC (2020) and WAEC (2021), many students could not determine intercept correctly, choose suitable scales for plotting graphs, properly compute and evaluate, and draw lines of best fit.

The teaching instructions fondly employed by physics teachers in most secondary schools in Jos metropolis are those which Josiah, Mallo and Inyang (2019) described as encouraging passivity in students, rote learning and note-copying with little or no learning. These methods, which include the lecture method, portray physics as boring and unmotivating, thereby affecting the performance of students. It would therefore be necessary to search for an effective teaching strategy which may improve students' achievement in physics, especially in concepts of simple harmonic motion and elasticity.

The afore-mentioned situation could be connected to the inability of students to understand contents while studying independently and poor skills in physics laboratory exercise. The WAEC further attributed such students' weaknesses to their lack of familiarity with common physics laboratory equipment or apparatuses and poor knowledge in the fundamental principles and procedures for practical physics. This suggests that if this problem is allowed to continue, students' performance in physics will continue to fluctuate, thereby making it difficult for the country to grow technologically. The present study therefore sought to provide answers to this broad question: Will secondary school students in Jos Metropolis, Nigeria perform better if placed in the laboratory to individually learn simple harmonic motion and elasticity concepts or will they perform better when they learn in groups? The study was guided by the following research questions:

1. What are the performance mean scores of senior secondary school two (SSS II) students taught physics before and after exposure to individual and group indoor laboratory methods?

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2. What are the performance mean scores of SSS II male and female students taught physics after exposure to individual and group indoor laboratory methods?

Two null hypotheses were formulated, which were tested at 0.05 level of significance:

1. There is no significant difference in the post-test performance mean scores of SSS II students in the individual and group indoor laboratory methods.

2. There are no significant interaction effects of treatments and gender on SSS II students' performance in physics.

LITERATURE/THEORETICAL UNDERPINNING

The laboratory is necessary in the teaching of physics, which is a science subject. The physics laboratory is a room, building or a place where experimental studies in science are carried out by both the teacher and students. Students have the opportunity to carry out experiments, verifications and other investigative activities. Physics laboratories can be classified into indoor and outdoor laboratories. The indoor physics laboratory utilizes instruction inside a building or room equipped with apparatus for physics teachers and students offering physics as a subject. The outdoor physics laboratory, however, is one that utilizes instruction outside the premises of the school building, such as the radiology laboratory in hospitals and building sites. Like the indoor physics laboratory instruction, the outdoor physics laboratory instruction also provides students with opportunities of becoming more knowledgeable with practical physics skills. The use of laboratories in the teaching and learning of physics is very vital as it enhances the understanding of the subject which is considered abstract in nature. This study, however, focused on the indoor laboratory, specifically instructing students through the two-method indoor physics laboratory.

Two methods of conducting practical physics using the indoor physics laboratory in schools in Nigeria can be identified as the individual and group indoor laboratory methods. The individual laboratory method involves allowing only one student to perform a set of practical activities and report the same following the format of presentation. In the individual laboratory method, whether an individual accomplishes the goal or not has no effect on the other students in the class. Salami (2022) pointed out that the individual laboratory method is a form of laboratory investigation where contents, instructional materials and pace of learning are based on the cognitive ability and interest of the individual student carrying out the laboratory activities. However, when the student needs assistance or clarification, he or she can relate with the classmates or teacher. Cronin and McCabe (2018) mentioned that students are of the opinion that individual laboratory work is beneficial to them. On the other hand, the group laboratory method allows students to be grouped together to perform the practical activities and report the same in the different groups. The group laboratory method can be seen as a teaching/learning process in which students of varying cognitive abilities are grouped to cooperatively carry out laboratory activities in which each member of the group willingly contributes to the group's performance.

It has been observed in literature that when teaching science subjects like physics, the group laboratory method has the advantages of the active learning methods. Olatoye, Aderogba and Aanu (2011) opined that the group laboratory method improves students' performance, self-

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esteem and intrinsic motivation, and develops students' positive attitudes towards learning. It also enables students to acquire the required practical skills, leadership and conflict resolution skills that are basic to productive working teams, and helps them to be able to socialize in the society. However, Johnson and Johnson, as cited in Bajon (2015), maintained that both individual and group learning enhance students' performance in science subjects.

In secondary schools in Nigeria, students are usually placed in groups of not less than four or five, due to insufficient apparatuses for practical physics. Consequently, most of the group members leave all the practical work to be done by only one member of the group. These students oftentimes wait to collect results at the end and therefore may not really gain any laboratory skill in physics. In the West African Examination Council (WAEC) Chief Examiners' report (2011), students lose more marks out of the 40% marks allocated to practical examinations because they lack knowledge and skills in the laboratory experience to effectively answer practical questions correctly. Ilorah and Adeniji (2018) stated that students' poor performance in physics can be attributed to poor knowledge and skills in laboratory experience in the classroom. In their study, Ugwu, Eze, Ngwu and Ezea (2020) evaluated the effects of group and individual laboratory activities on students' achievement in biology and the results showed that students taught using the group laboratory activity performed better than those taught using individual laboratory activity. Similarly, Kendra (2014) carried out research on the impact of collaborative groups versus individuals in undergraduate inquiry-based astronomy laboratory learning exercises. From the analysis of the study, it was revealed that students' understanding of scientific inquiry and astronomy increased regardless if the students were working in groups or individually in the laboratory. Antwi, Sakyi-Hagan, Addo-Wuver and Asare (2021) found out that students acquire scientific process skills and develop a positive attitude towards practical physics, thereby enhancing their performance in physics.

Gender disparity in performance is a topical issue. For instance, while Aina (2013), Lee and Suleiman's (2018) findings revealed that male students perform better in practical physics than female students, Akani (2015) had earlier investigated the role of the laboratory in students' performance in secondary school chemistry and found no significant difference in the performance of male and female students. Studies on individual and group methods of laboratory instruction seem to be unavailable. It is in this regard that the present study aimed at probing the effectiveness of the individual laboratory method as well as the group laboratory method on secondary school students' performance in physics in Jos Metropolis, Nigeria.

METHODOLOGY

The study adopted a quasi-experimental design, specifically non-equivalent control group pretest-posttest design. The population comprised all 1,112 senior secondary school two (SSS II) students offering physics across the 18 public secondary schools in Jos Metropolis, Nigeria. The population was obtained using the purposive sampling technique and was based on the criteria that each school must have both male and female students, well-equipped indoor physics laboratory and must be using the physics curriculum prepared by the Nigerian Educational Research and Development Council (NERDC). The sample consisted of 80 SSS II (44 males and 36 females) students from two intact classes, one each from two sample schools. Simple random sampling technique of the 'bowl containing water and live fishes' type was thereafter used to place one of the two intact classes into Experimental Group I, while the

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other was assigned Experimental Group II. The instrument used for the study was the Physics Performance Test (PPT) which was developed by the researchers using the concept of simple harmonic motion and elasticity. The PPT is a 40-item multiple choice test, with each item having four options and scored using 2.5 marks for any correct option chosen from A–D. A score of 60 % and above was considered a high performance while 0–59 % was considered a low performance. The PPT, which was validated by three experts from the University of Jos, Nigeria had a reliability coefficient of 0.73 computed using Kuder-Richardson formula 21 (K-R 21).

A pre-test was administered by the researchers a week before the four weeks treatment. During the treatment, Experimental Group I was taught concepts of simple harmonic motion and elasticity using the individual indoor laboratory method. Experimental Group II was taught the same concepts but using the group indoor laboratory method. The post-test was administered by the researchers the week after the treatment. The two research questions were answered using mean and standard deviation on the Statistical Package for Social Science (SPSS) Version 25, while the independent t-test of difference and Analysis of Covariance (ANCOVA) were employed to test the hypotheses at 0.05 level of significance also using the SPSS Version 25.

RESULTS/FINDINGS

Research Question One

What are the performance mean scores of senior secondary school two (SSS II) students taught physics before and after exposure to individual and group indoor laboratory methods?

Table 1: Results of Pre-test and Post-test Performance Mean Scores SSS II Students Taught Physics in Individual and Group Indoor Laboratory Methods

Group	Pre-test			Post-test		
	Mean	Std. Dev.	Mean Diff.	Mean	Std. Dev.	Mean Diff.
Group Method	16.04	2.084		34.50	2.755	
			0.04			2.94
Individual Method	16.00	1.443		31.56	2.631	

The results of analysis in Table 1 show that students in the group indoor laboratory had a pre-test mean performance score of 16.04 and those in the individual laboratory method had a mean of 16.00. This implies that students exposed to the group laboratory method had a slightly higher pre-test mean score of 0.04 than that of those in the individual laboratory method. Furthermore, it was found that students in the group indoor laboratory method had a post-test mean score of 34.50, while those in the individual laboratory method had a mean of 31.56. The results revealed a post-test mean difference of 2.94, which implies that students exposed to the group indoor laboratory method had a higher mean performance than their counterparts taught using the individual indoor laboratory method of teaching.

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Research Question Two

What are the performance mean scores of SSS II male and female students taught Physics after exposure to individual and group indoor laboratory methods?

Table 2: Results of Post-Test Performance Mean Scores of Male and Female SSS II Students Taught Physics in the Individual and Group Indoor Laboratory Methods

Group	Gender Exp 1	N	Mean	Std. Dev.	Mean Diff.
	Male	12	31.17	2.552	
Individual Method					0.25
	Female	13	30.92	2.753	
	Male	15	32.60	2.720	
Group Method					1.54
	Female	13	31.06	2.904	

The findings in Table 2 reveal that SSS II male students exposed to the individual indoor laboratory method of teaching had a post-test performance mean score of 31.17, while their female counterparts had a mean of 30.92. This implies that the male students in the group had a higher mean difference than that of their female counterparts, with a mean difference of 0.25. Furthermore, the results indicated that the male students exposed to the group indoor laboratory method had a mean score of 32.60 and female students in the group had a mean of 31.06. This means that male students exposed to the group indoor laboratory method also had a slightly higher mean performance score in concepts of simple harmonic motion and elasticity than their female counterparts. The post-test performance mean difference of 1.54 was in favour of the SSS II male students.

Hypothesis One

There is no significant difference in the post-test performance mean scores of SSS II students in the individual and group indoor laboratory methods.

Table 3: Results of Independent t-test of Difference in the Post-test Performance Mean Scores of SSS II Students in the Individual and Group Indoor Laboratory Methods

Test	Group	Mean	Std. Dev.	Df.	t-cal.	p	Decision
	Group Indoor	34.50	2.755				
Post-test				78	2.972	.002	Sig.
	Individual Indoor	31.56	2.631				

p<0.05

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The results of pre-test analysis in Table 3 reveal that t(78=2.972, p=.002), which shows that p<0.05 and the null hypothesis failed to be rejected. Based on this, an inference was drawn that there is a significant difference between the post-test performance mean scores of SSS II students exposed to the individual and group indoor laboratory methods. The study therefore concluded that students exposed to the group indoor laboratory method performed better than those exposed to the individual indoor laboratory method. This means that the use of the group indoor laboratory method has a significant effect on students' performance in concepts of simple harmonic motion and elasticity. The higher performance mean scores of students exposed to the group indoor laboratory method could be attributed to the treatment. Students working in groups construct knowledge by cooperating with their mates and sharing ideas to construct knowledge and develop skills, which enhances their performance.

Hypothesis Two

There are no significant interaction effects of treatments and gender on SSS II students' performance in physics.

Table 4: Results of ANCOVA Analysis of Interaction Effects of Treatments and Gender on SSS II Students in Physics

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.
Corrected Model	178.327[a]	2	89.163	1.805	.143
Intercept	56.25	1	56.25	.118	.889
Pre-test	117.28	1	117.28	22.63	.000
Treatments	11.267	1	11.267	1.601	.000
Gender	7.756	1	7.756	1.102	.305
Treatments * Gender	.020	2	.020	.004	.951
Error	154.833	78	7.038		
Total	25067.000	80			
Corrected Total	166.160	79			

a. R Squared = .437 (Adjusted R Squared = .417)

The findings from the results of the analysis in Table 4 reveal that F(2,78=1.805, p=.143), which means that p>0.05. The null hypothesis, therefore, was rejected. This implies that there were significant interaction effects of treatments and gender on students' performance in the concepts of simple harmonic motion and elasticity. However, it was found that treatments alone had a p-value of .000 or p<0.05 signifying that treatments had significant effect on students' performance in the concepts. Gender alone had a p-value of .305 or p>0.05, signifying no significant effect on students' performance. In order words, although a combination of both treatments and gender were found to have significant interaction effects on the performance of the students, the treatments (individual and group indoor laboratory methods) were the source of the interaction effect on the students' performance. The adjusted R square coefficient of 0.417 shows that only 41.7 percent of the changes in performance were due to the treatments

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and the students' gender; the remaining (58.3 percent) were caused by other factors not captured in the study.

DISCUSSION

The results of the analysis revealed that students exposed to the group indoor laboratory method performance performed higher in concepts of simple harmonic motion and elasticity than those exposed to the individual indoor laboratory method. This is because when students work together in groups, they participate in sharing the knowledge and skills in their individual laboratory experiences. This finding concurs with Bajon (2015), Ugwu, Ngwu, Eze and Ezea's (2020) findings that students exposed to the group laboratory method performed higher than their counterparts who were taught using the individual laboratory method.

The findings also revealed that male students in the group indoor laboratory method had a slightly higher mean performance scores in physics than their female counterparts. This is supported by the findings of Aina (2013) that male students performed higher than the female students in practical physics. Although further findings revealed no significant effect of treatments and gender on students' performance in concepts of simple harmonic motion and elasticity, it was found that treatments alone had a significant effect on the students' performance.

Furthermore, the findings revealed that even though there were significant interaction effects of treatments and gender on students' performance in concepts of simple harmonic motion and elasticity ($p>0.05$), gender had no significant effect on students' performance. This finding negates Bajon's (2015) finding that there is a significant difference in the performance of male and female students.

IMPLICATION TO RESEARCH AND PRACTICE

1. Curriculum developers should ensure that laboratory teaching methods are included in physics curriculum in order to enhance students' performance in the subject.

2. Physics teachers should be trained on how best to use the group laboratory method during physics lesson delivery so as to enhance students' performance in the subject.

3. When teaching students using group and individual indoor laboratory methods, physics teachers should take into cognizance that the methods enhance performance irrespective of gender.

CONCLUSION

The group indoor laboratory method has been found to be superior to the individual laboratory method in facilitating students' performance in concepts of simple harmonic motion and elasticity. Although gender has been found to have no significant effect on students' performance, male students performed slightly higher than their female counterparts when

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exposed to both individual and group indoor laboratory methods. Based on the findings, the study concluded that since the group indoor laboratory method enhanced students' performance in concepts of simple harmonic motion and elasticity in Jos Metropolis, Nigeria, it may also enhance their performance in physics.

FUTURE RESEARCH

This study investigated the effectiveness of two-method indoor laboratory instruction on secondary school students' performance in physics in Jos Metropolis, Nigeria. The following suggestions are proffered to guide further research:

1. The study can be replicated using other physics concepts other than simple harmonic motion and elasticity used in this study.

2. The study can also be replicated in other local government areas in Nigeria and globally, since this study was restricted to Jos metropolis, Nigeria.

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