Effects of Virtual Laboratory Instructional Strategy on Secondary School Students' Learning Outcomes in Physics Practical

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Abstract- The study investigated the effects of virtual laboratory instructional strategy on students' performance and attitude towards Physics practical in secondary schools. The study adopted the quasi-experimental design of pre-test, post-test and control group. The sample for the study comprised 50 Senior Secondary two (SS II) Physics students who were randomly selected from two co-educational Senior Secondary Schools in Osun state through multistage technique. The schools were randomly selected to experimental and control group. The experimental group was exposed to virtual laboratory instructional strategy while the control group was taught using conventional laboratory strategy. Physics Practical Test (PPT) and Physics Practical Attitude Scale (PPAS) were the two instruments used to collect relevant data for the study. The general questions raised for the study were answered using descriptive statistics of mean, standard deviation and bar chart. The hypotheses generated were analyzed using t-test. Decision was taken at 0.05 level of significance. The findings from the study showed that the treatment had positive effect on students' performance and attitude towards Physics practical. Based on the findings of this study, it was recommended that Physics teachers should make use of virtual laboratory instructional strategy to improve students' performance and cultivate students' positive attitude towards Physics practical in secondary schools.

Keywords: Virtual Laboratory, Instructional Strategy, Performance, Attitude, Physics Practical

I. INTRODUCTION

Physics is a science subject taught in theory and practical. In internal and external examinations, Physics practical is assessed separately as an integral part of the subject. Practical works in teaching and learning of the subject are activities in which students, working individually or in small groups, manipulate and observe the apparatus in the laboratory. Physics practical activities can be regarded as an effective method of making the teaching and learning of the subject more real to students as opposed to abstract or theoretical presentation of facts, principles and concepts of subject matters. Effective teaching and learning of Physics is a measure of students' experience, understanding and skills acquired as a result of frequent engagement of the students in practical activities which enable them to think and act in a scientific manner.

Students learn better in activity based class where they manipulate equipment and apparatus to gain insight into the concepts, understand theories and principles. Adane and Adams, (2011) reported that students who are given opportunities to work with apparatus/equipment during laboratory work are able to investigate scientific problems which make them understand theories and principles of science concepts better. Also Nwagbo and Chukelu, (2012) reported that students achieve greatly when the teaching and learning of science occurs in an environment where students are allowed to carry out investigations, not only in the aspect of understanding scientific concepts but also in acquiring scientific skills

Physics practical activities create learning experiences in which students interact with apparatus to support theoretical explanations with actual practices in laboratory. It makes students become familiar with mental processes such as observing, inferring, classifying, measuring and data interpretation. Thus, learning becomes engaging as a result of using concrete materials. According to Uhumuavbi and Okodugha (2014), the use of laboratory as a method of teaching science helps the students to develop manipulative skills. It leads to better retention of information and also the development of favourable attitudes towards school subjects. The students during the use of laboratory are active participants who acquire more knowledge by performing experiments.

Despite the importance of practical activities in learning Physics, there are a number of observable problems plaguing the practical activities in teaching and learning of the subject, especially at the secondary school level. These problems contribute to the low performance of students in Physics in secondary schools. Over the years, the students' low performance in Physics has prompted educational researchers to continuously make relentless efforts at identifying mitigating factors that might account for the observed poor performance. One of these problems is poor method of instruction. Jegede and Adedayo (2013) attributed the deterioration in students' achievement in Physics to ineffective method of teaching Physics. This is supported by the assertion of Owolabi and Oginni (2013) that inappropriate teaching methods used by Physics teachers had resulted to the low performance of students.

The teaching of Physics practical in secondary schools is characterized with conventional laboratory instructional strategy. This is a teacher-centered teaching method in the laboratory where teacher dominates the activities turning the students to passive learners. It is hand-on experiment where students sit back on stools beside/behind the benches in the laboratory observe/watch their teacher at a distance in front of the laboratory demonstrating experiment for them; after which the students also repeat what the teacher demonstrated. This method of teaching Physics practical in secondary schools does not seem to be meeting the demands of the Physics curriculum in Nigeria. Physics curriculum contents emphasized understanding of concepts, experimentation and right attitude. For proper manipulation of the apparatus, acquisition of necessary skills and understanding of principles, theories and concepts, practical actives in the laboratory should be closed to the students not at a distance. The students should also be actively involved in the activities.

As emphasized in the National Policy on Education, the teaching and learning of science focus on preparing individual with appropriate skills, abilities and competencies both mental and physical to live and contribute to the development of the society (FRN, 2014). To achieve creativity and overall national development; acquainting students with basic knowledge, skills and attitude needed for future work in science and science related fields boil down to adequate teaching and learning of science. Akinbobola (2011) reported that a critical look at the contents of Physics curriculum in Nigeria indicates that the teacher-centered approaches are not relevant and appropriate to promote efficient learning of the content of the programme. Also Adegbola (2016) reported that effective teaching and learning largely depends on the varieties of methods adopted by a teacher.

The persistent decline in students' performance in Physics is not only frustrating to the students and their parents, its effects are equally grievous on the society. Therefore, the use of appropriate teaching method could help to curb the ugly trend of poor performance in Physics in secondary schools. To maximize the performance and achievement of students in Physics classes, there is need to adopt practical approaches to the teaching and learning of the subject. The allocation of marks to theoretical and practical aspects of Physics in WAEC and NECO examinations is a clear evidence that it will be very difficult for a student to make a credit pass in Physics if the student performs poorly in practical aspect of the examination. Therefore, proper exposure of students to practical works in Physics in secondary schools is inevitable.

Consequently, effort should be made by Physics teachers to facilitate teaching and learning of Physics with practical activities which will help the students to acquire series of process skills such as observing carefully, classifying, interpreting, predicting event, designing experiments, reporting completely and accurately. Lack of proper exposure to practical activities contribute to the poor trend of performance in Physics in secondary schools. Practical activities are very important to the teaching and learning of Physics to tackle the current mass failure in Physics examinations in secondary schools. Afemikhe and Imobekhai, (2014) opined that it is expected that emphasis should be on engaging students in experimentation, questioning, discussion and problem solving.

Physics instructions should actively involve the students to construct their own knowledge by gainfully engaging the students with practical activities in laboratory. Learning of Physics will not be completed if practical activities are not properly taken care of. If Physics is to be learned effectively, it must be experienced and close to the students through practical activities. Activity-based method of teaching which is student-centered would give room for students' active participation during the Physics practical lessons. According to Jegede (2016), students by nature are curious. They are seen active in the learning process in which they are continually enquiring, testing, speculating and building their own personal constructs of knowledge.

From personal experience of the researchers, it has been observed that in some secondary schools, the time allocated to Physics on the school timetable is not enough to accommodate laboratory activities. As a result of this, Physics teachers in such schools focus attention on completing the scheme of work without making provision for laboratory activities. According to Boyo (2011), some Physics teachers pay little or no attention to laboratory practical activities. In this situation, the ample opportunity needed by the students to develop new content, knowledge, techniques and approaches to scientific activities and exploration is not made possible.

These shortcomings in Physics practical activities are contributing to the poor performance of students in Physics. There is therefore need to critically look for more suitable and appropriate methods of exposing students to practical works in Physics regularly with the aim of discouraging the teacher centered teaching method that characterized the teaching of Physics practical in secondary schools and at the same time overcome the challenge of time constraint which makes Physics teachers to focus attention on completing the scheme of work without making provision for laboratory activities; hence the need for virtual laboratory instructional strategy.

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One of the activity based and students-centered instructional strategies is Virtual Laboratory Instructional Strategy (VLIS) which is being investigated in this study. Activity based and students centered instructional strategies can attract and retain students in Physics classes by making lessons active, relevant, student oriented and participatory. Virtual Laboratory Instructional Strategy (VLIS) is a computer-based instructional strategy made up of three components: text, video and simulated experiment. The text section exposes the students to the title, aim, theory, apparatus and procedures of the experiments. The video section exposes the students to the steps in carrying out the experiments via video. The simulated experiment is a section where students carry out or perform experiments in virtual environment using computer program.

Virtual laboratory is a virtual studying and learning environment with the aim of developing laboratory skills of students by stimulating the real laboratory. It is a computer-based activity where students interact with experimental apparatus via a computer interface. It provides students with tools, materials and laboratory sets which are electronically programmed in computer to perform experiments anywhere and anytime (Babateen, 2011). Virtual laboratory makes students become active in their learning, provide opportunities for students to understand difficult concepts more easily. Virtual laboratory increases motivation and desire for lessons and laboratory activities in the process of learning (Pyatt and Sims, 2012). Gambari, Falode, Fagbemi, and Idris (2013) in their study on efficacy of virtual laboratory on the achievement and attitude of secondary school students in Physics practical reported that the application of the virtual laboratory had positive effects on students' achievements, retention and attitudes when compared to physical laboratory method.

Virtual Laboratory allows the learner to control and interact directly with the objects within the virtual environment as well as to experience total immersion in the case of immersive systems, allowing him or her to not just view but also experience the environment. This technology suggests the potential for an entirely new form of experiential learning. Such control and interaction, together with free exploration also provide a greater sense of empowerment, which makes a virtual environment very well suited for the learning problems that need to engage learners to learn through learner-centered activities. According to Burns (2012), an immersive environment allows learners to be totally immersed in a simulated environment while experiencing it as real. Immersive environments can offer learners rich and complex content-based learning while also helping learners hone their technical, creative, and problem-solving skills.

Virtual laboratory instructional strategy supports the philosophy of pragmatic learning theory. It provides exploratory learning environments in which students can learn through experimentation by manipulating the virtual objects. This virtual experience supports the pragmatist point of view which emphasizes that understanding is tracked by experience.

With virtual laboratory instructional strategy, the challenge of time constraint can be overcome by using devices such as iPad, iPhone, android phone and smart phone which are portable enough to be carried about. If virtual laboratory is installed on any of these devices, students can perform experiment anywhere any time. Installation of virtual laboratory on these devices would enhance laboratory skills and at the same time permit students to learn at their own pace.

Attitude affects academic performance. If it is positive, it enhances academic performance but if it is negative it brings about poor academic performance. Fakeye (2010) states that attitudes are positive or negative feelings that an individual holds about objects or ideas and the achievement of any learner will to a great extent depend on his/her attitude towards the learning materials. A positive attitude more often than not leads to a successful learning. Thus, students' attitude is one of the variables that affect the learning of Physics. This means that a favourable attitude could enhance performance in Physics while poor attitude of the students towards Physics may partly be responsible for their poor academic performance in the subject. The development of students' positive attitudes towards Physics as a school subject is one of the responsibilities of every Physics teacher. Without positive attitudes, students have little chance of learning proficiently, if at all learning will occur. Students' positive attitudes could be achieved through active involvement of the students in the learning process.

Physics practical is a sharpen tool for national technological advancement. It is therefore necessary for teachers to help the students to develop right attitude towards Physics practical. Relative to Physics, Godwin and Okoronka (2015) reported that a significant relationship exists between students' attitude and their corresponding academic performance in Physics. Right attitude is crucial to the understanding of concepts in Physics practical. With dynamism of science, an encouraging attitude is necessary in practical activities, attitude regulates the behaviour of the students in their availability, readiness for the subject and their interactive manner during the practical class. Attitude of the students towards Physics practical has a great consequence towards their performance. As a result of interactive and manipulative effects of apparatus by students in Physics practical activities using computer interface through virtual laboratory which is one of the modern teaching strategies of teaching science, the attitude of the students towards Physics as a science subject can be improved.

Purpose of the study

The purpose of this study was to investigate the effects of virtual laboratory instructional strategy on students' performance and attitude towards Physics practical in secondary schools. Specifically, the study intends to find out students' performance and attitude towards Physics practical when exposed to virtual laboratory instructional strategy.

Research Questions

The study answered the following questions:

1. what is the performance of the students in Physics practical in the two groups before and after treatment?
2. what is the attitude of the students towards Physics practical in the two groups before and after treatment?

Research Hypotheses

The following null hypotheses were generated for the study:

H_{01}: There is no significant difference in the students' attitude towards Physics practical using virtual laboratory instructional strategy before and after the treatment.

H_{02}: There is no significant difference in the students' performance mean scores in Physics practical using virtual laboratory instructional strategy before and after the treatment.

II. METHODOLOGY

Research Design

This study adopted quasi-experimental design of the pre-test, post-test and control group. The design is represented schematically as follows:

G_1:	O_1	x_1	O_2
G_2:	O_3	x_2	O_4

Where

G_1 - Experimental group

G_2 - Control group

O_1, and O_3 are the pre-test observations

O_2, and O_4 are the post-test observations

x_1 - Treatment for experimental group (Virtual Laboratory Instructional Strategy)

x_2 - Treatment for control group (Conventional laboratory Strategy)

Population, Sample and Sampling Technique

The population for this study consisted of all Senior Secondary two (SS II) Physics students in Osun State. The Senior Secondary two (SS II) students were considered appropriate for this study because they would have been exposed to a considerable knowledge of Physics in Senior Secondary one (SS I). The sample for the study consisted of 50 Physics students of Senior Secondary two (SS II) in two co-educational senior secondary schools in Osun State. The multistage sampling procedure was used to select the sample. Stage one involved the selection of two Local Government Areas from the three Senatorial Districts in Osun State using simple random sampling by balloting. The second stage involved the use of purposive sampling technique to select one secondary school with relatively-equipped Physics laboratory from each Local Government Area selected, and the third stage involved the use of students in an intact class of an arm randomly selected from each school considered.

Research Instruments

Two instruments were used for the study. The two instruments were Physics Practical Test (PPT) and Physics Practical Attitude Scale (PPAS). PPT was a practical test consisting of two parallel tests (alternative A and alternative B) adapted from West African Examination Council past examination papers. There were two practical tests in each alternative. Each of the tests carries 25 marks, making the maximum score obtainable to be 50 marks for each alternative. Alternative A was used for pre-test and Alternative B was used for post-test. The Physics Practical Attitude Scale (PPAS) was developed to measure the attitude of students towards Physics practical. The PPAS had two sections A and B. Section A consisted of students' personal bio-data such as name of school, gender, age range and class while section B consisted of 40 items-questionnaire intended to measure students' attitude towards Physics practical. The PPAS was structured in 4-points Likert scale: Strongly Agree (SA) – 4 points, Agree (A) – 3 points, Disagree (D) – 2 points and Strongly Disagree (SD) – 1 point. Each respondents was made to tick appropriate options, the responses were collated and scored for data analysis.

Validity of Instruments

The face and content validity of the instruments were carried out by experts in Physics education, Test, Measurement and Evaluation and Guidance and Counselling. The reliability of PPT was determined by test re-test method. The two sets of results were collated and analyzed using Pearson Product Moment Correlation Analysis. The reliability coefficient of 0.82 and 0.80 were obtained for alternative A and alternative B of PPT respectively, while 0.73 was obtained for PPAS using Cronbach's Alpha. These values were regarded as high enough to be used for the study.

Data Analysis
The data collected were collated and analyzed. The general questions were answered using descriptive statistics of mean, standard deviation and bar chart. The hypotheses generated were analyzed using t-test. The hypotheses were tested at 0.05 level of significance.

III. RESULTS

Question 1
What is the performance of the students in Physics practical in the two groups before and after treatment?

In order to answer the question, mean scores of performance of the students in Physics practical in the two groups before and after treatment were computed and compared. The result is presented in Table 1.

Table 1: Performance of the students in Physics practical in the two groups before and after treatment

Group	*N*	*Pre-test*		*Post-test*		*Mean Difference*
		Mean	*SD*	*Mean*	*SD*	
Virtual Laboratory	20	6.45	1.76	44.65	5.12	38.20
Control	30	6.70	2.25	17.70	3.53	11.00
Total	50					

The performance of the students in Physics practical in the two groups before and after treatment are further depicted in Figure 1.

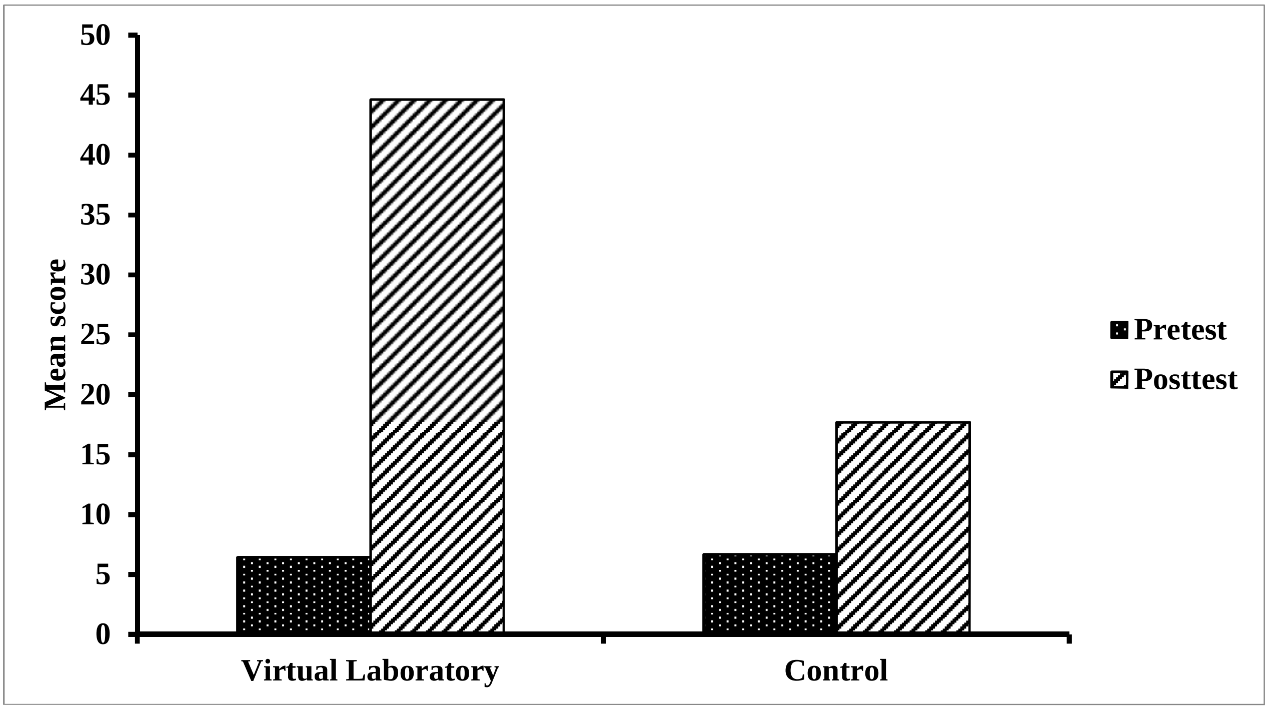

Figure 1: Bar chart showing performance of the students in Physics practical in the two groups before and after treatment

Question 2
What is the attitude of the students towards Physics practical in the two groups before and after treatment?

In order to answer the question, mean scores of attitude of the students towards Physics practical in the two groups before and after treatment were computed and compared. The result is presented in Table 2.

Table 2: Students' attitude towards Physics practical in the two groups before and after treatment

Group	*N*	*Pre-test*		*Post-test*		*Mean Difference*
		Mean	*SD*	*Mean*	*SD*	
Virtual Laboratory	20	63.20	4.77	132.56	9.04	69.36
Control	30	64.21	6.08	90.10	8.77	25.89
Total	50					

The attitude of students towards Physics practical in the two groups before and after the treatment are further depicted in Figure 2.

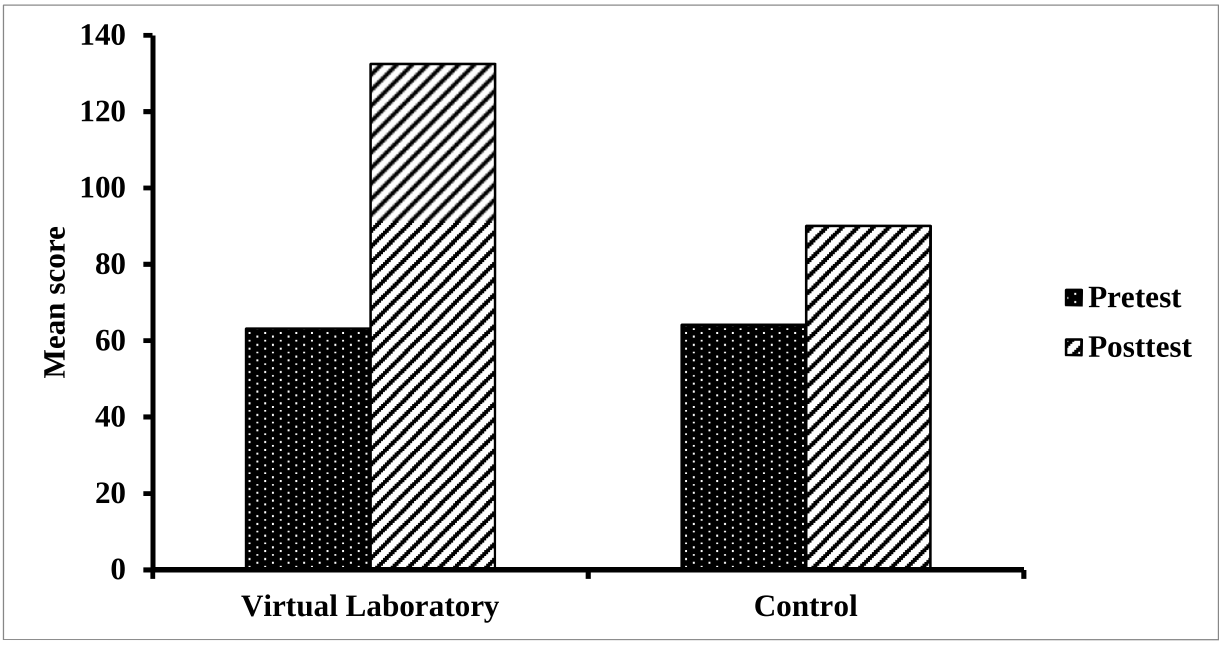

Figure 2: Bar chart showing attitude of the students towards Physics practical in the two groups before and after treatment

Testing of Hypotheses

H_{01}: There is no significant difference in the students' attitude towards Physics practical using virtual laboratory instructional strategy before and after the treatment.

In testing the hypothesis, scores of students' attitude towards Physics practical using virtual laboratory instructional strategy before and after the treatment were computed and compared for statistical significance using t-test statistics at 0.05 level of significance. The result is presented in Table 3.

Table 3: t-test of students' attitude towards Physics practical in virtual laboratory group before and after treatment

Variable	**N**	**Mean**	**SD**	**df**	**t_{cal}**	**P_{value}**	**Decision**
Pretest-Attitude	20	63.20	4.765	19	56.330^*	0.000	Significant
Posttest-Attitude	20	132.56	9.040				

$^*p<0.05$

Table 3 showed that the effect of the treatment on students' attitude towards Physics practical was statistically significant at 0.05 level (t=56.330, p<0.05). The null hypothesis is rejected. It implies that there was significant difference in the students' attitude towards Physics practical using virtual laboratory instructional strategy before and after the treatment.

H_{02}: There is no significant difference in the students' performance mean scores in Physics practical using virtual laboratory instructional strategy before and after the treatment.

In testing the hypothesis, scores of students before and after being exposed to virtual laboratory instructional strategy were computed and compared for statistical significance using t-test statistics at 0.05 level of significance. The result is presented in Table 4.

Table 4: t-test showing students' performance before and after being exposed to virtual laboratory instructional strategy

Variable	N	Mean	SD	Df	t_{cal}	P	Decision
Pretest	20	6.45	1.76	19	35.292*	0.00	Significant
Posttest	20	44.65	5.12				

***p<0.05**

Table 4 showed that the effect of the treatment on students' performance in Physics practical was statistically significant at 0.05 level (t=35.292,p<0.05). The hypothesis is hereby rejected. This implies that there was significant difference in the students' performance mean scores in Physics practical using virtual laboratory instructional strategy before and after the treatment.

Discussion

Table 1 revealed that Physics students in the virtual laboratory instructional strategy group had mean score of 6.45 while those in conventional laboratory strategy group had mean score of 6.70 prior to treatment. This implies that the performance of the students in Physics practical in the two groups before treatment were generally low. On exposure to treatment, students taught using virtual laboratory instructional strategy had the higher mean score of 44.65, while the students in the conventional laboratory strategy group had the mean score of 17.70. This implies that the performances of the students in Physics practical in the two groups after treatment were high.

Figure 1 showed the students' performance mean scores in Physics practical in the two groups before and after treatment. The Bar Chart showed that students taught using virtual laboratory instructional strategy performed better than the students exposed to conventional laboratory strategy. The comparison between the pre-test and post-test mean scores in the two groups showed that the post-test mean scores are higher than the pre-test mean scores. This implies that the treatment had positive effect on students' performance in Physics practical. The Bar Chart further showed that virtual laboratory instructional strategy is more effective for enhancing students' performance in Physics practical.

Table 2 revealed that Physics students in the virtual laboratory instructional strategy group had mean scores of 63.20 while those in the conventional laboratory strategy group had mean scores of 64.21 prior to treatment. This implies that the attitude of the students towards Physics practical in the two groups before treatment was unsatisfactory. On exposure to treatment, students taught using virtual laboratory instructional strategy had the mean score of 132.56 while the students in the conventional laboratory strategy group had the mean score of 90.10. This implies that the attitude mean scores of the students towards Physics practical in the two groups after treatment were high.

Figure 2 showed the students' attitude mean scores towards Physics practical in the two groups before and after treatment. The Bar Chart showed that the post-test attitude mean score of students taught using virtual laboratory instructional strategy is higher than that of the students exposed to conventional laboratory strategy. The comparison between the pre-test and post-test attitude mean scores in the two groups showed that the post-test attitude mean scores were higher than the pre-test attitude mean scores. This implies that the treatment had positive effect on students' attitude towards Physics practical. The Bar Chart further showed that virtual laboratory instructional strategy is more effective for enhancing students' attitude towards Physics practical.

Table 3 showed that there was significant difference in the students' attitude towards Physics practical using virtual laboratory instructional strategy before and after the treatment.

Table 4 showed that there was significant difference in the students' performance mean scores in Physics practical using virtual laboratory instructional strategy before and after the treatment.

Results indicated significant effects of treatment on students' performance and attitude in Physics practical. The results showed that virtual laboratory instructional strategy has potential of improving students' learning outcomes in Physics practical. This finding provides empirical support to earlier finding of Gambari *et al* (2013) which established that virtual laboratory improves students' achievement and attitude in Physics practical.

IV. Conclusion

This study shows that virtual laboratory instructional strategy is an effective instructional strategy for teaching Physics practical in secondary schools. It had positive effect on students' performance and attitude towards Physics practical.

V. Recommendation

Based on the findings of this study, it was recommended that Physics teachers should make use of virtual laboratory instructional strategy to improve students' performance and cultivate students' positive attitude towards Physics practical in secondary schools.

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