Effect of Virtual Laboratory Strategy on Secondary School Physics Students' Attitude in Simple Harmonic Motion in Ogun State

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Abstract

The study examined effect of virtual laboratory strategy on secondary school Physics students' attitude in Simple Harmonic Motion in Ogun State. One hypothesis was formulated and tested at 0.05 levels of significance. The study adopted pre-test, post-test, control group, quasi-experimental design. A total of 166 Senior Secondary School 2 (SS2) Physics students in two senior secondary schools intact classes in Ogun State were selected through multi-stage sampling technique, participated in the study. One school was exposed to each of the virtual laboratory strategy and conventional method for 8 weeks. Physics Attitude Scale (PAS) with 20 items on a four-point Likert type scale (r=0.73) was used for data collection. Data were analyzed with descriptive and inferential statistics. There was a significant main effect of virtual laboratory strategy on students' attitude towards Physics ($F_{(1,123)}$=5.318, $p<0.05$, η^2=0.041).

The study concluded that virtual laboratory is more effective instructional strategy than conventional method of teaching in enhancing students' attitude towards Physics because every student participated in one activity or the other which enhanced conceptual understanding, creativity and critical thinking. Consequently, it was recommended that this strategy should be constantly

used, while workshops and seminars should be organized for the teachers for effective use of the strategy.

Keywords:Virtual Laboratory, Attitude, Simple Harmonic Motion, Physics, Multi-stage Technique

Introduction

Science is primarily designed to transform the environment towards improving the general quality of life, thus making the world a better place. It is the foundation on which contemporary technological breakthroughs and advancement rest. Science systematically studies the nature of the materials and physical universe behaviour through observation, experimentation, measurement, and recording (Thomas, 2021). Science is considered to be a systematic, precise, and objective way to study the natural world (Arziqulogli & Iixomovich, 2022). Physics, Chemistry, Mathematics, and Biology constitute the fundamental disciplines of science (Selin & Kaya, 2020). In recent times, countries all over the world, especially developing ones like Nigeria, are striving hard to develop scientifically and technologically, since the world is a scientific and technological global village where all proper functioning of lives largely depends on science. Without the application of science, it would have been difficult for a man to explore the other planets of the universe. The development of any society is based on its technological level, and Physics education is a significant factor in enhancing technology development. Physics is a branch of science that deals with the nature and properties of energy and matter. Physics is a pure science subject with overwhelming impacts on this present globalised world. Physics is a science of observation of the world around us (Al-Khalili, 2020). It is a core subject in Science and Technology since it studies the essence of natural phenomena and helps people understand the rapidly technological changing society (Edoja & Gbadamosi, 2020).

Physics is the natural development of experiments, observations, and theories to explain the fundamental structure of all we perceive which is crucial for effective living in this jet age of Science and Technology (Novitra, 2021). Being fundamentally the study of various forms of energy interactions and inter-conversions with matter, Physics is the study of the nature of our environment and how different energies of nature can be produced, conserved, and changed to another form (Gulbin & Topsakal, 2021). The Nigeria Federal Ministry of Education regards Physics as a crucial subject for effective living in the modern age of science and technology (Agbele et al., 2020). This means that every student must be allowed to acquire some Physics concepts, theories, principles, and skills. These concepts, theories principles, and skills are clearly explained in the objectives of Physics education enshrined in the new Senior Secondary School Physics Curriculum (Soecharto et al., 2019). The objectives of Physics education are to provide a basic literacy in Physics for functional living in society; obtain elementary theories and principles of Physics as training for advanced studies; acquire essential scientific skills and attitudes as a preparation for the technological application of Physics, and stimulate and enhance creativity (Usman eta al., 2019).

Therefore, Physics is included in the Nigerian senior secondary school science curriculum to build a strong technological foundation for students. There are five concepts of Physics (Simeon et al., 2020). These include the concepts of space, time, and motion, conservation principles, waves, fields, and Quanta. One important aspect of Physics is Mechanics. The importance attached to Mechanics topics in Physics as underscored by the Senior Secondary School Examination of West African Examinations Council (WAEC) and National Examination Council (NECO) indicated that more than 30 percent of senior secondary school Physics examination questions were from Mechanics and that the poor performance in Physics recorded on the concepts of Mechanics are mainly in the areas of Elasticity Properties of Solid, Kinetic Theory, Simple Harmonic Motion, Projectiles Motion, the

Relative Density of a solid, Properties of Matter, equilibrium of forces and mechanical energy, simple mathematical computation, interpretation of expressions and equations affected students' performance in this aspect of Physics (Edoja & Gbadamosi, 2019, West African Examinations Council, 2019).

Effective teaching of Science does not only depend on the teacher's knowledge of the methods but also on his/her ability to use the appropriate method or combination of methods. Attitude as a variable, continues to receive considerable attention from researchers in different subjects' areas because attitude is an integral part of learning. Attitude is a social psychological construct representing an individual's evaluation of attitude objects. Attitudes are essential determinants of human behavior. Thus, attitudes, when acquired, could influence student's likes and dislikes of a particular subject, attitudes are formed by people as a result of some kinds of learning experiences and if the experience is favourable, a positive attitude is formed and vice versa. Furthermore, the attitude people hold can frequently influence the way they act and respond to situations. However, an interesting result was observed from a study which posit that the students' science attitudes do influence their actual achievement in science and their science achievement does not necessary influence their attitudes (Mao et al., 2021). Thus, although positive attitudes can increase the students' science achievement, a high science achievement does not necessarily create positive attitudes towards science by the students. Finding shows that high achievement could serve to predict a positive attitude but a positive attitude alone could not predict stronger achievement (Geisler et al., 2023). Negative attitude towards a certain subject makes learning difficult (Wakhata et al., 2023). Attitude of both teachers and students have become one of the most important issues in science education because it has strong influence on performance. The reason why many students have not been opting to study science further and not progressing to scientific careers over the years has been partly related to low levels of interest and negative attitudes developed quite early in life.

Students achieve better when they are interested in whatever they are doing (Wigfield, 2023). It was argued that emotional attitudes can have profound effects on learning efficiency (Tan et al., 2021). The kind of attitude one holds in a learning situation therefore is of great significance. Students' attitude toward Physics plays vital roles in the teaching-learning process. This is because whatever attitude students have in Physics will affect their achievement. The way science is taught, both at high school and college level also plays a major role in shaping students' attitudes toward science. Students' attitudes towards a rapidly changing technological environment will influence their ability to cope with it emotionally as well as in material ways. Therefore, an investigation of students' attitudes towards Physics and recommendations on ways of improving their attitudes towards Physics, enrolment in Physics and their performance in the subject matter is important. Understanding students' attitudes towards Physics is fundamental in sourcing a practical approach to enhancing students' performance and motivation in Physics.

Science should be taught in such a way that students will be allowed to experiment and discuss in groups as they make meaning of tasks and set out to solve challenging problems. Activity-based and student-centred instructional strategies can attract and retain students in Physics classes by making lessons active, relevant, student-oriented and participatory. One of these activity-based and students-centered instructional strategies is the virtual laboratory instructional strategy which is being investigated in this study. A virtual laboratory is a virtual studying and learning environment to develop the 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 computers to perform experiments anywhere and anytime (Justkaite, 2009).

A computer-based teaching method known as Virtual Laboratory Instructional Strategy (VLIS) consists of

three parts: text, video, and a simulated experiment. The title, purpose, theory, equipment and methods of the experiments are all introduced to the students in the text section. The students are shown through a video the procedures involved in conducting the experiments in the video section. In the section known as "simulated experiment," students use computer programs to conduct experiments in a virtual setting. It was reported that, in comparison to the physical laboratory approach, the use of the virtual laboratory had positive effects on students' achievements, retention, and attitudes (Husnaini & Chen, 2019). Many studies have shown that using virtual experiments can help students develop better practical skills, which can be reflected in their performance in real laboratory settings (Fajarwati et al., 2020).

An investigation was carried out on a study to explore the impact of VL software on teaching “acid-base and neutral solutions” to seventh-grade students (Yusuf et al., 2023). The results showed that VL software impacted the students’ satisfaction and efficiency and enabled them to better understand abstract concepts, and that it was also very helpful in hypothesis verification and increasing motivation. In addition, the students used VLs to improve their skills in a risk-free practice environment. In most studies, it is clear that VL has a positive influence on student performance and attitudes towards science, as well as improving student learning (Berlianti & Hayati, 2021). A virtual Chemistry laboratory was created and tested with experiments on students (Tsai et al., 2021). The virtual Chemistry laboratory is an efficient and exciting way to conduct practical. For instance, a survey design and questionnaire were used as an instrument in an empirical study carried out in China on the sustainability innovation experiential learning model in a virtual reality Chemistry laboratory at a secondary school (Su & Cheng, 2019). The study found that students' motivation and self-efficacy during the learning process are impacted by the virtual laboratory technology used to conduct practical Chemistry. Hence, students feel more interested and engaged when carrying out practical in the virtual Chemistry laboratory.

Likewise, a study on the academic performance of students in Chemistry using the Chemistry Virtual Laboratory (Kartimi et al., 2022). Ninety (90) pupils, drawn at random from three distinct ninth-grade courses, were split into control and experimental groups for the study. The instructor taught the control group practical skills using a real chemistry laboratory while teaching the experimental group the same concept using a virtual chemistry laboratory. Both groups were given the Laboratory Equipment Test (LET), Chemical Changes Achievement Test (CCAT), and Unstructured Observations. The data analysis revealed no significant difference in achievement between the control and experiment groups. Additionally, students in the virtual Chemistry laboratory were able to identify laboratory equipment just like those in the real Chemistry laboratory. The results showed that virtual Chemistry laboratory software was just as effective as a physical laboratory.

Statement of the Problem

The attitude of Nigerian secondary school pupils in Physics has not been encouraging. Despite the need for Physics education due to the desire for technological advancement, students' attitudes about the subject are consistently low. Students' low performance in Physics can be attributed to a wide range of factors, such as the use of inappropriate teaching methods by teachers, inadequate laboratory facilities, poorly planned laboratory activities, low student and teacher commitment to the laboratory, partial or complete lack of a laboratory, a shortage of qualified Physics teachers, and the type of laboratory activities used in Physics Laboratory. Studies have established that in conducting laboratory activities, teachers are using mainly teacher-centered approaches. The National Policy on Education stated goals for Physics education in Nigerian secondary schools are sometimes cast in doubt due to the unsuitable teaching strategies employed by Physics teachers in secondary schools. The majority of teaching strategies, including lectures and demonstrations, which are employed in Physics classes and laboratories, encourage memorization and deprive students of the

chance to work with materials and think back on their actions as they are being taught and learning. Concretizing learning may be greatly aided by the interactions between students during practical laboratory exercises. Similarly, on the effectiveness of using virtual experiments on students' learning in the general Physics laboratory, students with virtual components acquired a deeper understanding of Physics concepts and were better prepared for carrying out real experiments (Oluwasegun, & Owolabi, 2020). In the study of the use of virtual learning environments and achievement in Physics content tests**,** the mean achievement scores in Physics content tests improved significantly post-intervention in a virtual learning environment (Ghadeer & Ahmad, 2020). The researcher is interested in the instructional strategies among all the issues that lead to students' low attitude in Physics. It is against this background that, the study investigated the effect of virtual laboratory Instructional Strategy on secondary school Physics students' attitudes in Simple Harmonic Motion in Ogun State, Nigeria.

Hypothesis

There is no significant main effect of virtual laboratory strategy on students' attitude in Simple Harmonic Motion in Physics in secondary school in Ogun State.

Methodology

The study adopted a pre-test, post-test, control group, quasi-experimental design. The target population for this study was all the SSII students offering Physics in public schools of Ogun Central Senatorial district of Ogun State. The sample consisted of only two public senior secondary schools which are government-owned (for the uniform standard) and which offer Physics up to the Senior Secondary School Certificate (SSSC) level, using a multi-stage sampling technique. A total of one hundred and sixty-two (166) students offering Physics (seventy-five (75) in the experimental group and ninety- one

(91) in the control group participated in the study. Three research instruments were developed and used for the study. These are: The Physics Attitude Scale (PAS) with the reliability coefficient of 0.73 using Cronbach alpha coefficient, Instructional guide on virtual laboratory strategy and Instructional guide on Conventional Method. The Physics Attitude Scale (PAS) from Fennema-Sherman attitude scale was adapted for use by the researcher. It consisted of 20 items for measuring student's attitude towards Simple Harmonic Motion (SHM) in Physics. The questionnaire contains two sections A and B. Section A contained personal information and section B contains twenty attitude items towards Simple Harmonic Motion (SHM) which the participant responded to. It is made of 20-items on a 4-point Likert scale of Strongly Agree (SA), Agree (A), Disagree (D) and Strongly Disagree (SD) to which respondents indicated their degree of Agreement or otherwise to the 20-items on the scale. These guides were given to the experts in the Physics department, Science Educators in the Science and Technology Education department and practicing two senior secondary school Physics teachers for the corrections and observations. These guides consisted of notes of lessons in which the major roles of individuals participating in the study (Teacher and Students) were clearly stated. Specific in the notes of the lesson are the following items: subject, class, topic, instructional materials, objectives to be achieved, previous, knowledge, presentation and assessment. The following time schedule was adopted for the process:

a) The first week for the training of research assistant
b) One week for pre-test
c) Five weeks for carrying out the treatment
d) One week for post-test

The hypothesis formulated was analysed using Analysis of Covariance (ANCOVA) with pre-test scores as covariates. The analysis was done at 0.05 level of significance.

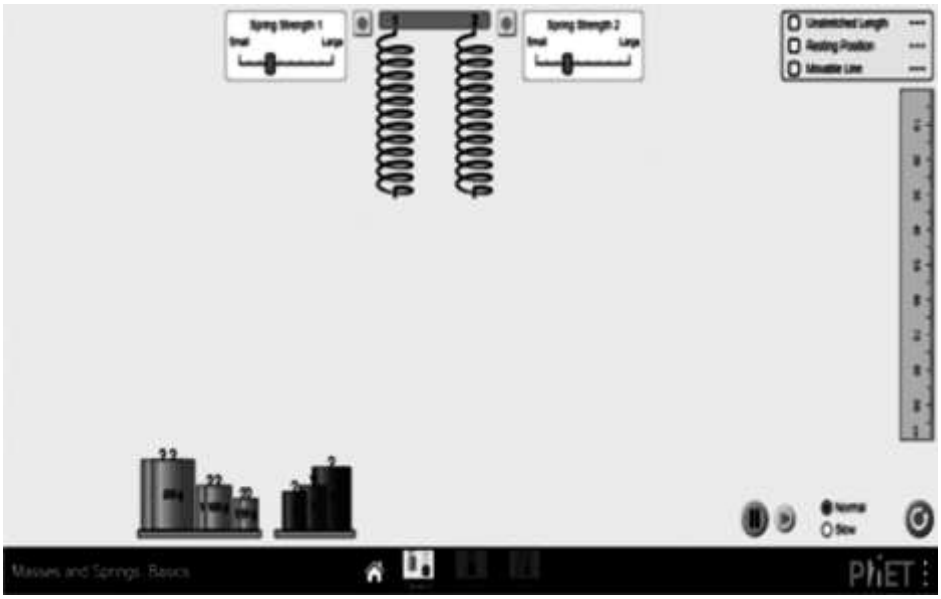

Fig1: virtual lab for experiment on verification of Hooke's Law

Fig. 2: virtual lab for determination of force constant of a spring

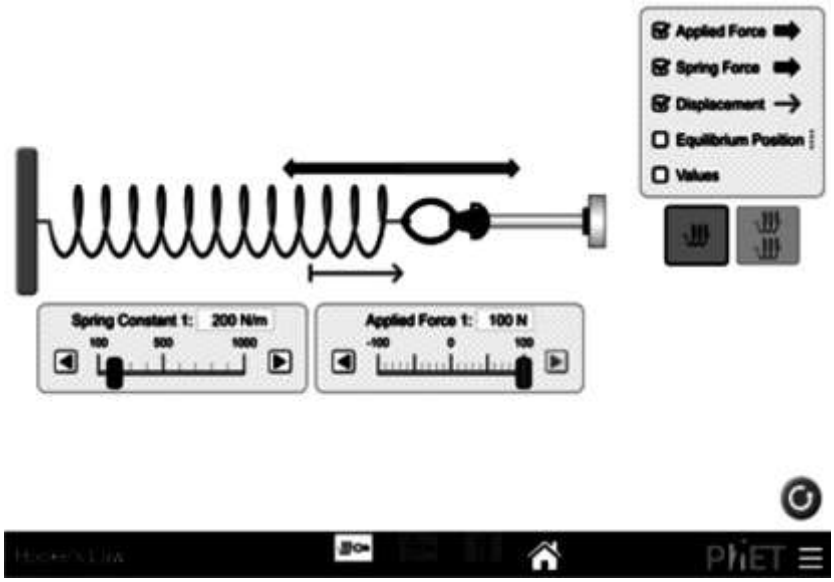

Fig. 3: virtual lab for determination of the effective mass of a spiral spring by oscillation method

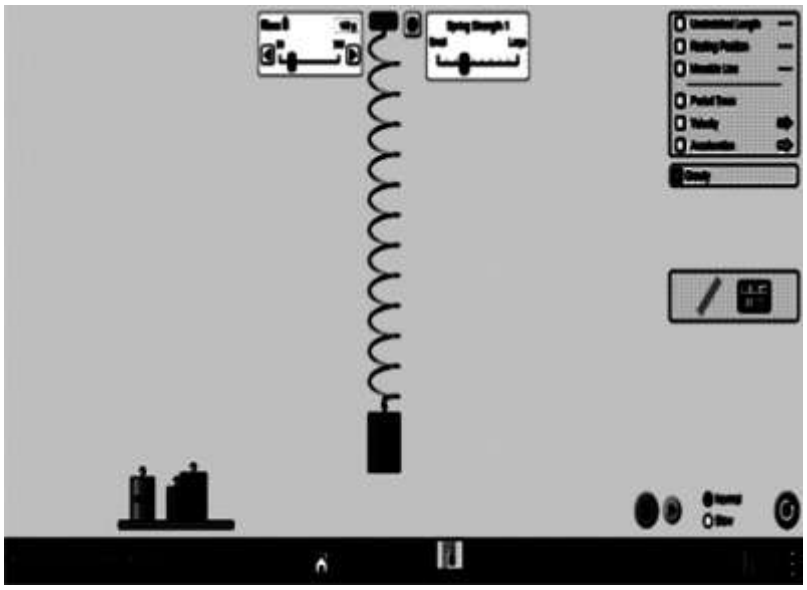

Fig. 4: virtual lab for determination of acceleration due to gravity by means of the simple pendulum and acceleration due to gravity by means of the simple pendulum from inaccessible height.

Demographic Data Analysis

The below are the socio-demographic characteristics of the participants.

Table 4.1: Distribution of the Participants by Sex

Sex	Frequency	Percent
Male	70	42.2
Female	96	57.8
Total	**166**	**100.0**

Source: Field Survey, 2024

Table 4.1 reveals that seventy (70) (42.5%) of the participants were males, while ninety-six (96) (57.8%) were females. This means that, most of the participants were females.

Table 4.2: Distribution of the Participants by Class

Class	Frequency	Percent
SS2	166	100.0

Source: Field Survey, 2024

Table 4.2 reveals that one hundred and sixty-six (166) (100.0%) participants were in SS 2. This means that all the participants were in SS 2.

Table 4.3: Distribution of the Participants by Age

Age	Frequency	Percent
12-14 years	59	35.5
15-16 years	94	56.6
17 years and above	13	7.8
Total	**166**	**100.0**

Source: Field Survey, 2024

Table 4.3 reveals that Fifty-nine (59) (35.5%) of the participants were in the age range of 12-14 years, ninety-four (94) (56.6%) were between 15-16 years, while thirteen (13) (7.8%) were 17 years and above. This means that, most of the participants were in the age range of 15-16 years, while the participants who were over 17 years were the least.

Table 4.4: Distribution of the Participants by Groups

Treatment Groups	Percent
Virtual Laboratory Strategies (Experimental Group)	27.8
Control Group	72.2
Total	**100.0**

Source: Field Survey, 2024

Results

Analysis of Covariance of Main Effect of Virtual Laboratory Strategy on Students' Attitude towards Simple Harmonic Motion in Physics

Source	Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	194.302	2	97.151	2.917	0.058	0.045

Intercept	4077.415	1	4077.415	122.412	0.000	0.499
Pretest	1.071	1	1.071	0.032	0.858	0.000
Treatment	177.138	1	177.138	5.318	0.023	0.041
Error	4096.999	123	33.309			
Total	403920.000	126				
Corrected Total	4291.302	125				

Source: Field Survey, 2024

The table shows that there was a significant main effect of Virtual Laboratory strategy (treatment) on students' attitude towards Simple Harmonic Motion in Physics in secondary school in Ogun State ($F_{(1,123)}$=5.318, p<0.05, η^2=0.041). The null hypothesis was therefore rejected. This implies that the treatment was effective on students' attitude towards Simple Harmonic Motion in Physics in secondary school in Ogun State. Also, the eta square value of 0.041 shows the contributing effect size of 4.1%.

Discussion of Findings

This finding agrees with the earlier findings of a computer simulated pre- laboratory, which aimed to prepare students cognitively to real laboratory activity about acid- base titration and concluded that the experimental group of students showed a positive attitude towards learning(Emi & Linda,2019). The finding of this study is also in consonance with the fact that learning using computer simulations was able to change the attitudes of students to be more motivated towards Chemistry subject (Mukama & Byukusenge, 2022). Also, the finding of this study supported the finding of the effects of a Virtual laboratory and of a microcomputer-based laboratory via a questionnaire which shows that students were positive in their attitude and willingness to use virtual laboratory (Wong et al., 2020). A study about changes in attitudes

towards Chemistry among 238 Kenya students which found that computer simulations can change attitudes and motivate students to learn Chemistry also corroborated the finding of this study (Jane & Florence, 2022)

Conclusion

This study investigated the effects of virtual laboratory instructional strategy on secondary school Physics students' attitude in Simple Harmonic Motion in Ogun State. The instructional strategy that was employed in this study emphasised the participation and active intellectual involvement of students. This learner centered activity based strategy proved better than the conventional method. The result of the study revealed that there was significant main effect of instructional strategy (virtual laboratory) on students' attitude towards Physics.

Recommendation

Based on the findings of this study, it was recommended that:

1. Physics teachers should be trained on the use of virtual laboratory to improve the teaching of Physics in secondary schools.
2. Physics teachers should be encouraged to make use of virtual laboratory instructional strategy to teach Physics in secondary schools.
3. Physics teachers should be discouraged from using teacher-centered instructional strategies but student-centered instructional strategies such as virtual laboratory.

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