

**Effect of Predict-Observe-Explain and Virtual Laboratory Strategies on Secondary School  
Physics Students' Attitude to and Achievement in Simple Harmonic Motion Concept in  
Ogun State, Nigeria**

**Temitope Matthew ADEPOJU  
LCU/PG/002629**

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in Physics Education**

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### Certification

This is to certify that Temitope Matthew Adepoju with matriculation number LCU/PG/002629 carried out this research work titled “Effect of Predict-Observe-Explain and Virtual Laboratory Strategies on Secondary School Physics Students’ Attitude to and Achievement in Simple Harmonic Motion Concept in Ogun State, Nigeria” in the department of Science Education, Faculty of Education, Lead City University, Ibadan, Oyo-State, for the award of Doctor of Philosophy Degree (PhD) in Physics Education and that this has not been previously submitted for any publication.

.....  
**Prof. P. O. Yara**  
**(Supervisor)**

.....  
**Date**

.....  
**Prof. P. O. Yara**  
**(Head of the Department)**

.....  
**Date**

## **Dedication**

This research work is dedicated to Almighty God, the author and the finisher, and to the memories of my father, Mr Adepoju Adebisi (of blessed memory) and also the late Oyinwonuola Oluwaseun who we started this programme together but unfortunately did not see the end.

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“Even though the above-mentioned institutions and persons have assisted in the process of this research work, the researcher alone stand responsible for the errors, if any, found in the work”

## Abstract

Students' achievement in Physics in external examination had dwindled over the years. The problem of poor performance in Physics sometimes had not been limited to the students alone but also to teachers' pedagogical strategies. The study examined effect of Predict-Observe-Explain and Virtual Laboratory strategies on secondary school Physics students' attitude to and achievement in Simple Harmonic Motion in Ogun State. Fourteen hypotheses were formulated and tested at 0.05 levels of significance. The study adopted pretest- posttest control group quasi-experimental design involving 3x2 factorial matrix. A total of 166 SS2 Physics students in three senior secondary school intact classes in Ogun State participated in the study. Physics Achievement Test (PAT) with 30 multiple-choice questions ( $r=0.81$ ), Physics Attitude Scale (PAS) with 20 items on a four-point Likert type scale ( $r=0.73$ ) were used for data collection.

Data were analyzed with descriptive (frequency and percentage) and inferential statistics (ANCOVA). There was a significant main effect of Predict-Observe-Explain strategy on students' attitude to Physics ( $F_{(1,128)}=6.349$ ,  $p<0.05$ , partial  $\eta^2=0.047$ ). There was a significant main effect of Predict-Observe-Explain strategy on students' achievement in Simple Harmonic Motion ( $F_{(1,128)}=682.814$ ,  $p<0.05$ , partial  $\eta^2=0.842$ ). There was a significant main effect of Virtual Laboratory strategy on students' attitude to Physics ( $F_{(1,123)}=5.318$ ,  $p<0.05$ , partial  $\eta^2=0.041$ ). There was a significant main effect of Virtual Laboratory strategy on students' achievement in Simple Harmonic Motion ( $F_{(1,123)}=625.120$ ,  $p<0.05$ , partial  $\eta^2=0.836$ ). There was no significant main effect of gender on students' attitude to Physics ( $F_{(1,163)}=1.747$ ,  $p>0.05$ , partial  $\eta^2=0.011$ ). There was no significant main effect of gender on students' achievement in Simple Harmonic Motion ( $F_{(1,163)}=0.067$ ,  $p>0.05$ , partial  $\eta^2=0.000$ ). There was a significant interaction effects of Predict-Observe-Explain and Virtual Laboratory Strategies on students' attitude to Physics ( $F_{(2,162)}=4.322$ ,  $p<0.05$ , partial  $\eta^2=0.047$ ). There was a significant interaction effects of Predict-Observe-Explain and Virtual Laboratory strategies on students' achievement in Simple Harmonic Motion ( $F_{(2,162)}=586.719$ ,  $p<0.05$ , partial  $\eta^2=0.047$ ). There was no significant interaction effects of Predict-Observe-Explain and gender on students' attitude to Physics ( $F_{(1,126)}=1.073$ ,  $p>0.05$ , partial  $\eta^2=0.008$ ). There was no significant interaction effects of Predict-Observe-Explain and gender on students' achievement in Simple Harmonic Motion ( $F_{(1,126)}=2.009$ ,  $p>0.05$ , partial  $\eta^2=0.016$ ). There was no significant interaction effects of Virtual Laboratory strategy and gender on students' attitude to Physics ( $F_{(1,121)}=0.356$ ,  $p>0.05$ , partial  $\eta^2=0.003$ ). There was a significant interaction effects of Virtual Laboratory strategy and gender on students' achievement in Simple Harmonic Motion ( $F_{(1,121)}=5.219$ ,  $p<0.05$ , partial  $\eta^2=0.041$ ). There was no significant interaction effects of Predict-Observe-Explain, Virtual Laboratory strategies and gender on students' attitude to Physics ( $F_{(2,159)}=0.649$ ,  $p>0.05$ , partial  $\eta^2=0.008$ ). The study concluded that Predict-Observe-Explain and Virtual Laboratory strategies enhanced students' performance in Physics

Based on the findings of this study, it was recommended that Physics teachers should adopt Predict-Observe-Explain and Virtual Laboratory strategies to teach Physics in secondary schools.

**Keywords:** Predict-Observe-Explain, Virtual Laboratory, Attitude to Physics, Achievement in Simple Harmonic Motion, Gender in Physics

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### List of Acronyms

<b>Abbreviation</b>	<b>Meaning</b>
KLA	Key Learning Area
SSII	Senior Secondary Two
SSCE	Secondary School Certificate Examination
WAEC	West African Examinations Council
NECO	National Examination Council
SHM	Simple Harmonic Motion
POEIS	Predict- Observe-Explain Instructional Strategy
VLIS	Virtual Laboratory Instructional Strategy
PAT	Physics Achievement Test
PAS	Physics Attitude Scale
ANCOVA	Analysis of Covariance

TIG	Teachers' Instructional Guide
LGA	Local Government Area
CM	Conventional Method
VLP	Virtual Laboratory Package
PhET	Physics Education Technology

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# Chapter One

## Introduction

### 1.1 Background to the Study

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 employs observation, experimentation, measurement, and recording to methodically investigate the properties of materials and the behavior of the physical universe<sup>1</sup>. Science is considered to be a systematic, precise, and objective way to study the natural world<sup>2</sup>. Physics, Chemistry, Mathematics, and Biology constitute the fundamental disciplines of science<sup>3</sup>.

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 human being 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 known as the study of the nature and characteristics of matter and energy. The pure science of Physics has enormous effects on the modern and globalised society. The science of observing the environment around us is called Physics<sup>4</sup>. Physics 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<sup>5</sup>.

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<sup>6</sup>. 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<sup>7</sup>. It has been noted that teaching Physics in secondary education involves imparting the fundamental knowledge and concepts of science, helping students develop the skills and abilities necessary to participate in scientific processes, and instilling in them a positive attitude towards and appreciation for science and its applications<sup>8</sup>. Physics is a critical subject for effective living in the scientific and technological age, according to the Nigerian Federal Ministry of Education<sup>9</sup>. This implies that all students must be afforded the chance to learn certain Physics ideas, theories, concepts, and abilities. The goals of Physics education, as stated in the new Senior Secondary School Physics Curriculum, provide a clear explanation of these ideas, theories, and skills<sup>10</sup>.

The subject is one of the oldest disciplines and was formally part of natural Philosophy during the scientific revolution period. It has emerged as a unique research subject with new ideas which explain the fundamental mechanics of other sciences and open new avenues for research in other Science areas and Mathematics. The goals of Physics education are to cultivate and improve creativity, provide a foundational understanding of Physics for living in society, prepare students for higher education by teaching them the fundamental theories and principles of Physics, and equip them with the necessary scientific knowledge and mindset for using physics in technology<sup>11</sup>. Reaching these goals is crucial, and it calls for a teacher who employs learner-centered teaching strategies since learning occurs when students are actively engaged in the teaching and learning process. Therefore, the difficulties a teacher faces are in creating meaningful instruction that will result in meaningful learning<sup>12</sup>.

The economic potential of developed nations rests squarely on their advancement in science and technology and Physics played a major role in that aspect. Physics is one of the elective subjects in the Key Learning Area (KLA) of science education<sup>13</sup>. It is for functional living in society, in which

students are trained in the art of finding a physical explanation for what they experience, while also having opportunities to experience the scientific methods that can be applied when making critical investigations. The Physics curriculum serves as a continuation of the science where Senior Secondary one to three (SS1-3) curriculum builds on the strength of the current Physics curriculum. Every student is given an opportunity to acquire some of its concepts, principles, and skills. Physics education is expected to develop student's world view in terms of linking reality, putting in personal effort in the enriching learning environment, and constructing their own understanding from the available resource material.

Physics indeed is the pillar of technological and scientific development of most developed nations in the world, for example, improved knowledge of electromagnetism and nuclear Physics led to the inventions of television, the computer, and nuclear materials such as domestic appliances and nuclear weapons. Advances in thermodynamics led to the development of industries while the development in calculus was based on the advances in Mechanics. Thus, there is a need for technically literate citizens with complex problem-solving skills for the purpose of taking wise decisions and understanding the challenges that might occur in the nearest future. The laws, principles, and theories of Physics are being applied in solving many problems of human beings on earth. It was pointed out that Physics is the heart of science and a pillar of all technological activities<sup>14</sup>.

Many developed nations like the USA, Japan, France, China, and Russia attained their positions of world power as a result of development in science and technology and Physics played a key role in that direction. The discipline has proven its benefits to mankind as almost every human activity and virtually every profession involves some elements of Physics<sup>15</sup>. Agronomy, Engineering, Geophysics, Biophysics, Material Sciences, Nuclear Physics, Medicine, and Communication Technology are just a few of the disciplines that rely on the fundamentals of Physics<sup>16</sup>. The field of Information and

Communication Technology (ICT) has greatly benefited from the application of Physics concepts. Devices like computers, iPads, smartphones, and satellites have made the globe smaller by enabling communication between people across vast distances.

Additionally, Physics knowledge promotes sustainable industrial development for the advancement of materials beneficial to humankind's well-being. In order to respond to widespread and rapid changes in all parts of life, students studying Physics can develop problem-solving and science process abilities that will boost proper critical thinking and inquiry<sup>17</sup>. Hence, the teaching and learning of the subject need serious attention at the secondary school level to enhance sustainable technological development in Nigeria.

It is generally accepted that critical thinking should be an important dimension of science education<sup>18</sup>. Critical thinking should not only be an educational choice but rather an inseparable part of education. Since the world has changed quickly, it demands that education should develop students' critical thinking at all levels rather than teaching obsolete knowledge. Critical thinking can be taught and learned<sup>19</sup>. Students will improve their critical thinking when teachers use appropriate instructional methods and curriculum material and active learning strategies<sup>20</sup>. In addition, critical thinking is considered as the aim of instruction in which the students learn to apply cognitive skills such as hypothesizing, designing, performing, and analyzing a series of investigation<sup>21</sup>.

Physics Teachers are, therefore, obligated to help students develop the skills necessary to synthesize the nuances of a modern and complex society. Thus, to enhance national development in information, science, technology, and innovation, basic concepts and principles of Physics are highly indispensable. Hence, 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<sup>22</sup>. These include the concept of space, time, and motion, conservation principles, waves, fields, and Quanta. One important aspect of Physics is Mechanics.

The significance of Mechanics topics in Physics was highlighted by the Senior Secondary School Examination of the West African Examinations Council (WAEC) and the National Examination Council (NECO), which showed that over thirty percent of the questions on the Senior Secondary School Physics examination were related to Mechanics. The areas where students performed poorly in Physics were primarily the 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, and the interpretation of expressions and equations<sup>5, 23</sup>. Simple Harmonic Motion (SHM) is a topic in Physics which consists of content knowledge and calculation. The sub content includes period, frequency and amplitude of Simple Harmonic Motion, relationship between Simple Harmonic Motion and circular motion, speed and acceleration of Simple Harmonic Motion, relationship between linear acceleration and angular velocity, energy of Simple Harmonic Motion, free vibration, damped vibration, force vibration and resonance. Effective understanding of Simple Harmonic Motion entails that the theoretical presentations, practical presentations and calculations should be understood by the students. It was stressed that, the cardinal principle of teaching is that the whole is greater than the sum of its part<sup>24</sup>. Simple Harmonic Motion is a perceived difficult concept for students to understand because it often involves a complex equation<sup>25</sup>. Students shy away from mathematical analysis of the concept, which includes period, frequency, amplitude, velocity, and acceleration of Simple Harmonic Motion<sup>25</sup>.

Simple Harmonic Motion can be observed using a spring and a simple pendulum. This motion is a type of periodic motion or oscillation motion where the restoring force is directly proportional to the displacement and acts in the direction opposite to the displacement<sup>26</sup>. The spring that is stretched or compressed around the equilibrium position is proportional to the force applied by force following Hooke's law. The following were observed as candidates' weaknesses as regards Simple Harmonic Motion; poor mathematical representation, inability to accurately give the statement of definitions,

state equations, formulas, and substitution to draw conclusion<sup>27</sup>. However, despite the relevance of Physics to the scientific and technological breakthroughs of nations, the subject has been faced with a myriad of problems in Nigeria.

Several studies have revealed that the performance of Nigerian students in secondary school Physics is generally and consistently poor over the years<sup>28</sup>. Numerous causes have been attributed to the low academic performance of science students. The general low academic achievement of students in Physics can be attributed to various factors such as inadequate laboratory facilities, insufficient teaching and learning resources compared to the continuously growing student population, and the incapacity of Physics teachers to impart clear and concise knowledge to their students<sup>29</sup>. Students' performance in Senior Secondary School examinations is hampered by the poor state of laboratory facilities and the inadequate use of instructional materials<sup>30</sup>. The conventional method of teaching that is commonly used does not support the development of skills, objectivity, or critical thinking abilities that will enable the student to function well in society.

The reports of West African Examination Council (WAEC) on the Senior Secondary School Certificate Examination, (SSCE) from 2015 to 2019 on students' performances revealed that between 30% and 60% of candidates passed Physics at credit level out of 1,064,384 that sat for the examination in the 5-year period in Nigeria<sup>23,31</sup>. Simple Harmonic Motion is one of the most topics in Physics at the senior secondary school level in which learners perceived difficult despite being essential for the understanding of other topics<sup>32</sup>. One of the main barriers that students encountered in understanding Physics concepts is misconceptions which they had about the concepts. Many studies persistently report of the poor performance of students in Physics especially in the area of Simple Harmonic Motion call for urgent attention<sup>33</sup>. This challenging situation has been attributed to a whole number of factors such as students' attitude, poor study habits, the learners' interest in the subject, the learners' self-concept, gender and the teaching method<sup>34</sup>. Many learners experience difficulties when learning abstract concepts because the concepts are taught at theoretical level with

no visual or mental representative<sup>35</sup>. Consequently, learners fail to understand the concepts and therefore develop a negative attitude to Physics. The science classrooms are still being dominated by teachers-centred strategy of lecture method of teaching<sup>36</sup>. Research findings in the last decades revealed that students commonly lack a deep conceptual understanding of the key ideas regarding the concept of Simple Harmonic Motion and often fail to integrate their mental models into a coherent conceptual framework<sup>37</sup>. Effective teaching method employed by the teacher is the major contributory factor that influences learners understanding of concept of Simple Harmonic Motion<sup>38</sup>. A teaching strategy therefore is the way a lesson is approach that will be used to achieve a set of given objectives. If proper choice of strategy is made and the plan well executed students will actively engage in the lesson and derive benefits immediately<sup>39</sup>. There are varieties of teaching strategies from which a teacher can select for teaching and learning of Physics concepts, but the method employed will depend on a number of variables such as: age of the students, their learning styles, the cognitive level, subject matter, availability of instructional materials and environmental variables among others. Two or more teaching methods can be employed within a lesson content delivery for effective teaching to take place. Computer simulations, laboratory and demonstration methods are essentials for teaching the concept of Simple Harmonic Motion<sup>40</sup>. 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. In all countries, teachers are the key to realizing the curriculum aims and the quality of science education which students receive rests ultimately on them<sup>41</sup>. Historically, Physics has been taught at the high school by the lecture method together with laboratory activities with the aim of verifying concepts taught theoretically. Students who participated in active learning resulted to change in their pre-conceptions about phenomena in Physics and discover new concepts.

Achievement is another important variable in this study, it is the outcome of education to which a student, teacher or institution has been able to realize their educational goals<sup>42</sup>. Achievement

implies something that somebody has done successfully especially using his/her own efforts and skills<sup>43</sup>. Achievement is the act of obtaining a result through efforts in the quality and quantity of students' work. On the other hand, academic achievement is a measure of knowledge gained through education process usually indicated by test scores, grade point average and degree<sup>44</sup>. This is why some schools define this as a certain grade point average (GPA), or ranking in class. Academic achievement can be defined as performance of students in schools<sup>45</sup>. It could be getting high grades and a high GPA level. This high GPA level may be achieved through the use of innovative teaching strategies. In this regard, the use of innovative teaching strategies may help students to develop better understanding of a subject such as Physics which may lead to improved performance in achievement<sup>46</sup>.

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 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, peoples' attitudes frequently affect their actions and reactions 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<sup>47</sup>. 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<sup>48</sup>. Learning is challenging when one has a negative attitude towards a subject<sup>49</sup>.

Additionally, students tend to perform well in a subject when they have a favorable attitude towards it. One of the most significant goals of science education is to change students' attitudes towards science<sup>50</sup>. 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 Physics further and not progressing to scientific careers over the years has been partly related to low levels of interest and negative attitude developed quite early in life. Students achieve better when they are interested in whatever they are doing<sup>51</sup>. It was argued that emotional attitudes can have profound effects on learning efficiency<sup>52</sup>. The kind of attitude one holds in 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' attitude towards science. Students' attitudes towards Physics rapidly changing technological environment will influence their ability to cope with it emotionally as well as in material ways. Therefore, an investigation on 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 are fundamental in sourcing a practical approach to enhancing students' performance and motivation in Physics.

Gender has also remained a burning issue that has relevance in education because it has been linked to achievement and participation in certain professions<sup>52</sup>. Research studies have shown that gender has an influence in students' achievement in science and in practical<sup>53</sup>. Male students have higher level of learning outcomes than the female students in sciences<sup>54</sup>. It was found that there was no significant difference in learning outcomes with regard to gender<sup>55</sup>. Others, however reported no differences in the performance of boys and girls<sup>56</sup>. It was found that females perform better than males in language skills, verbal memory and perceptual speed, whereas male perform better in

Mathematics, Science and Social Science<sup>57</sup>. Some research findings are in support of boys performing better than girls in some areas<sup>58</sup>, while it was reported that girls performing better than boys in other areas<sup>59</sup>. Findings have also reported that gender has the potential of influencing students' learning outcomes irrespective of the instructional strategies used<sup>60</sup>. Research is inconclusive in the area of gender, so it is still a very important moderating factor in subject learning in schools, hence its inclusion as a moderating variable in this research.

Science lessons should be designed to provide students the freedom to experiment and engage in group discussions as they attempt to make sense of assignments and tackle difficult challenges. By making lessons engaging, student-centered, and interactive, activity-based and student-centered teaching practices can draw in and hold the attention of students in Physics classes. The Predict-Observe-Explain instructional strategy (POEIS) and the Virtual Laboratory instructional strategy (VLIS), which are being investigated in this study, are two of these activity-based, student-centered instructional strategies. The theory of practical activities, which emphasizes learning by doing, is the foundation of the Predict-Observe-Explain instructional strategy. Predict, Observe and Explain are the three tasks that students complete in this instance.

The POEIS functions well in demonstrations that enable real-time observations. The POEIS approach was claimed to be based on the traditional research model, which entails stating a hypothesis, providing evidence for its viability, gathering pertinent data, and discussing the findings<sup>61</sup>. Based on the idea of practical tasks that incorporate learning by doing, the Predict-Observe-Explain teaching technique was developed. It entails students making predictions about a demonstration's outcome and discussing the rationale behind them, performing and witnessing the demonstration, and then providing an explanation of any differences between their expectations and observations. Computer-based teaching and learning is increasingly becoming widespread and it has been important especially at difficult subjects in science for over two decades. Computer-based learning is a method, which uses computers in a learning media and strengthens students' motivation and

educational processes. It gives opportunities to both students and teachers to learn and teach more quickly and to combine active learning with computer technology.

A computer-based teaching method known as Virtual Laboratory Instructional Strategy (VLIS) consists of three parts: text, video, and a virtual experiment. Students are introduced to the experiment's title, purpose, theory, equipment, and methods in the text section. The steps involved in conducting the experiments are demonstrated to the students through a video in the video section. In the simulated experiment segment, 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 benefits on students' achievements, retention, and attitudes<sup>62</sup>. Students that participate in a virtual laboratory are more engaged in their education and have greater opportunity to comprehend complex ideas. Constructivist learning should be the foundation for developing virtual laboratory training, given their demonstrated effectiveness in the teaching and learning process.

The virtual laboratory fosters a greater desire and motivation for classes and laboratory exercises during the learning process<sup>63</sup>. Virtual Physics laboratory is highly interactive software, comprising simulations of real Physics laboratory customized for the needs of researchers and students. These software programmes provide students with the opportunity to study under the control and within the knowledge of the teacher, and to learn using trial and error. The most important attribute of virtual Physics laboratory is that they should have a highly interactive user interface. Users are able to perform experiments using the laboratory materials in any order by moving the objects using input device.

The key to teaching Physics well is to use practical laboratory exercises to reinforce theoretical explanations. A lot of the practical work done in Physics is done in laboratories. The examination of nature by observation, induction, hypothesis, experimentation, computation, prediction, and control was the focus of the Physics practical. It suggests that Physics is an empirical science in which

students relate ideas to one another through theories, experiments, and observations. Physics practical are laboratory-based investigations conducted to uncover unknowns and validate hypotheses.

The main goal of laboratory exercises is to help students gain a better grasp of Physics concepts through observation, analysis, and inference from experiments. Students get a wide range of fundamental skills in data processing and experimental Physics in the laboratories. It is advisable to let students use a variety of laboratory apparatus, both in the classroom and in the laboratories, to make observations, since it is essential that they have a wide experience with techniques using laboratory equipment in order to improve their abilities in conducting experiments. Therefore, it is inevitable that secondary school students would be properly exposed to practical Physics projects.

## **1.2 Statement of the Problem**

The attitude and performance of Nigerian secondary school students in Physics have not been encouraging. Despite the need for Physics education due to the desire for technological advancement, students' academic performance and 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 lecture and demonstration, 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.

In a study carried out to determine the effects of Predict-Observe - Explain (POE) instructional strategy on senior secondary school students' practical skills in Physics<sup>64</sup>. Findings of the study revealed that Predict- Observe-Explain instruction was more effective than the conventional practical instruction. Also, in the effectiveness of Predict- Observe- Explain (POE) model with PhET to improve critical thinking skills of senior high school students<sup>65</sup>. The result of the study shows that the scores of students' critical thinking skills in grade eleven of Group 1 and Group 2 increase after the implementation of Predict -Observe -Explain (POE) learning model with PhET and both of them present positive responses to the learning component and show a good interest. Similarly, in practicality and effectiveness of learning tools with Predict-Observe-Explain assisted conceptual change text to minimize students' misconceptions carried out<sup>66</sup>. The results of this study indicated that the learning tools are proven to be practical and effective so that they are feasible to be used more widely. In study of the effect of Prediction, Observation, Explanation supported project-based environmental education on the levels of attitude and behavior toward the environment<sup>65</sup>. The study found that the Prediction, Observation, Explanation supported project-based environmental education provided a significant development on students' attitude and behavior. Moreover, in developing concepts in Physics through virtual laboratory experiment, the students learned concepts of the Photoelectric effect through virtual laboratory in a better way as compared to real laboratory<sup>63</sup>.

Similarly, on the effectiveness of using virtual experiments on students' learning in the general Physics laboratory, students with virtual components acquired deeper understanding of Physics concepts and were better prepared for carrying out real experiments<sup>64</sup>. 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 virtual learning environment<sup>65</sup>. Also, in the study of effects of Predict-Observe-Explain and Virtual Laboratory instructional

strategies on secondary school students' performance in Physics practical carried out, Predict-Observe-Explain and Virtual Laboratory Instructional Strategies improved students' performance in Physics practical<sup>64</sup>.

Furthermore, not much study has focused on the Predict-Observe-Explain and Virtual Laboratory Strategies simultaneously. The researcher is interested in the instructional strategies among all the issues that lead to students' low academic performance in and attitude to Physics. It is against this background that, the study determined the effect of Predict-Observe-Explain and Virtual Laboratory Instructional Strategies on secondary school Physics students' attitude to and achievement in Simple Harmonic Motion in Ogun State, Nigeria. The study also examined the moderating effects of gender on students' attitude to and achievement in Simple Harmonic Motion (SHM).

### **1.3 Aim and Objectives of the Study**

The aim of this study is to determine the effect of Predict-Observe-Explain and Virtual Laboratory strategies on secondary school Physics students' attitude to and achievement in Simple Harmonic Motion in Ogun State. Specifically, the objectives of this study are to:

- i. determine the main effect of using Predict-Observe-Explain strategy on students' attitude and achievement in Simple Harmonic Motion in Physics in secondary school in Ogun State
- ii. determine the main effect of using Virtual Laboratory strategy on students' attitude and achievement in Simple Harmonic Motion in Physics in secondary school in Ogun State
- iii. examine the main effect of gender on students' attitude and achievement in Simple Harmonic Motion in Physics in secondary school in Ogun State
- iv. determine the 2-way main effect of Predict-Observe-Explain and Virtual Laboratory strategies on students' attitude and achievement in Simple Harmonic Motion in Physics in secondary school in Ogun State

- v. determine the 2-way interaction effect of Predict-Observe-Explain and gender on students' attitude and achievement in Simple Harmonic Motion in Physics in secondary school in Ogun State
- vi. investigate the 2-way interaction effect of Virtual Laboratory and gender on students' attitude and achievement in Simple Harmonic Motion in Physics in secondary school in Ogun State
- vii. investigate the 3-way interaction effect of Predict-Observe-Explain, Virtual Laboratory, and gender on students' attitude and achievement in Simple Harmonic Motion in Physics in secondary school in Ogun State.

#### **1.4 Hypotheses**

The study tested the following null hypothesis at 0.05 level of significance:

H<sub>0</sub>1: There will be no significant main effect of Predict-Observe-Explain strategy on students'

- i. attitude
- ii. achievement in Simple Harmonic Motion in Physics in secondary school in Ogun State

H<sub>0</sub>2: There will be no significant main effect of Virtual Laboratory strategy on students'

- i. attitude
- ii. achievement in Simple Harmonic Motion in Physics in secondary school in Ogun State

H<sub>0</sub>3: There will be no significant main effect of gender on students'

- i. attitude
- ii. achievement in Simple Harmonic Motion in Physics in secondary school in Ogun State

H<sub>0</sub>4: There will be no significant main effect of Predict-Observe-Explain and Virtual Laboratory strategies on students'

- i. attitude
- ii. achievement in Simple Harmonic Motion in Physics in secondary school, Ogun State

H<sub>0</sub>5: There will be no significant interaction effect of Predict-Observe-Explain and gender on students'

- i. attitude

ii. achievement in Simple Harmonic Motion in Physics in secondary school in Ogun State

H<sub>06</sub>: There will be no significant interaction effect of Virtual Laboratory and gender on students'

i. attitude

ii. achievement in Simple Harmonic Motion in Physics in secondary school in Ogun State

H<sub>07</sub>: There will be no significant interaction effect of Predict-Observe-Explain, Virtual Laboratory strategies and gender on students'

i. attitude

ii. achievement in Simple Harmonic Motion in Physics in secondary school in Ogun State

### **1.5 Significance of the Study**

The findings of this study will be helpful and beneficial to the following stakeholders: Teachers, Parents, Students, Curriculum Developers, Educational Technologists and Researchers in the field of education. The comprehensive goal of teaching secondary school Physics is to develop students' knowledge and understanding. Primarily, the purpose of classroom teaching and learning is to satisfy the set objectives of instruction with the aim of attaining the goals of education. It is therefore expected that almost all classroom activities are geared towards the attainment of educational goals to the benefit of the society. It is against this background that the study's findings offer Physics teachers helpful information on effective instructional strategies.

The findings of this study are significant not only because it may help improve the students' understanding of difficult concepts in the area of Simple Harmonic Motion but also learning outcomes (attitude and achievement) in Physics. The findings provide the empirical foundation for the use of Predict-Observe-Explain and Virtual Laboratory instructional strategies for enhancing and improving the teaching and learning of perceived difficult concepts in Physics. Practicing Physics teachers can adopt these instructional strategies and make sure that the steps proffered are sequentially followed when designing instructions in order to ensure easy understanding of Simple Harmonic Motion. Parents stand to benefit from the findings of the study as the findings could

improve performance of their wards in both internal and external examinations thereby justifying the huge amount invested in their education.

Also, students could benefit, in that the use of Predict-Observe-Explain and Virtual Laboratory instructional strategies will improve learning content and make Physics interesting. As students find the subject easy and interesting to learn, their performance in Physics will improve. The findings are expected to expand frontier of knowledge on effective strategies for teaching Physics and bring to the knowledge of Physics textbook and authors' information on effectiveness of the Virtual Laboratory and Predict-Observe-Explain strategies. The findings are expected to be useful to educational technologists who could rely on the empirical evidence to recommend the strategies to teachers, especially those teaching Physics in secondary schools. Other stakeholders in education, such as government and curriculum planners may benefit when the result of the study is disseminated at seminars, workshops and published in Journals. This will give them further insight on how to guide teachers in planning their instructions for effective teaching and learning using the virtual laboratory and predict-observe-explain instructional strategies.

### **1.6 Scope of the Study**

The study determined the effects of Predict-Observe-Explain and Virtual Laboratory Strategies on Secondary School Physics students' attitude and achievement in Simple Harmonic Motion concept. Gender is only the moderating variable. The study focused on public senior secondary schools in Ogun Central Senatorial District of Ogun State, Nigeria. It covered the following content areas: Experiment on verification of Hooke's Law, determination of force constant of a spring, determination of effective mass of a spiral spring by oscillation method, 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.

### **1.7 Limitations of the Study**

Every research has in one way or the other some limitations and this research suffered the same fate.

Limitations of this study include:

- i. Time allotted for Physics lesson on the school times table is not adequate enough to accommodate effective use of these strategies
- ii. Research of this nature requires adequate time in order to allow for a detail investigation. Owing to the fact that researcher undertook this study alongside other rigors of PhD, such time could not be created. Resilience and hard work led to the completion of the study
- iii. The two strategies are instructional materials intensive which are either lacking or inadequate in some schools thereby imposing extra cost on the researcher of either improvising or borrowing from the nearby schools.

### **1.8 Operational Definition of Terms**

The major terms and variables used in this study are operationally defined as follows:

**Academic Achievement in Simple Harmonic Motion:** These are the students' scores in pre-test and post-test derived from Physics Achievement Test (PAT)

**Attitude to Physics:** This refers to students' perception of his or her interest, reaction, perceived benefits, thinking and views about the teaching and learning of Physics. This will be determined by the score obtained by the students in the validated Physics Attitude Scale (PAS)

**Conventional Method of Teaching:** This is the method of teaching, common in our secondary schools, where the teacher gives out facts to the students, asking occasionally questions but does most of the talking

**Gender:** The sex of students offering Physics being male or female

**Instructional Strategies:** These are the plans adopted in teaching Senior Secondary School Two (SS II) students Physics to ensure effective achievement and improved attitude to Physics.

**Predict-Observe-Explain:** These are practical activities which involves learning by doing.

**Simple Harmonic Motion:** This is the concept of to and fro or back and forth movement of an object

**Virtual Laboratory:** This is a laboratory without physical building

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## Chapter Two

### Literature Review

This chapter reviewed related literature of the study under the following sub-heading:

- 2.1 **Conceptual Review**
  - 2.1.1 Concept of Attitude
  - 2.1.2 Academic Achievement in Physics
  - 2.1.3 Virtual Laboratory

- 2.1.4 Predict-Observe-Explain Strategy
- 2.1.5 Gender issue in Science Education
- 2.1.6 Concept of Physics
- 2.1.7 Mechanics
- 2.1.8 Simple Harmonic Motion (SHM)
  - 2.1.8.1 Terms in Simple Harmonic Motion (SHM)
  - 2.1.8.2 Energy of Simple Harmonic Motion
- 2.2 **Theoretical Framework**
  - 2.2.1 Cognitive Constructivism Learning Theory
- 2.3 **Review of Empirical Studies**
  - 2.3.1 Virtual Laboratory and Students Attitude to Physics
  - 2.3.2 Virtual Laboratory and Students Academic Achievement in Physics
  - 2.3.3 Predict-Observe-Explain Instructional Strategy and Students Attitude to Physics
  - 2.3.4 Predict-Observe-Explain Instructional Strategy and Students Academic Achievement in Physics
  - 2.3.5 Gender and Students Attitude to Physics
  - 2.3.6 Gender and Students Academic Achievement in Physics
- 2.4 **Conceptual Framework**
- 2.5 **Summary of Literature Reviewed**

## **2.1 Conceptual Review**

The conceptual review is discussed under the following: concept of attitude, academic achievement in Physics, Virtual Laboratory, Predict-Observe-Explain strategy, gender issue in science education, concept of Physics, Mechanics, Simple Harmonic Motion, Terms in Simple Harmonic Motion, and Energy of a Simple Harmonic Motion,

### **2.1.1 Concept of Attitude**

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 psychological construct representing an individual's evaluation of objects. Students' attitudes and interest could play significant role among students studying science. Attitude implies favourable, dis-favorable or neutral evaluative reactions towards something or item. In other words, attitude is a way of looking or viewing at things. In the theory of attitude, attitude is the intermediary for all types of reactions which can be categorized into three main components namely emotion, cognitive and behaviour<sup>1</sup>. These three components explain students' attitude towards learning. Attitude is the sum total of a human's instinct and feelings, prejudice or bias, preconceived notions, fears, threats, and convictions about any specified topic<sup>2</sup>.

In this study, attitudes generally are regarded as the positive or negative feelings of individual towards Physics learning. Positive learning attitudes are an important aspect in the process of learning science or science related subject like Physics. Attitudes are essential determinants of human behavior. Thus, attitudes, when acquired, could influence students' 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, people's attitudes frequently affect their actions and reactions to circumstances. Most students tend to have a negative attitude towards Physics presumably because they dislike the subject, they do not obtain high marks in examination even though they have tried their best, they cramped syllabus content, also do not like Physics teachers or lecturers<sup>3</sup>. Thus, pupils tend to perform better in a subject when they have a favorable attitude toward it. One of the most significant goals of science education is to change students' attitudes toward science<sup>4</sup>. 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 attitude developed quite early in life<sup>5</sup>.

Students achieve better when they are interested in whatever they are doing<sup>6</sup>. It was argued that emotional attitudes can have profound effects on learning efficiency<sup>7</sup>. The kind of attitude one holds in 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 secondary school and tertiary level also plays a major role in shaping students' attitude toward science. Students' attitudes towards rapidly changing technological environment will influence their ability to cope with it emotionally as well as in material ways<sup>8</sup>. Therefore, an investigation on 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 are fundamental in sourcing a practical approach to enhancing students' performance and motivation in Physics.

Individuals have different opinions about what is difficult in Physics. Some find the algebraic aspect difficult, while others find the Physics concepts difficult to understand<sup>9</sup>. It was stressed further that others complain about the work load or the level of critical thinking that is required in the subject. The attitude of students towards Physics is that many secondary school students are afraid of Physics and what they are afraid of is that Physics is difficult<sup>10</sup>. It was emphasized that their attitude towards Physics is caused by a variety of sources such as parents, friends, family, teachers and the society. The fear exhibited by students towards Physics was attributed to lack of necessary mathematical skills, even though there is a general consensus among students, the society and teachers that Physics is a very difficult subject<sup>11</sup>. Given students option, many students will drop Physics in favour of other Science subjects and that the mathematical calculation in Physics makes the subject a preserve for

few learners<sup>12</sup>. Whatever the cause may be, there seems to be a general fear of Physics in our society, and this fear has negative effect on the achievement of students.

Attitudes, are acquired through learning and can be changed through persuasion using variety of techniques<sup>13</sup>. Attitudes are a psychological construct with considerable implications for human behavior. It is commonly conceptualized as an individual's evaluation of any aspect of their social world. In other words, it can likely impact a student's preferences and dislikes of a subject. The attitude of students is likely to play a significant part in any satisfactory explanation of variable level of achievement shown by the students in the school Science subjects. Recognising learners' attitudes toward Physics is critical to developing a practical strategy for improving students' Physics proficiency and motivation.

Generally, students perceived Physics as a difficult and abstract subject. This is one of the reasons many students set aside from choosing it as one of their science subjects' combinations for Senior Secondary School Certificate Examination (SSCE) despite its potent applications in technology and national development. Some students attribute the difficulty of Physics to its interface with Mathematics. Students' perception of Physics and the learning environment are very important on their achievement in Physics<sup>14</sup>. It was stressed further that a good learning environment plus a good and effective teaching approach to reduce the abstractness in Physics have a significant difference in the academic achievement of students in the subject. This implies that students perform better in Physics when they are taught under a well-equipped and functional laboratory, and with a good and effective methodology.

Attitude can be seen as a learned tendency of an individual to reciprocate positively or negatively towards a target, position, or a person. It is furthermore viewed as a prediction agreed by individuals that thinks their views and feelings can be sometimes manifested in behavior<sup>15</sup>. Attitudes, behavior, and feelings are reticulated in such a way that attitude of people decide their behavior towards objects, people, and situations. They also influence the relationships that occur among these

variables<sup>15</sup>. Attitude involving by several dimensions or aspects. It considered three components: emotion, cognition, and behavior. Emotions are the senses of touch of enjoyment or pleasure in learning the subject or viewing it as boring, difficult, and dull. Cognition represents the student's perceived usefulness of the subject. Conversely, behavior is affiliated to student's motivation to acquire what is reflected with students' actions, commitment, and accomplishment in class<sup>16</sup>.

Many studies have showed that students' attitudes towards Physics are straight off and significantly related to students' performance. Students gain attitudes over period through direct learning of Physics or by obtaining information about the subject<sup>16</sup>. The attitude is the link between all types of reactions, which can be classified as three major components such as emotion, cognition and behaviour<sup>1</sup>. The students' attitude towards learning is explained by these three elements. The main factor in his or her success is the level of Emotional Quotient, where 20% of a student's success depends on an IQ, while 80% will depend on how he or she reacts effectively to emotions<sup>1</sup>. The cognitive attitude refers to the way information is processed, how knowledge is used and changed within human beings' minds as they make choices. The cognitive process can be natural, or it could have been developed in a subconscious way. Therefore, in order to clarify the concept that is to be perceived and practiced, cognitive attitude is a reaction based on knowledge.

### **2.1.2. Academic Achievement in Physics**

Achievement is another important variable in this study. It is the outcome of education to which a student, teacher or institution has been able to realise their educational goals<sup>17</sup>. Achievement implies something that somebody has done successfully especially using his/her own efforts and skills<sup>18</sup>. Achievement is the act of obtaining a result through efforts in the quality and quantity of students' work. On the other hand, academic achievement is a measure of knowledge gained through education process usually indicated by test scores, grade point average and degree<sup>19</sup>. This is why some schools define this as a certain grade point average (GPA), or ranking in class. Academic achievement can be defined as performance of students in schools<sup>20</sup>. It could be getting high grades

and a high GPA level. This high GPA level may be achieved through the use of innovative teaching strategies. In this regard, the use of innovative teaching strategies may help students to develop better understanding of a subject such as Physics which may lead to improved performance in achievement<sup>21</sup>. Achievement, which expresses the success or failure of the teaching and learning process, is an important factor in education. The results of the teaching and learning process are achievement in academics. The degree to which a student, teacher or institution is successful depends on their education goals. Academic achievement is described as the scholastic standing of a student at a given moment which states individual's intellectual abilities; which can be measured by grades obtained from examinations or continuous assessments (tests or quiz)<sup>22</sup>.

In general, academic achievement can be divided into two broad and narrow definitions, in which academic achievement in a broad sense refers to the improvement of students' overall quality during their school years. It is believed that academic achievement includes cognitive and non-cognitive outcomes, as well as psychological and behavioral outcomes<sup>23</sup>. It is argued that academic achievement includes: knowledge, values and attitudes, and skills or appropriate behaviors<sup>23</sup>. The National Leadership Council on Liberal Education and America's Promise believes that student academic achievement cannot simply mean admission rates and the percentage of degrees earned, as it once did, but that the more important question is whether students have acquired the knowledge and competencies that are essential to their future life, work, and civic activities. Academic achievement is not only about students' academic performance in school, but should also include all aspects of their knowledge, competence and literacy development<sup>23</sup>. Academic achievement in a narrow sense refers to the measured performance of students through examinations at a certain study stage.

In Nigeria, grades obtained from external examinations carried out by examination bodies such as West African Examinations Council (WAEC), National Examinations Council (NECO) and Joint Admissions and Matriculation Board (JAMB) determine the level of academic achievement of

students in senior secondary schools. Therefore, academic achievement refers to the attainment of educational objectives, education outcomes for students or more specifically how much each student, teacher or instructor has achieved in terms of learning targets. In this regard, the use of innovative teaching strategies may help students to develop better understanding of a subject such as Physics which may lead to improved performance in achievement<sup>21</sup>. Poor or underachievers are people whose performance is consistently below average in the educational system. The performance of students in the subjects they study in school is referred to as academic attainment<sup>24</sup>. The status of students in the class is determined by their academic success. It provides a chance for children to develop their talents, improve their grades and prepare them for future academic challenges. To achieve identity in the community, to gain good career opportunities, to be accepted by peers, parents and teachers as well as improve their self-confidence and abilities, students with high academic achievements are considered.

Academic success is considered one of the criteria to assess a person's overall potentialities and capabilities, as part of today's competitive world. A child who has excellent academic performance may be regarded as able to succeed in his or her professional career, whereas failure in studies can lead to disappointment, stress, inferiority complex, rejection by family and corruption. Physics as a course of study is perceived generally to be very interesting, vast, mathematical and experimental in nature. All living and non-living creatures have one thing or the other to do with it. It is one of the pre-requisite subjects for the study of engineering, technology, medicine, and other applied science courses in the university.

Physics is a challenging and rewarding subject. It is at the heart of almost every facet of modern life<sup>25</sup>. However, researches over the years have shown that, Physics has been mystified as a difficult subject<sup>26</sup>. Students who hold negative stereo type image of scientists, science and technology in society are easily discouraged from pursuing scientific disciplines and usually perform poorly in science subjects especially Physics<sup>27</sup>. The assessment of Physics subject at Senior Secondary

Certificate Examination by the West African Examination Council (WAEC), and National Examination Council (NECO), is in three parts; theory, objective and test of practical. Physics is different from other non-science subjects in school curriculum in the sense that it is practical oriented and that its lessons take place in the laboratory where both students and teachers carry out experiments and demonstrate practical skills. Practical work is encouraged in Physics because it facilitates the learning understanding of its concept. Unfortunately, most students lack this practical skill and therefore, usually perform poorly in the practical test during examination.

In Nigerian secondary schools, Physics is taught mainly by lecture method. Nigerian secondary school students who are taught Physics by chalk and talk lecture approach have repeatedly demonstrated poor achievement in Physics examination<sup>28</sup>. It was expressed further that students, probably perform poorly in Physics because the lecture method of teaching they are exposed to, does not enable them go beyond the lowest hierarchy of learning outcomes in Physics, that is the knowledge or factual recall level. It was reported that for over a century, the laboratory had been given a central and distinctive role in science education, and science educators have suggested that there are rich benefits in learning that accrue from using laboratory activities<sup>29</sup>. Practical work in science subjects especially Physics would provide students with opportunities to; make observation; select observation relevant to their investigations for further study; seek and identify patterns and relate these to patterns perceived earlier; suggest and evaluate explanations of the patterns; design and carry out experiments, including appropriate forms of measurements, to test suggested explanations for the pattern of observation<sup>30</sup>. The process skills listed above need to be tested by the teachers of Physics in an internal (school) practical examination to determine how well the students understand the nature of scientific investigation before exposing them to external (WAEC or NECO) examinations. This is the why it was reported that these process skills when tested in practical examination will reveal students' ability to handle simple apparatus which they consider as

paramount in the teaching and learning of science<sup>30</sup>. Therefore, the teaching of Physics should be tailored towards students acquiring the practical skills for better achievement in Physics.

### **2.1.3 Virtual Laboratory**

Physics and other natural science courses require laboratory work as a necessary component. It enables students to learn concepts and practical skills so as to illustrate theory<sup>31</sup>. In addition, students' curiosity and positive attitudes towards science are increased in the practical laboratory<sup>32</sup>. Despite its significance, laboratory work still faces several obstacles, such as the high cost of supplies and equipment and the risks involved in handling experiments<sup>32</sup>. At the same time, there is evidence in literature that ICTs such as simulations, animations, videos and visualizations are very promising for real practical use<sup>32</sup>.

One method of utilizing ICT for education, a virtual laboratory and a real, practical laboratory will be combined to create the Physics Laboratory<sup>32</sup>. Virtual education has exploded within the past few years and has become even more centric to the school life worldwide especially during the outbreak of COVID-19 pandemic. There are various ways of defining virtual laboratory. It can be defined as a computer programme that allows student to run simulated experiments via the web or as a stand –alone application. Virtual laboratory could be a set of simulations put together (examples are applets, flash base demons and animations). This allows the students to perform the experiments remotely at any time. In addition, experimental-oriented problems can be conducted without the overheads incurred for maintaining a physical laboratory. Virtual learning is a learning experience that is enhanced through utilizing computers and/or the internet both within and outside and inside the classroom components. The instruction most commonly takes place in an online environment. The teaching activities are carried out online whereby the teacher and learners are physically separated in terms of place, time, or both<sup>33</sup>. The course contents are conveyed through IT applications, multimedia resources, the Internet, videoconferencing among others. Virtual learning can also be

defined as distance learning conducted in a virtual learning environment with electronic study content designed for self-paced (asynchronous) or live web-conferencing (synchronous) online teaching and tutoring<sup>33</sup>

A virtual laboratory is also particularly useful when some experiments may involve hazardous chemicals and risky equipment. Virtual Laboratory is also used in the system aiming to replace physical machine with virtual machines on one host server. The students could manipulate various parameters of the simulations and observed the result<sup>34</sup>. In this approach there are certain advantage- It is very easy to learn how to use them, the leaning objectives is more clearly defined.

Another approach to a virtual laboratory could be providing a virtual work place that obeys the laws of Physics. A virtual laboratory is an online environment that consists of a set of experiment (simulations and videos) that allow learning to run experiments virtually and has the potential to promote and improve face-to-face practical-based learning<sup>35</sup>. Using laptops and smartphones, students can learn scientific concepts and acquire new skills in a virtual laboratory anytime and anywhere<sup>36</sup>. In a virtual laboratory, students will have the opportunity to make mistakes with minimal negative consequences compared to real laboratory, thus improving their confidence in carrying out real work.

Furthermore, a virtual laboratory can assist learners to perform experiments virtually that were difficult to be conducted in a real laboratory due to lack of equipment, costly materials and/or dangerous situations<sup>37</sup>. Additionally, by observing visual representations of natural events, gathering information, formulating predictions, and writing hypotheses in virtual laboratories, students can actively participate in scientific research processes<sup>37</sup>. The Virtual Laboratory Instructional Strategy (VLIS), one of the activity-based and student-centered teaching strategies, is being examined in this study. Physics teachings can be made more engaging, relevant, student-oriented, and participative through the use of activity-based and student-centered instructional strategies.

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<sup>38</sup>. 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 programmes 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<sup>39</sup>. Virtual laboratories encourage student participation in their education and provide them the chance to more readily grasp challenging ideas. Virtual laboratory instruction should be built based on constructivist learning method, since they have been found to be beneficial in the teaching and learning process.

In today's society, it is imperative to recognize the potential advantages of a virtual laboratory environment for Physics practical. Students that participate in a virtual laboratory are more engaged in their learning and have greater opportunity to build and comprehend complex ideas. In addition, it gives students the chance to learn from mistakes made in the laboratories or due to mishandling the equipment, and it makes it easier for them to avoid potential hazards that arise in actual laboratory settings. During the learning process, using a virtual laboratory boosts motivation and desire for the lectures. Additionally, it offers a working environment that is easy, safe, affordable, and perfect<sup>40</sup>. The learner can experience complete immersion in the case of immersive systems, enabling them to not only view but also feel the environment, and in the Virtual Laboratory, they

can control and interact directly with the objects within the virtual environment. This technology raises the possibility of a completely new kind of experiential learning. A virtual environment is highly suitable for learning challenges that require learners to be engaged in learner-centered activities because it allows for control, interaction, and free exploration, all of which contribute to a higher sense of empowerment.

Learning can take place in a simulated environment where students can fully immerse themselves and perceive 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. Learners can refine their technical, creative, and problem-solving skills in immersive environments, which can also provide rich and complex content-based learning opportunities<sup>41</sup>. The pragmatic learning theory philosophy is supported by the virtual laboratory instructional strategy. Students can learn through experimentation by manipulating the virtual objects in the exploratory learning environments that are provided. This virtual experience lends credence to the pragmatic viewpoint, which emphasizes that experience is the primary gauge of understanding. The issue of time constraints can be addressed with the virtual laboratory instructional strategy by utilizing portable devices, such as iPads, iPhones, Android phones, and smart phones that can be carried around. Students can conduct experiments at any time and from any location if the virtual laboratory is installed on any of these devices. By installing a virtual laboratory on these devices, students can learn at their own pace and improve their laboratory skills at the same time. In the learning process, a virtual laboratory fosters a greater desire and motivation for lessons and laboratory activities<sup>42</sup>. Virtual Physics laboratory is highly interactive software, comprising simulations of real Physics laboratory customized for the needs of researchers and students. These software programmes provide students with the opportunity to study under the control and within the knowledge of the teacher, and to learn using trial and error<sup>42</sup>.

The most important attribute of virtual Physics laboratory is that it should have a highly interactive user interface. Users are able to perform experiments using the laboratory materials in any order by moving the objects using input device. Virtual laboratory uses tools that simulate phenomena that cannot be investigated or observed in natural environments or in cases where the laboratory facilities are limited<sup>43</sup>. Thanks to these programmers, users have the opportunity to learn by experimenting and testing using different parameters. For example, they provide the opportunity to perform experiments in different environments with different gravitational forces (example, on another planet or at the poles), and to investigate the incidents in detail by controlling the time (example, slowing down the movements of electrons in a conductor for easy observation).

Furthermore, virtual laboratory also provides the opportunity to conduct investigations and experiments without harming any living creatures. Virtual laboratory is capable of simplifying experiments based on the user's skill level. For example, they enable users to understand the subject and solve the problem by showing multiple forces affecting an object directionally. Virtual laboratory is classified into five enclaves based on different sorts of simulations<sup>44</sup>. They are: classical simulations which have certain elements of laboratory experiments and are available locally (Simulations); classical simulations which have certain elements of laboratory experiments and are accessible on the web and are available as JAVA-Applets (Cyber Laboratories); simulations which attempt to represent laboratory experiments as closely as possible (Virtual Laboratories); simulations of laboratory experiments using virtual reality techniques (VR Laboratories); and real experiments which are controlled via internet (Remote Laboratories). The roles of virtual laboratory in teaching and learning process cannot be over-emphasized, therefore, it was proposed that virtual experiments can be used in different contexts and steps to increase accessibility of laboratory activities and to assist students who previously had no access to physical laboratory<sup>44</sup>. Such limit may emanate from a student's reduced dexterity, physical disability, or geographic distance<sup>44</sup>.

#### **2.1.4. Predict-Observe-Explain Strategy**

Instructional practices have changed as a result of ongoing modifications to the teaching and learning processes. This has exposed teachers to the elements and environments that are most conducive to learning and has helped to enhance and expand students' educational experiences. Students-centered teaching methods are currently the focus of a trend of changes in the teaching and learning processes. To make sure that students grasp scientific concepts, teachers should use a variety of teaching strategies and methods<sup>45</sup>. Researchers are urging a shift towards methods that allow learners to build their own understanding<sup>46</sup>. Constructivism is where these techniques originated. It is a learner-centered trend.

Therefore, it is crucial to use a teaching strategy that sparks students' interest in science. Students should be given the freedom to experiment and engage in group discussions while they interpret assignments and attempt to solve difficult problems when learning science. By making lessons lively, relevant, student-oriented, and participatory, activity-based and student-centered instructional strategies can draw in and keep students in Physics classes. Predict-Observe-Explain Instructional Strategy (POEIS), one of these activity-based and student-centered instructional strategies, is being examined in this study.

Learning can be done by using the previously existing knowledge for new knowledge. The teacher may let the students accommodate, assimilate or replace the previously existing knowledge with the new one. The accommodation, assimilation or replacement, however, often causes misconception among students. Students' prior knowledge should also be considered to make it more of a meaningful learning experience for the students<sup>47</sup>. Therefore, it is important for teachers to identify students' conceptions, both before and during teaching and learning<sup>48</sup>.

The POE (Predict-Observe-Explain) is one of the learning strategies used in the learning activities, helping students shape their investigation, and strengthening student prediction and conception. Application of POE learning has a positive effect on reducing student misconceptions in learning<sup>49</sup>. Therefore, there is need to develop teaching and learning strategies that can help students

to acquire new knowledge without misconceptions. To make an active teaching-learning process, students need to be able to clearly express themselves in written form and verbal form; teachers need to introduce a new teaching strategy like the Predict-Observe-Explain (POE) that can be used in association with demonstrations and hands-on activities that can help to enhance classroom practice by identifying the learner's conception<sup>50</sup>. The POE is also suited to be applied in physical subjects that can mostly be observed in experiments, and help to solve misunderstanding<sup>51</sup>.

In regard to science learning, teachers can involve students to make hypotheses, investigate, and analyze data to develop students' critical thinking<sup>52</sup>. One model of learning that is capable of developing students' thinking optimally is Predict, Observe and Explain Instructional Strategy (POEIS). The POEIS technique was created to ascertain each student's predictions regarding a particular event, as well as the rationale behind them<sup>53</sup>. Learning by doing is the guiding principle of the approach. Because students learn best by experiencing things and events for themselves, it is also known as the "power of experience"<sup>54</sup>. The POEIS is a strategy often used in science. It works best with demonstrations that allow immediate observations, and suits Physical and Material World contexts.; It can be used for finding out students' initial ideas; providing teachers with information about students' thinking; generating discussion; motivating students to want to explore the concept; generating investigations. The POEIS can include ways that can be taken by a teacher to assist students in improving the understanding of the concept and their psychomotor.

By making lessons lively, relevant, student-oriented, and participatory, activity-based and student-centered instructional strategies can draw in and keep students in Physics classes. The theory of practical activities, which emphasizes learning by doing, is the foundation of the predict-observe-explain instructional strategy. Predict, observe, and explain are the three tasks that students complete in this instance. With demonstrations that enable for instant observation, the POEIS functions best. It was asserted that the POEIS procedure is based on the classic model of research where a hypothesis is stated and reasons are given for why this may be true, relevant data are

gathered and results are discussed<sup>55</sup>. It involves students predicting the result of a demonstration and discussing the reasons for their predictions; carrying out and observing the demonstration and finally explaining any discrepancies between their predictions and observations. The POEIS engages students in predicting a phenomenon, observations through demonstrations or experiments, and finally explain the results of the demonstration as well as their hypothesis. By doing this way, acquired knowledge will be preserved in students' memory and increase students' science processing skills<sup>56</sup>. By giving students three distinct tasks to complete, this strategy tests their understanding. First, based on procedures or instructions from the teacher regarding who should do what, the student makes predictions about how certain events will turn out. Lists of explanations are provided by the learner to back up his/her predictions. The real-life event observation task comes next, and it can be completed by conducting experiments or by performing some sort of demonstration. Some of the anticipated results in this could prove to be true or false. |

In order to resolve discrepancies between predictions and observations, the learner then summarizes or clarifies what has been seen and compares the initial predictions with the actual observations. This teaching method, which is a type of discovery learning, enables students to independently discover ideas, theories, and facts by actively engaging in activities that have been prepared by the teacher specifically for the class. Intellectual forecasting, justifying forecasts, observing happenings, and providing an explanation for observations are all part of POE activities. The role of the teacher is minor. Students learn best by "doing" and "experiencing" things on their own, which is the basic premise underlying the POE instructional technique. Rather than acting as a leader, he or she functions as a facilitator and lets the learner act as the main event<sup>57</sup>. By using POE instruction in the classroom, learners gain first-hand knowledge of science instead of being told the results of events by their teachers.

In this instructional strategy, learners are directly involved in experiential activities and events, which enable them to better master and remember information. There are three procedural steps in

Predict-Observe-Explain Instructional Strategy: prediction, observation, and explanation<sup>58</sup>. Predict—Observe—Explain consists of the following steps:

**Prediction Phase:** Prediction Phase: Learners are given some questions to which they are expected to provide answers (predictions). It is also required that they give and discuss the reasons for their predictions.

**Observation Phase:** During this phase, learners verify their predictions through experimentation. Reading texts and carrying out experiments are among the things to do here in order to observe actual life situations or happenings in the laboratory.

**Explanation Phase:** Students explain their observations and compare them to their initial forecasts. This is where conceptual changes take place and new knowledge or ideas are generated. Learners' initial predictions are rejected, accepted or modified, as the case may be. When using Predict-Observe-Explain-(POE) in the classroom, the role of the teacher shall include<sup>59</sup>:

**Phase 1:** The teacher provides all the important background information about the experiment/situation so that students have the building blocks for a reasonable prediction. It is not fair for the teacher to leave out critical details if these are central to making a prediction. Where the teacher and the students are running a live experiment, the teacher may need to provide safety advice and information about the equipment required

**Phase 2:** It is important that students participate in the observation phase attentively. It can be a shame to ruin an otherwise great teaching moment through insufficient student attention at a critical moment, leading to them missing the whole point. If the experiment is very brief or the key event is easy to miss, the teacher can draw students' attention to the essential aspect to observe, but this should only be done after their predictions are completed.

**Phase 3:** After observation, the teacher facilitates a discussion where students attempt to understand their incorrect starting assumptions or theories, and try to construct new theories that better match the reality they have observed. Depending on the topic and any additional materials that the teacher

provides at this stage, there may be little for the teacher to do other than guiding the general discussion of students as they develop their new understanding; in other cases, the teacher may need to help students articulate their initial misconceptions, and then help them place together a new theory by drawing their attention to key observations. Some benefits of the Predict-Observe-Explain (POE) strategy are outline as follows; it can be used to explore students' initial ideas; generating good discussions between students with students and students with teachers; provide motivation to students to investigate concepts that have not been understood; and awakening the students' curiosity<sup>60</sup>. In order to identify students' ideas, concepts and misconceptions in science, the POE strategy is useful. In doing so, learners will be encouraged to develop their own ideas about concepts and the teacher will compile a list of reasons for this as well as allow them to discuss those. The instructor reserves judgment regarding the causes until the students have seen the actual occurrence. Finally, the consistency of learners' ideas and comparing their original forecasts to observations is useful in understanding differences so that they can be corrected for misconceptions.

The Predict-Observe-Explain instructional approach is a type of deductive reasoning, which involves reasoning from predictions to observations. It is important because it enables students to participate in learning activities in small groups as opposed to the conventional teacher-led full class setting. It allows students to work at their own pace, allowing them to go back and edit their initial responses, allowing them to control the demonstrations. It ensures that the learners are independent and have a thorough discussion and analysis of their predictions, reasoning and observations. The instructional strategy's observation phase is vital because it effectively gives students feedback on their predictions<sup>61</sup>. It has been said that the Predict-Observe-Explain educational style is a relatively new way to teach science<sup>50</sup>.

The Demonstrate-Observe-Explain (DOE) approach was the original design for the strategy<sup>62</sup>. This strategy was first employed to elicit thought processes from University of Pittsburgh first-year Physics students. The DOE is about real-world situations or real-world experiences. The strategy

involves formulating a question for prediction of the results of situation and then observing the effect of the change and explaining results. The advantage of DOE strategy includes a reduction in the quantity of verbal description and a reliance on open-ended questions which provide data to make inferences about students' conceptualisations<sup>62</sup>. The DOE was modified into the Predict-Observe-Explain (POE) model by Gunstone and White in 1981. The scholars used POE strategy to probe children's understanding of science concepts in elementary science. The scholars opine that in POE, the students must first predict the outcome of an event, describe their observation and then reconcile contradictions between what they predicted and what they observed. The POE is a strategy that lets the students explore concepts and generate investigation<sup>51</sup>.

Furthermore, the students are given the chance to express their schema and experience the science ideas behind the activity to satisfy their curiosity. Since then, researchers have employed the method to help secondary school students comprehend science concepts<sup>63</sup>. Additionally, pre-service Physics students employed the POEIS method<sup>64</sup>. All of these studies led to a change in the students' conceptual understanding by correcting their previous misconceptions and facilitating the acquisition of new knowledge during the investigation. It is against this background that the current study was designed to investigate the efficacy of an instructional strategy that could encourage active participation of learners in the teaching-learning process and which has the ability of engendering improved students' practical skills. According to the given statements, Predict-Observe-Explain (POEIS) should be able to be applied as one of the solutions to solve the problem at school regarding the topic of Simple Harmonic Motion (SHM)

### **2.1.5 Gender issue in Science Education**

Gender has also remained a burning issue that has relevance in education because it has been linked to achievement and participation in certain professions<sup>65</sup>. Gender inequality is still very prevalent. In Nigerian society, male folks are viewed as possessing superior characteristics in most endeavours including the intellectual and that is why many girls or women were left behind in

different sectors of Nigeria public services because of the popular belief that women education ends in the kitchen. The issue of gender is an important one in science education especially with increasing emphasis on ways of boosting manpower for technological development as well as increasing the population of female in science and technology fields<sup>66</sup>. Certain vocations and professions have traditionally been regarded as men's career (Medicine, Engineering, and Architecture) and others as women's career (nursing, catering, typing, and arts). Typically, parents call boys to wash cars, cut grass, fix bulbs, or climb ladders to fix or remove things. On the other hand, chores such as washing dishes, cooking, cleaning and so on, are reserved for the girls. In a nutshell, what are regarded as complex and difficult tasks are allocated to boys, whereas girls are expected to handle the relatively easy and less demanding tasks. As a result of this way of thinking, the larger society has tended to see girls as the "weaker sex", consequently, an average Nigerian child goes to school with these fixed stereotypes.

Gender issues, both on the part of the teachers and students, have been documented to affect achievement generally<sup>67, 68</sup>. Gender differences in Physics has remained an issue for decades<sup>69</sup>. This difference has persisted to the present<sup>70</sup>. Gender is a socially constructed concept. Gender is all around us<sup>71</sup>. It is actually taught to us; from the moment we are born. Gender expectations and messages bombard us constantly through upbringing, culture, peers, community, media, and religion, which influence the shape of our understanding of this, core aspect of identity. How we learn and interact with gender as a young child directly influences how we view the world today. Gender interaction between parent and child begin as soon as the sex of the baby is known. Like other social constructs, gender is closely monitored by society.

Practically everything in society is assigned a gender—toys, colours, clothes and behaviour are some of the more obvious examples. Through a combination of social conditioning and personal preference, by age most children prefer activities and exhibit behaviors typically associated with their sex. Gender refers to the socially determined ideas and practices of what it is to be female or male<sup>72</sup>.

It emerges in human life as a source of determining individual as well as social identity. Gender refers to the social attributes and opportunities associated with being male and female and the relationships between women and men; girls and boys, as well as the relations between women and those between men<sup>73</sup>. These attributes, opportunities and relationships are socially constructed and are learned through socialization processes. Gender systems are established in different socio-cultural contexts which determine what is expected, allowed and valued in a woman/man and girl/boy in these specific contexts.

The main focus of great concern in the field of science education are the biases and misconceptions about women and science<sup>74</sup>. Science is viewed as a male enterprise<sup>75</sup>. The behavioral, cultural, or psychological characteristics that are usually linked to one sex are known as gender<sup>76</sup>. Within this study, the term "gender" is used to differentiate between humans who are male and female according to the differences in their physiological structures. Everyone agreed that socialization practices in most African environments, including Nigeria, place enormous restrictions on the female gender and demand from her a higher input of daily domestic labour than from the male<sup>77</sup>. This perception automatically schemes female out from any consideration for serious professional discipline even in cases where the female appears to be more brilliant than their male counterpart. It was believed that gender discrimination in employment is one of the factors contributing to gender inequality in pursuit of Science, Technology and Mathematics education<sup>78</sup>.

Many employers of labour, sometimes including female employers prefer employing men to women<sup>79</sup>. There are more men in civil and other technological courses than women<sup>80</sup>. Female gender discrimination in all forms of likeness representation has been documented<sup>81</sup>. Conferences like the World Summit for Children in New York in 1990, the World Conference on Education for All (EFA) in 1990, the Pan-African Conference on Education of Girls in Ouagadougou in 1993, and the United Nations Conference on Women Development in Beijing, China in 1995 were organized as a result of this discrimination<sup>82</sup>. Based on this declaration, the 1999 constitution of the Federal Republic of

Nigeria was amended which prohibits inter alia discrimination on the ground of gender. Sections 18 and 42 of the 1999 Nigerian constitutions provides for equal educational opportunities at all levels for every citizenry such as free secondary education, free compulsory universal primary education, free adult literacy, however, many factors have restricted elimination of discrimination practices against women in Nigeria<sup>83</sup>.

Discrimination against women can take many different forms. Professional prejudice is one of these faces<sup>84</sup>. Concerning matters of career choice, women are consistently subjected to discrimination or are on the receiving end of it. Female students unanimously call for equal opportunities and career prospects in Physics from the Nigerian government<sup>85</sup>. The socio-economic development of any nation hinges on scientific and technological advancement, which is heavily reliant on Physics as a prerequisite. Any country's capacity for technological advancement might be more precisely determined by the caliber of its physics education, since a nation's technology culture cannot be deeply ingrained without Physics<sup>86</sup>. Women are glaringly underrepresented in science, as evidenced by the observation of female gender in science across the globe<sup>87</sup>.

Findings from a study on women's participation in science courses at Nigerian colleges of education indicated that in the 1997–1998 academic year, only 25.95% of the 1,029 students admitted to study Physics were female, and in the 1998–1999 academic year, only 36.38% of the 962 students admitted to study Physics were female<sup>88</sup>. The under-representation of women in Physics is indicated by this. Numerous researches indicated that in Nigerian schools, there are not many female students studying Physics<sup>89</sup>. It is noteworthy to emphasise that, on average, female post-secondary students studying Physics achieve significantly the same as their male counterparts<sup>90</sup>. With constitutional provision of equality, evidences abound of the persistent gender inequality in employment and educational attainment<sup>91</sup>.

Gender imbalance in enrolment and achievement is pronounced at all levels and across disciplines and programmes in secondary and tertiary levels of education in Nigeria<sup>92</sup>. It was reported

that consistent disparity in student's enrolment against the female at the primary and secondary levels of education is far reaching and has direct consequences on the gender distribution in university enrolments and consequently in the participation of women in high-level man power occupation<sup>93</sup>. The campaign of the human rights and freedom for women has gained support in the developed world with United Nations intervention that women should be empowered<sup>94</sup>.

Gender role differentiations are also encouraged in pictorial illustrations in textbooks which usually portray males as doctors, lawyers, engineers and professors, while the females are seen as nurses, cooks, mothers among others. This creates mental picture in the mind of the readers of the role expectation from the society<sup>95</sup>. Parents at home are not left out in this gender stereotype; parents buy ball for the male child and "teddy bear" for the female child. Teachers also encourage gender stereotype by giving different treatment to males and females in class. Teachers often go further to give different career guidance to males and females. The society also frowns at seeing a male cooking or female climbing a tree. The males are also assigned leadership positions and females are to assist or to follow, since Nigeria gained her independence, she had never produced a female president or governor<sup>96</sup>.

In Nigeria, a lot has not been achieved as a number of factors still militate against gender equity and women achievement of human rights. Such factors include social, economic, cultural, political and religion beliefs to mention a few<sup>97</sup>. In striving to achieve gender equity in science and technology and making women relevant in all sector of the nation's economy, efforts should as well guide against abandonment of our social institute, customs and cultural heritage but rather preserve them as education should prepare us for a changing society and itself generate social change<sup>98</sup>. Even though women are underrepresented in Physics in Nigeria, African-American women who study the subject have made significant contributions to their country's advancement in science and technology. Deborah J. Jackson contributed to the creation of the Cassini space probe's photonic flying hardware. The Atomic Energy Commission heavily relies on a book written by Ann T. Nelms to expedite its

experiments. Rosa Clark Webster focused on maximizing the photovoltaic capabilities of ion-implanted gallium-arsenic solar cells, the electro optical properties of p-n junction devices, and the optical properties of ion-implanted gallium-arsenic-iridium light emitting diodes (LEDs). The first female African American doctoral recipient from Massachusetts Institute of Technology in Theoretical Physics was Shirley Ann Jackson. The Nuclear Regulatory Commission appointed her as its chair in 1995<sup>99</sup>. The contributions of African-American women to the advancement of science and technology through Physics are numerous, and this is simply a brief list.

### 2.1.6 Concept of Physics

The Greek word "Physics" means "knowledge of nature". Physics is a natural science that studies matter and how it moves in space and time, as well as ideas like force and energy that are related to it. More broadly, it is the study of nature, usually with the goal of comprehending the behavior of the universe. Physics is the study of matter's physical characteristics in connection to energy. One of the sciences that is crucial to the advancement of technology in our country is Physics. The goal of Physics is to explain the basic principles underlying the universe and its functioning. This is because Physics is very important to everything in the world. The science of Physics is experimental<sup>100</sup>. Reproducible observations must be predicted and explained for any physical theory to be accepted.

The study of the nature and characteristics of matter and energy is known as Physics. A pure science, Physics has enormous effects on the modern, globalized society. The science of observing the environment around us is called Physics<sup>101</sup>. Science and technology consider it to be a core subject, since it studies the essence of natural phenomena and helps people understand the rapidly technological changing society<sup>102</sup>. 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<sup>103</sup>. 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<sup>104</sup>. Physics teaching in Secondary schools has been found to include the learning of the fundamental facts and principles of science, development of abilities and skills needed to engage in the processes of science, inculcation of positive attitudes about and appreciation of science the and consequence of science<sup>105</sup>.

The Federal Ministry of Education in Nigeria considers Physics to be an essential subject for living well in the current scientific and technological era<sup>106</sup>. This implies that each student must be given the chance to learn some basic Physics ideas, theories, concepts, and skills. The objectives of Physics education, as enshrined in the new Senior Secondary School Physics Curriculum, clearly explain these concepts, theories, principles, and skills<sup>107</sup>. The subject is one of the oldest disciplines and was formally part of natural Philosophy during the scientific revolution period. It has emerged as a unique research subject with new ideas which explain the fundamental mechanics of other sciences and open new avenues for research in other Science areas and Mathematics.

The objectives of Physics education aim to provide a fundamental understanding of Physics necessary for functional living in society. It also seeks to impart elementary theories and principles of Physics for advanced studies and to acquire essential scientific skills and attitudes that prepare individuals for the technological application of Physics. Additionally, Physics education aims to stimulate and enhance creativity<sup>108</sup>. Reaching these goals is crucial, and it calls for a teacher who employs learner-centered teaching strategies since learning occurs when students are actively engaged in the teaching and learning process. Therefore, the difficulties a teacher faces are in creating meaningful instruction that will result in meaningful learning<sup>109</sup>. The economic potential of developed nations rests squarely on their advancement in science and technology and Physics played a major role in that aspect.

Physics is one of the elective subjects in the Key Learning Area (KLA) of science education<sup>110</sup>. It is for functional living in society, in which students are trained in the art of finding a physical explanation for what they experience, while also having opportunities to experience the scientific methods that can be applied when making critical investigations. The Physics curriculum serves as a continuation of the science, Senior Secondary One to Three (SS1-3) curriculum builds on the strength of the current Physics curriculum. Every student is given an opportunity to acquire some of its concepts, principles, and skills. Physics education is expected to develop student's world view in terms of linking reality, putting in personal effort in the enriching learning environment, and constructing their own understanding from the available resource material.

Physics indeed is the pillar of technological and scientific development of most developed nations in the world, for example, improved knowledge of electromagnetism and nuclear Physics led to the inventions of television, the computer, and nuclear materials such as domestic appliances and nuclear weapons. Advances in thermodynamics led to the development of industries while the development in calculus was based on the advances in Mechanics. Thus, there is a need for technically literate citizens with complex problem-solving skills for the purpose of taking wise decisions and understanding the challenges that might occur in the nearest future.

The laws, principles, and theories of Physics are being applied in solving many problems of man on earth. It was pointed out that Physics is the heart of science and a pillar of all technological activities<sup>111</sup>. Many developed nations like the USA, Japan, France, China, and Russia attained their positions of world power as a result of development in science and technology and Physics played a key role in that direction. The discipline has proven its benefits to mankind as almost every human activity and virtually every profession involves some elements of Physics<sup>112</sup>. Agronomy, Engineering, Geophysics, Biophysics, Material sciences, Nuclear Physics, Medicine, and Communication technology are just a few of the disciplines that rely on the fundamentals of Physics<sup>113</sup>. Many scientific, technological, and economic developments, including Information and Communication

Technology, have made extensive use of the principles of Physics, which has reduced the world into a global village through the use of smartphones, computers, iPad, and satellites. Understanding Physics also contributes to sustainable development in the industrialization sector for the development of materials helpful to human well-being. Through the study of Physics, students can develop their problem-solving and scientific method skills, which will improve their ability to critically analyze and ask insightful questions and prepare them for future, significant changes in all areas of life<sup>114</sup>. Hence, the teaching and learning of the subject need serious attention at the secondary school level to enhance sustainable technological development in Nigeria. Physics teachers are, obligated to help students develop the skills necessary to synthesize the nuances of a modern, complex society. Thus, to enhance national development in information, science, technology, and innovation, basic concepts and principles of Physics are highly indispensable.

Therefore, Physics is included in the Nigerian senior secondary school science curriculum to build a strong technological foundation for students. There are 10 concepts of Physics<sup>115</sup>. These include the concept Equilibrium and linear Motion, Newton's laws of Motion, Momentum and Energy, Gravity, Projectiles and Satellites, Fluid Mechanics, Temperature, Heat and Thermodynamics, Heat Transfer and Change of Phase, Electrostatics and Electric Current, Magnetism and Electromagnetic Induction, Waves, Sound, Light waves and Properties of Light, Atoms and Quantum Theory, The Atomic Nucleus and Radioactivity. However, Physics is a human endeavor that involves cognitive processes, manipulation, computing, and techniques used by man to find the laws governing the cosmos. One of the hardest scientific subjects to study has continued to be Physics. The curriculum for schools reveals how challenging Physics is as a subject<sup>116</sup>.

#### **2.1.7. Mechanics**

Mechanics is the branch of Physics dealing with the study of motion when subjected to forces or displacements, and the subsequent effects of the bodies on their environment. There are two sub disciplines Classical Fields and Quantum Fields, Classical mechanics deals with the question of how

an object moves when it is subjected to various forces, and also with the question of what forces act on an object which is not moving. The word “classical” indicates that we are not discussing situations in which an object moves with a velocity which is an appreciable fraction of the velocity of light or phenomena on the atomic scale<sup>117</sup>.

The description of atomic phenomena requires quantum mechanics, and the description of phenomena at very high velocities requires Einstein’s Theory of Relativity. Both quantum mechanics and relativity were invented in the twentieth century; the laws of classical mechanics were stated<sup>118</sup>. The laws of classical mechanics enable us to calculate the trajectories of bullets and baseballs, planets and space vehicles. Using these laws, we can predict the position-versus-time relation for a cylinder rolling down an inclined boat or for an oscillating pendulum and can calculate the tension in the wire when a picture is hanging on a wall<sup>118</sup>.

Mechanics can also be defined as the Science of the motion of bodies. Instead of using real objects, mechanics makes use of their models. In general, the model of a given object (body) is an image reflecting only those attributes of the object that are essential to investigate the phenomena of interest for a particular branch of science. To the basic models applied in mechanics belong to the following ones:

A particle (material point): A body possessing mass but having such small dimensions that it can be treated as a point in a geometric sense. However, in practice, bodies whose angular velocities are zero by assumption or whose rotational motion can be neglected are treated as particles regardless of their dimensions;

- i. A system of particles: A collection of particles;
- ii. A rigid body: The distances between elements of such a body remain constant for arbitrarily large magnitudes of forces acting on the body. In reality, structures, machines, and

mechanisms are deformable bodies. However, usually their deformations are small, and hence in many cases their effect on the statics/dynamics of the studied bodies can be neglected.

- iii. A system of rigid bodies: A collection of rigid bodies. The laws of mechanics introduced by Newton serve to illuminate the motions of material systems. They enable us to create a mathematical model, that is, to formulate equations of motion of particles and bodies. The main goal of mechanics is to formulate the laws of motion suitable for the investigation of a variety of real bodies. It turns out that any real body, solid, liquid, or gaseous, can be modeled as a collection of particles.

The following branches of Mechanics deal with problems in the previously mentioned fields:

Mechanics of rigid bodies (statics and dynamics), Mechanics of deformable bodies (strength of materials, elasticity theory, plastic theory, or rheology) and Mechanics of fluids. Incompressible (mechanics of liquids) and compressible (mechanics of gases, aeromechanics); the mechanics of incompressible fluids such as water is known as hydraulics. Quantum mechanics can be thought of roughly as the study of Physics on very small length scales, although there are also certain macroscopic systems it directly applies to. The descriptor “quantum” arises because, in contrast with classical mechanics, certain quantities take on only discrete values.

However, some quantities still take on continuous values. In quantum mechanics, particles have wavelike properties, and a particular wave equation, the Schrodinger equation, governs how these waves behave. The Schrodinger equation is different in a few ways from the other wave equations, but these differences would not keep us from applying all of our usual strategies for solving a wave equation and dealing with the resulting solutions.

In some respect, quantum mechanics is just another example of a system governed by a wave equation. However, it is fairly straightforward to deal with the actual waves, there are many things about quantum mechanics that are a combination of subtle, perplexing, and bizarre. Some of these things are: the measurement problem, hidden variables along with Bell’s theorem, and wave-particle

duality. Even though there are many things that are highly confusing about quantum mechanics, the nice thing is that it is relatively easy to apply quantum mechanics to a physical system to figure out how it behaves<sup>119</sup>.

### 2.1.8 Simple Harmonic Motion (SHM)

In Mechanics and Physics, Simple Harmonic Motion is a type of periodic motion or oscillation motion where the restoring force is directly proportional to the displacement and acts in the direction opposite to that of displacement. Simple Harmonic Motion can serve as a mathematical model for a variety of motions, such as the oscillation of a spring. In addition, other phenomena can be approximated by Simple Harmonic Motion, including the motion of a simple pendulum as well as molecular vibration. Simple Harmonic Motion is typified by the motion of a mass on a spring when it is subject to the linear elastic restoring force given by Hooke's Law. The motion is sinusoidal in time and demonstrates a single resonant frequency. Mathematically, such a system is described by a simple sine or cosine wave as:

$$y(t) = A\sin(\omega t + \varphi) \dots\dots\dots 1$$

where  $A$  is the amplitude of the motion,  $\varphi$  is the phase angle, and  $\omega$  is the angular frequency. One application of simple harmonic motion is the mass-spring oscillator, which consists of a mass attached to one end of a spring. The equation that describes this system is governed by Newton's second law which states that:

$$F = m\ddot{y} \dots\dots\dots 2$$

where  $m$  is the inertial mass, and  $\ddot{y}$  is the acceleration. When the mass is displaced from its equilibrium position, the spring exerts a force that resists the displacement and is given by Hooke's Law:

$$F_{spring} = -ky \dots\dots\dots 3$$

where  $k$  is the stiffness of the spring, and  $y$  is the displacement of the mass. Spring period is affected by the spring constant ( $k$ ) and mass ( $m$ ). The pendulum's period is given by

$$T = 2\pi \sqrt{\frac{m}{k}} \dots\dots\dots 4$$

A pendulum with a length of rope and the mass  $m$  that is fixed rotating at the pivot point. The period of motion is given by:

$$T = 2\pi \sqrt{\frac{l}{g}} \dots\dots\dots 5$$

Where  $g$  is the acceleration of gravity

Since acceleration is the second derivative of position, simple harmonic motion is governed by the following second order ordinary differential equation:

$$m \frac{d^2y}{dt^2} = -ky \dots\dots\dots 6$$

In addition, due to their mechanical nature, most systems experience damping; this is a force that can either oppose or amplify the oscillatory motion of the spring and is written as:

$$F_{friction} = -by \dots\dots\dots 7$$

where  $b$  is the damping coefficient, and  $y$  is the velocity of the mass. Finally, the system can experience forcing when other external forces, such as gravity, electricity, or magnetism act upon the system. Using Newton's second law, these individual force equations can be combined into a single second order ordinary differential equation that describes the motion of the mass-spring system and is given by:

$$m\ddot{y} + b\dot{y} + ky = F_{ext}(t) \dots\dots\dots 8$$

where  $F_{ext}(t)$  are the external forces applied to the system. For such a system, the term resonance describes the state at which the system oscillates at its natural frequency of vibration, also known as its resonance frequency, and absorbs a maximum amount of energy<sup>120</sup>. Different variations of equation (8), ranging from simple to highly complex, are used in a variety of fields including Quantum Physic, Biology, Oceanography and Environmental Science<sup>120</sup>. For Simple Harmonic Motion to be an accurate model for a pendulum, the net force on the object at the end of the

pendulum must be proportional to the displacement. This will be a good approximation when the angle of swing is small. Simple Harmonic Motion provides a basis for the characterization of more complicated motions through the techniques of Fourier analysis. Simple harmonic motion is the motion of a particle traveling in a straight line with an acceleration that is always directed toward a fixed point on the line and whose magnitude is proportional to the distance from the fixed point.

However, if the mass is displaced from the equilibrium position, the spring exerts a restoring elastic force that obeys Hooke's law. There are many objects around us that exhibit oscillation behaviour such as the beatings of butterfly wing, trembling building due to earthquakes, pendulum motion of grandfather clock, and the motion of rodeo cowboy, while riding hopping bull. However, most of natural oscillations are nonlinear which is formed by an infinite number of harmonics<sup>121</sup>.

Simple Harmonic Motion (SHM) is a basic type of oscillations where each motion is mathematically expressed in a sinusoidal function of time with a single frequency<sup>122</sup>. Although kinematics of an object undergoing simple harmonic motion has been established, the mathematical formulas (position, velocity, and acceleration) are still in general solution.

Hence, students may have difficulties either with the determination of its phase constant or the initial conditions for the corresponding kinematic quantities. Therefore, laboratory work is necessary to support the theoretical literature. However, there are other problems occurring in SHM experiments. Laboratory work is designed to provide students the opportunity to acquire the necessary skills and techniques in manipulating apparatus as well as ample understanding of the instruments themselves<sup>123</sup>. In other words, the experiment should be carefully carried out in order to ensure the validity of the obtained data. Thus, it would be better if the system is equipped with apparatus to record the raw data as a function of time. This would enable students to focus on data interpretation and analysis instead of wasting most of their time collecting data<sup>123</sup>.

There are several ways of observing Simple Harmonic Motion, and determining oscillation period is one of them. Some experiments utilize photogate as a means of measurement<sup>124</sup>. Another

way of observing SHM is through the trajectory of the object in which video recording is commonly used. This method captures the object movement whose image will be processed through a certain image processing algorithm and pixel conversion. However, this method can only produce one out of three kinematic quantities which is position of load. The SHM is a topic present in several branches of Physics and Engineering.

One application of Simple Harmonic Motion is the mathematical model of mood variation in bipolar patients which is used to study mental disorders in the fields of psychology and medicine<sup>125</sup>. Bipolar II disorder is psychological disorder that is characterized by alternating hypomania and depressive episodes. By making the assumption that these mood swings are periodic and intensify without medical treatment, a negatively damped harmonic oscillator can be used to model their variation. The equation that governs the oscillatory mood variations of an untreated patient with bipolar II disorder is generally presented in the form:

$$\ddot{x} - \alpha \dot{x} + \omega^2 x = 0$$

where  $x$  is the patient's emotional state,  $\dot{x}$  is the rate of the mood changes between hypomania and major depression,  $\omega$  is the natural frequency of the oscillator, and  $\alpha$  is the damping coefficient. This mathematical approach to studying bipolar disorder is a valuable technique, as it offers an alternative method for examining the dynamic characteristics of psychological illnesses. However, the unbounded oscillations which result from the negative damping coefficient make the model problematic and unrealistic; such unlimited oscillations imply that untreated individuals will experience mood swings that become infinitely severe over time. Nevertheless, this equation is useful as it allows researchers to make predictions regarding various medical treatments and their potential for controlling the mood variations of patients with the disorder. Thus, when applied to the study of mental illnesses, harmonic motion equations prove to be valuable tools for understanding and analyzing the oscillatory emotional behaviour of individuals suffering from bipolar II disorder.

Simple Harmonic Motion is also used in the subject areas of Environmental Science and Agricultural Economics when studying the vibrations and dynamic movement of trees in response to mechanical harvesting techniques<sup>126</sup>. Trees are dynamic structures that respond to forces with complex movements that are directly related to their mass distribution and organ stiffness. When mechanically harvesting fruit, a trunk shaker applies vibrations to the tree's stalk.

These vibrations are transferred to the branches of the tree, causing the fruit to detach. Trees use a variety of different damping techniques to dissipate energy; some sources of damping include friction generated in its stem and roots and aerodynamic drag produced by its canopy area. The forced vibrations applied by the machine when combined with the natural damping mechanisms of the tree, cause the tree to behave as a damping harmonic oscillator. It is common for students to find SHM a difficult topic to understand. This can be attributed to the excessive focus given to mathematical demonstrations, to the detriment of physical analysis of phenomena<sup>127</sup>. A way to circumvent these obstacles to teaching SHM and generate an evolution of the concepts brought by students can be found in the studies. The Simple Harmonic Motion (SHM) is a content usually seen in the form of lectures only. Due to its degree of abstraction, the topic is often considered difficult to understand.

#### 2.1.8.1 Terms in Simple Harmonic Motion (SHM)

- Frequency,  $f$ . This is the number of complete revolutions per unit of time. It is the reciprocal of the period.

$$f = \frac{\text{no of cycles}}{\text{time}}, \quad f = \frac{1}{T}$$

- Period,  $T$ . This is the time required to make one complete revolution about a point of reference. It is the reciprocal of frequency.

$$T = \frac{\text{time}}{\text{no cycles}}, \quad T = \frac{1}{f}$$

Recall that  $\theta = \omega t$ , if a complete cycle is made then  $\theta = 360^\circ = 2\pi$  and  $t=T$

$$2\pi = \omega T, 2\pi = \omega \times \frac{1}{f}$$

$$\omega = 2\pi f$$

$$T = \frac{2\pi}{\omega}$$

- Amplitude, (a). This is defined as the maximum displacement of the body from the equilibrium position

### 2.1.8.2 Energy of Simple Harmonic Motion

Since force and displacement are involved in simple harmonic motion, energy is also involved. At any instant of the motion, the system may contain some energy as kinetic or potential or both. For example, consider a mass suspended from the end of a spring which is made to execute a simple harmonic motion.

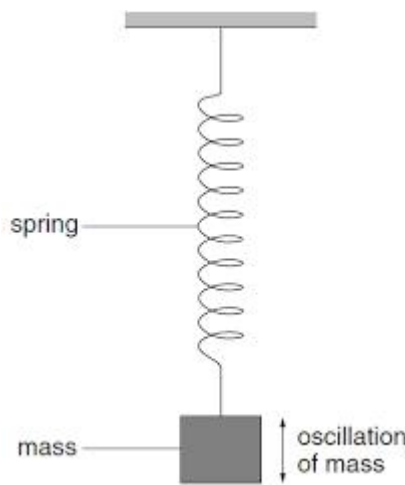


Fig 2.1. Energy of a Simple Harmonic Motion of a mass suspended on a spring

The force necessary to stretch the spring a distance,  $x$  is given by  $F = kx$

Where  $k$  is the force constant or stiffness of the spring. The work done in stretching the spring is given by

Work = Average force  $\times$  displacement

$$= \frac{1}{2} kx \cdot x = \frac{1}{2} kx^2$$

Thus, the energy stored in the stretched spring is  $\frac{1}{2}kx^2$ . Maximum energy stored or maximum potential energy (PE) in a stretched spring is given by

$$PE_{max} = \frac{1}{2}ka^2$$

Where a, is the maximum displacement or amplitude of the motion. This maximum energy is conserved throughout the simple harmonic motion. The kinetic energy (KE) at any instant of the motion is  $\frac{1}{2}mv^2$ , where m is the mass of the body and v is its velocity at that instant. When the oscillating spring is momentarily at rest at the position of maximum displacement, where  $v=0$  and kinetic energy equals zero, the potential energy equals  $\frac{1}{2}ka^2$ . Total energy = K.E + P.E =  $\frac{1}{2}ka^2$ .

At the equilibrium position where the speed is a maximum total energy is in the form of kinetic energy,  $\frac{1}{2}mv^2$  and P.E equals zero since x is zero at this point. Given that the system's total energy is always conserved, v can be found by

$$\frac{1}{2}mv^2 = \frac{1}{2}ka^2 = \sqrt{\frac{k}{m}} a$$

At other positions,  $v = \sqrt{\frac{k}{m}(a^2 - x^2)}$

This follows from the fact that any position, x, from the central point,  $\frac{1}{2}mv^2 + \frac{1}{2}kx^2 = \frac{1}{2}ka^2$

The energy in a simple harmonic motion may change form, P.E to K.E, but the total energy is always constant at  $\frac{1}{2}ka^2$ .

The total energy is always proportional to the square of the amplitude of the motion.

Considering the simple harmonic motion of a simple pendulum as another example

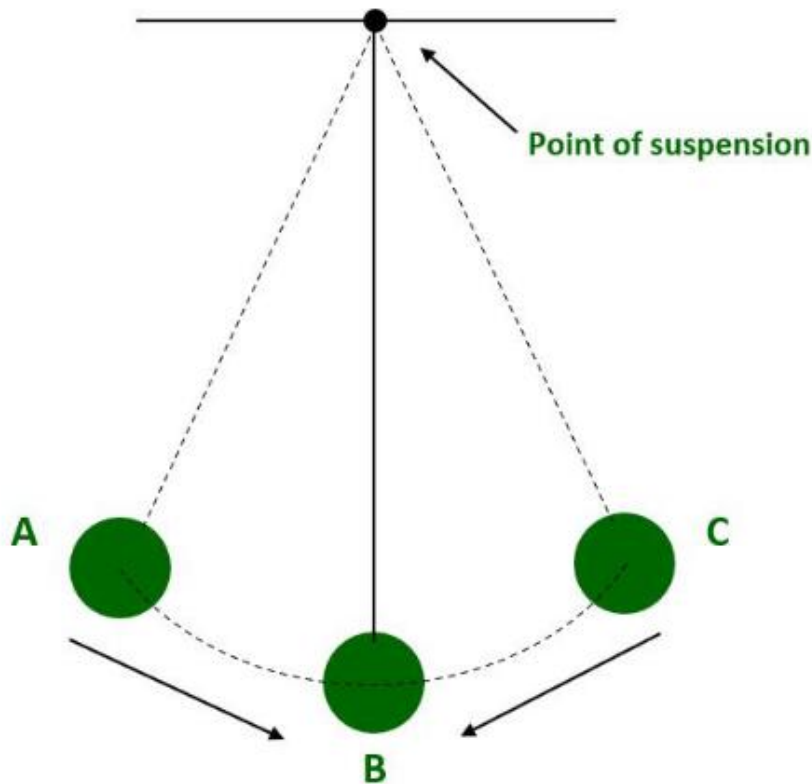


Fig 2.2. Energy of a Simple Harmonic Motion of a simple pendulum

At A or C, where the bob momentarily comes to rest, total energy is potential energy =  $mgh$  where  $h$  is the height of C above the equilibrium point B,  $m$  is the mass of bob and  $g$  is acceleration due to gravity. At B, where the speed of the bob is maximum and  $h$  is zero, all energy is kinetic ( $=\frac{1}{2}mv^2$ ).

Thus, we can find the maximum velocity of the motion by equating maximum K.E. to P.E.

$$\frac{1}{2}mv^2 = mgh, v = \sqrt{2gh}$$

At other positions of motion, the K.E and P.E. each contribute energy where the sum is always equal to  $mgh$ , the maximum potential energy

## **2.2 Theoretical Framework**

### **2.2.1 Constructivist Learning Theory**

Constructivist learning theory provides the theoretical framework upon which this study is based.

The constructivist theory was proposed by Bruner, in 1960 to describe the active nature of learning.

Constructivist is a model used to explain how people acquire knowledge. To explain constructivist learning theory, three key principles were identified as: personal experience, active learning and social interactions<sup>128</sup>.

- **Personal Experience**

The belief is that learners construct knowledge based on experiences they have encountered in the real world. Learners are actively creating and modifying thoughts, ideas and understanding based on their experiences<sup>128</sup>. Knowledge does not look the same for every individual. It is unique and exists in a variety of formats. To foster this type of learning environment, teachers that utilize constructivist design theory present students with problems and activities that are relevant and meaningful to them

#### • **Active Learning**

In an active learning environment, learners are more than passive recipients of information. Learners are actively engaged in their learning by solving problems and analyzing complex questions<sup>128</sup>. Often times, the phrase “learning by doing” is associated with this type of learning environment<sup>129</sup>. Teachers create active learning environments by employing instructional models such as cognitive apprenticeship and project-based learning<sup>129</sup>. In addition, because the active learning activities that learners engage in are grounded in realistic and relevant contexts, assessments reflect that, instead of focusing on rote memorization techniques often associated with standardized tests, authentic assessments are often used

#### • **Social Interaction**

The process of interacting with peers as well as the teacher helps learners” construct new understanding or reflect on their existing ones, simply because the experiences of individuals are different, social interactions allow learners to hear other perspectives and ideas<sup>130</sup>. Through these interactions learners must work to make sense of the new ideas presented as they consolidate new information with their own experiences<sup>128</sup>. To foster this type of learning environment, the teacher’s primary role is to serve as a facilitator or guide<sup>131</sup>. The teacher should create a collaborative learning environment in which students feel comfortable sharing ideas and having discussions. Often times, group projects are a key component of constructivist design theory.

The basic idea is that problem solving is at the heart of learning, thinking and development. As people solve problems and discover the consequences of their actions through reflecting on past and immediate experiences, they construct their own understanding. Learning is thus an active process that requires a change in the learner. This is achieved through the activities the learner engaged in, including the consequences of those activities and through reflection<sup>132</sup>.

Constructivists believe that prior knowledge impacts the learning process. In trying to solve novel problems, perceptual or conceptual similarities between existing knowledge and a new problem can remind people of what they already know. This is often one's first approach towards solving novel problems. Information not connected with a learner's prior experiences will be quickly forgotten. In short, the learner must actively construct new information into his or her existing mental framework for meaningful learning to occur. According to the theory, students build new knowledge into cognitive structure (schemata) <sup>133</sup>.

A typology was developed to analyze the learning impediments in terms of prior knowledge<sup>134</sup>. It was suggested that, if students do not have appropriate prior knowledge, intended learning cannot take place. This kind of learning impediments was labelled a 'null learning impediments. This 'null' means that students do not have or at least do not seem to have prior knowledge that is assumed to be what they have learnt from the prior instructions and where they start to build new knowledge. In order to teach any subject successfully in the classroom, teachers should be aware of what students' prior knowledge is, and how it affects teaching and learning<sup>135</sup>. The role of prior knowledge in teaching and learning can be considered as both foundation for learning and barrier to understanding<sup>135</sup>. "It is commonly believed that having prior knowledge serves as the basis for further learning". It is important for the curriculum to be organized in a spiral manner, allowing students to continuously build upon what they have learned in the past <sup>136</sup>. It has been stated that the spiral curriculum aids in students' mastery of material by having them review the same fundamental concepts in various learning contexts based on their level of readiness for learning<sup>137</sup>. The current

curriculum in our educational settings is a reflection of those ideas. As a result, it is structured in a way that progresses from simple to complex, from general to detailed, and from concrete to abstract, ensuring that students consistently learn the fundamental ideas in every subject as they advance from lower to higher grades. Students are able to acquire certain prerequisite information and skills as a result. Students are able to acquire certain prerequisite information and skills as a result. Because of the required sequencing, students can make connections between each lesson as they progress upward in their study. When new skills and knowledge are added in subsequent lessons, they complement what has already been learned and establish connections with previously taught material. The student gains a comprehensive understanding of interconnected topics, which is not possible in curricula that treat each topic as separate and isolated<sup>138</sup>.

Learning becomes meaningful only after the new materials are well connected with existing related knowledge or schemata. Individual can only learn if her / his conceptual schema provides the framework upon which to fit new knowledge<sup>139</sup>. The more the information a learner acquires, the more the schema changes in terms of scope and structure of the network. On the contrary, learning conflict occurs if there is a contradiction between the existing schema and new ideas, forcing the learner to consider whether to reject the new idea or discard the old<sup>140</sup>. For effective learning therefore, it is important to draw upon relevant previous experiences of learner in teaching new materials. In this sense, prior knowledge refers to the knowledge that students have acquired from previous lessons before receiving further instructions. In other words, existing knowledge serves as the basis for subsequent learning and should be acquired before being taught new material. Students' normal pre-instructional knowledge and a thorough conceptual examination of the subject to be taught should be the foundations upon which the teaching sequence is built. This approach allows for the identification of curriculum goals and the creation and evaluation of instructional activities<sup>141</sup>.

Therefore, what has already been learnt is crucial to any meaningful learning. For there to be any meaningful learning, the student must have some prior information that is relevant, and the

teacher must draw the required connection to assist the student understand the importance of that knowledge. If one of these conditions is not met, rote learning will occur instead of meaningful learning<sup>142</sup>. Similarly, a great deal of cognitive learning theorists stresses the beneficial connections between what has been learned and what still needs to be learned. They contended that because knowledge is linked in logical and psychological ways, appropriate arrangements and presentations would increase the likelihood of learning to transfer vertically and sequentially<sup>143</sup>. This implies that learning cannot take place without any previous knowledge. "In brief, our prior knowledge plays a crucial role in determining what we learn from our experiences."

Many studies have been carried out to investigate the effect of prior knowledge on students' achievement and attitude, mostly in the tertiary institutions. Some of the studies found positive relationships between prior knowledge and achievement<sup>144, 145</sup>. It was also reported that, there was no significant effect of prior knowledge on achievement<sup>146</sup>. Students with high prior knowledge in the content area had higher content knowledge gain at the end of instruction, while on the other hand, students with less prior knowledge had higher content knowledge gain at the end of their study<sup>147, 148</sup>. The theory played a crucial role in this study by providing guidance to the researcher on the necessary steps to follow during instruction. This included planning, organizing, implementing, and evaluating the instruction throughout the experiment. It also helps the researcher to arrange the materials sequentially from known to unknown so that the teaching of productive skills in Simple Harmonic Motion through the application of constructivist-based learning will enhance effective teaching and learning processes and enhance senior secondary school Physics students' performance and also, since the study is building on the prior knowledge of students to make learning meaningful.

The application of Predict-Observe-Explain and Virtual Laboratory techniques is also within constructivist active learning, which involves students actively participating in the teaching and learning process. These strategies also have its activities built on critical assessment of students'

needs to determine instructional goals. The needs assessment involves a critical appraisal of students' prior knowledge, just as advocated by constructivists

## **2.3 Review of Empirical Studies**

### **2.3.1 Virtual Laboratory and Students' Attitude to Physics**

Virtual laboratories encourage student participation in their learning and provide them the chance to more readily grasp challenging ideas. Reviewing empirical studies on virtual laboratories, it was discovered that, in comparison to traditional laboratory methods, virtual laboratories had a positive effect on students' achievements and attitudes<sup>149</sup>. Attitude is a predisposition to respond positively or negatively to a given subject<sup>150</sup>. Several studies have reported that students prefer working with simulation programmes.

A study was conducted to investigate how undergraduate Chemistry students responded to a computer-based learning environment called Simulation Laboratory. The study found that students enjoyed working with Simulation Laboratory as it was motivating and provided a lot of experience. They also believed that this experience could be remembered more easily<sup>151</sup>. Research stated that students preferred the Chemistry virtual laboratory over the physical laboratory<sup>152</sup>.

A study was conducted to compare the efficacy of virtual laboratory with the physical laboratory method in teaching Physics practical to secondary school students. The study reported that the virtual laboratory method had a positive impact on students' achievements, retention, and attitudes. In comparison to the physical laboratory method, the virtual laboratory method proved more effective<sup>153</sup>. "One's attitude has an impact on their academic performance. If a student has a positive attitude, it can enhance their academic performance. Conversely, a negative attitude can lead to poor academic performance. Having a positive attitude is usually the key to successful learning. One of the variables that affects the learning of Physics is the attitude of the students. This means that a positive attitude towards Physics could improve academic performance, whereas a negative attitude may contribute to poor performance.

The responsibility of every Physics teacher is to develop positive student attitudes towards the subject. Without a positive attitude, students may struggle to learn effectively, or may not learn at all. Active student involvement enhances positive attitudes towards learning. The Physics practical serves as a valuable instrument for advancing a nation's technology. It is important for teachers to help students develop a positive attitude towards practical Physics. According to a study, there is a significant correlation between students' attitudes and their academic performance in Physics<sup>154</sup>. Having the right attitude is essential for a better understanding of the concepts in practical Physics. In order to keep up with the constantly evolving field of science, it is important to have a positive and proactive approach towards practical activities. During practical classes, students' attitude affects their behavior, availability, readiness, and interaction. The attitude of students towards Physics practical can significantly impact their performance. Students' attitudes toward Physics as a science subject can be improved as a result of the interactive and manipulative effects of the apparatus by students in Physics practical activities using computer interface through virtual laboratory, which is one of the modern teaching strategies of teaching science<sup>155</sup>.

Attitude is a determining factor in Physics achievement, according to studies, and it predicts achievement. For example, studies have found that students' positive attitudes toward Physics had a positive effect on their academic achievement on high school and college students<sup>156</sup>. Students' attitudes, together with context and knowledge, are one of the factors that determine student competency<sup>157</sup>. 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<sup>158</sup>. 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<sup>158</sup>. Learning is challenging when one has a negative attitude toward a subject<sup>158</sup>. Different studies have

shown no significant difference in achievement based on attitude. According to a study conducted on freshman Physics students, their attitudes towards Physics did not significantly predict their Physics achievement<sup>159</sup>.

Furthermore, a study employing affective questionnaires and conceptual tests in the field of microscopy examined the effects of combining the use of a virtual laboratory and a research laboratory on the knowledge, interest, and attitudes of university students<sup>160</sup>. The findings showed that students might benefit from combining virtual and research laboratories to boost their learning beyond what either experience could provide alone, with the whole being larger than the sum of its parts. In research conducted on 45 female students and 45 male students from three secondary schools in Minna, Nigeria. It was found out that learning using computer simulations was able to change the attitudes of students to be more motivated towards Chemistry subject<sup>161</sup>.

A study about changes in attitudes towards Chemistry among 238 Kenya students also found that computer simulations can change attitudes and motivate students to learn Chemistry<sup>162</sup>. Due to the rapid changes in science and technology in today's world, new methods and techniques are needed in science teaching. One of the most important teaching techniques is experimental techniques. This technique involves all the senses and enables learning to be more meaningful. This technique will be more effective if students' attitude towards science is more positive. The uses of Virtual Laboratory in experimental techniques have led to greater achievement and improve students' attitudes toward Chemistry. Virtual Laboratory experiments have a big role in education by providing a genuine interactive model for students. Therefore, it is proposed that virtual experiments can be used in different contexts and steps<sup>163</sup>.

A survey among students regarding the application of Virtual laboratories in the Physics course, mainly related to circuits, electric fields, magnetic fields was carried out<sup>164</sup>. The Circuit laboratory software was used as the training environment. Students listed their positive and negative views on them. Among the positive gains listed were the opportunity to re-conduct experiments, to design new

experiments, the satisfaction when working on a personal computer, the opportunity to conduct experiments individually, having fun, among others. Among the negative experiences were not being in a physical environment and also some students were having difficulties using the laboratory.

A study investigated the application of Virtual Laboratory for Mechanical Engineering and Fluid Mechanics education in India<sup>165</sup>. Feedback was taken from the students and analyzed. The results showed that 96% of the students were happy with the Virtual Laboratory experiments and 80% stated that VL shows the limitations of conventional laboratories. However, it should be mentioned that in courses such as Fluid Mechanics it is hard to observe some concepts in a real scenario, while Virtual laboratories have no such limitations. The study also investigated the students' opinions regarding the ease of implementation of Virtual Laboratory, the substitution of real laboratory with Virtual Laboratory, and the integration of Virtual Laboratory in the course curriculum, which was generally positive.

A study presented the results about the implementation of Physics education using a low-cost Virtual laboratory and for Bachelor's degree students<sup>166</sup>. After the training, a survey was used to assess the student's opinions. The results showed that 53% of the respondents were very satisfied and 36% were dis-satisfied. The study, also investigated 15 questions, regarding the students' motivation, ease of access, expectations and benefits. The study investigated the effectiveness of virtual and microcomputer-based laboratories using a questionnaire.<sup>167</sup> The results showed that most students found both approaches useful and easy to use. Furthermore, they were positive in their attitude and willingness to use them.

Another study examined the effectiveness of virtual experiments on the students' attitude and practical skills<sup>168</sup>. During the investigation, video materials, excel sheets, and simulations were used. A control and an experimental group were used in order to assess the effect and their results were assessed with a test. The results from the analysis showed that there is no statistical difference in the obtained results, according to the study virtual instruments are as good as face-to-face traditional

instructions. Another interesting result is that 60% of the students were initially stressed during their first virtual experiment, while the level of stress and anxiety decreased significantly during the 2nd and 3rd experiments as the students became familiar with the teaching methods.

A study investigated the role of Virtual Laboratory as massive open online courses<sup>169</sup>. The study compared results of 2019 pre-COVID students and of the 2020 students that used remote learning. It also used survey-obtained data to assess the 2020 students' opinions. The results showed that 95% of the students agree virtual laboratory could be used in the absence of an instructor. Even though 79% of the students answered that virtual laboratory helped them in learning practical aspects of equipment laboratory, experience, and analysis of results, 81% of them were quite convinced that Virtual Laboratory can replace real laboratory. They also stated that the application of Virtual Laboratory requires knowledge of computer usage and 24% of the students suggested that Virtual Laboratory should be used as a pre-laboratory learning material and 36% as self-learning material.

A study revealed the results about six laboratories for the degrees of Civil, Mining, Geology, and Petroleum Engineering that were virtualized using 3D models<sup>170</sup>. Students' and trainers' opinions about the advantages and disadvantages of the VL were obtained using questionnaire. More than 63% of the students agreed that VL are easy to use and 52% stated that they are useful for learning. The lecturers were more in favour of the VL as 77% agreed with the above two statements. A computer simulated pre- laboratory, which aimed to prepare students cognitively to real laboratory activity about acid- base titration was developed<sup>171</sup>. As a result of their study, it was concluded that the experimental group of students showed a positive attitude towards learning.

Having the right attitude is essential for a better understanding of the concepts in practical Physics. In order to keep up with the constantly evolving field of science, it is important to have a positive and proactive approach towards practical activities. During practical classes, students' attitude affects their behavior, availability, readiness, and interaction. The attitude of students towards Physics practical can significantly impact their performance. Students' attitudes toward Physics as a

science subject can be improved as a result of the interactive and manipulative effects of the apparatus by students in Physics practical activities using computer interface through virtual laboratory, which is one of the modern teaching strategies of teaching science<sup>172</sup>.

### **2.3.2 Virtual Laboratory and Students' Academic Achievement in Physics**

Several studies have been carried out about whether virtual laboratory or traditional laboratory experiments are more effective on students' achievement about science courses (Physics inclusive). An investigation was conducted to compare the achievement of students instructed using hands-on Chemistry laboratory versus those instructed using a Virtual Chemistry laboratory<sup>173</sup>. There was no significant difference in achievement gain scores between students who used traditional laboratory and those who used virtual laboratory. The study showed that students who completed the traditional hands-on experiment performed equally as well as those who completed the virtual experiments. The performance of chemical engineering students on a test measuring underlying principles was not significantly different when compared with the performance of virtual and physical equipment for measuring heat exchange, mass transfer, and humidification<sup>174</sup>. There is no significant difference between virtual and physical experiments on tests of conceptual understanding as reported for students designing a car or for undergraduates learning about heat and temperature for measures of inquiry skills<sup>175</sup>. Studies carried out found no significant difference in virtual and physical experiments for students investigating the behavior of springs<sup>176</sup>. These studies illustrate that, for acquiring conceptual knowledge, virtual laboratories may replace physical ones. These studies also suggest that tactile information does not appear to be a requirement for the development of conceptual knowledge or inquiry skills with the exception of students, especially young children who do not have previous relevant physical experience with the phenomenon or concept under study; for example, it was found that young children (aged 5 to 6) learning about the working of the balance beam gained more knowledge from physical laboratories than from virtual laboratories<sup>176</sup>. On the other hand, some other studies reported that computer simulations are more effective. Many studies

show the advantages of virtual interactive exploration of unobservable phenomena compared with physical experiments of observable phenomena. For example, university students who investigated simulated electric circuits showing moving electrons acquired more conceptual knowledge than those using physical materials<sup>177</sup>.

Similarly, students using virtual optics materials displaying light rays outperformed those using physical materials<sup>178</sup>. Studies showed that virtual experiments can enable students to use complex inquiry practices to separate variables that might be difficult to use in physical experiments. The idea that virtual experiments support the acquisition of conceptual knowledge because they produce clean data is also supported in research. For example, first-year secondary students conducting virtual Physics experiments outperformed those using a physical laboratory on conceptual understanding, which was partly explained by the data produced by the physical laboratory<sup>179</sup>. Many studies have found positive effect associated with technology aided instruction<sup>180</sup>. Students' knowledge level and achievement in science were examined through the use of multimedia and computer animations<sup>181</sup>. Computer simulations were found to produce better results than conventional methods for teaching students.

Also, Research was conducted on the effect of the virtual laboratory on students' attitudes and achievement in Chemistry<sup>182</sup>. The study utilized a quasi-experimental design, specifically the pretest and posttest experimental-control-group model. Two scales were used in the study: a 15-item knowledge scale (KS) questionnaire. The sample population consisted of 341 high school students. Two different t-test were conducted during the study. The study indicated that virtual laboratory applications have a more significant impact on student achievement compared to traditional teaching method.

The effect of virtual laboratories on student learning and motivation in science laboratory instruction was assessed<sup>183</sup>. The results indicated that the interaction effect of time point and

laboratory order group on motivation and quiz scores was not significant. The achievement of a Virtual Science Laboratory (VSL) on middle school students' cognitive knowledge, skill development, and attitudes toward science was explored<sup>184</sup>. The findings of the study revealed that students' cognitive knowledge and attitudes toward science were positively changed as expected. However, the results from paired sample *t*-test found no statistical significance. However, the result of the research conducted revealed statistically significant differences in students' achievement defined by averages on quiz scores in virtual laboratories compared with traditional face-to-face laboratories and traditional laboratories<sup>185</sup>. The result is also in conformity with the similar study that investigates the ways in which the unique perceptual-motor features of science laboratory environments can affect students' learning<sup>186</sup>. The study employed several different measures to answer the research questions, including concept tests and interviews. The findings indicated that the perceptual-motor features of science laboratory environments did indeed shape learners' understanding of the underlying science concepts. Similarly, the findings indicated that Virtual Laboratory had higher learning outcome than the traditional laboratory, however there was no significant difference in either of the laboratory instructions<sup>187</sup>.

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<sup>188</sup>. 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<sup>189</sup>. 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<sup>190</sup>. A virtual Chemistry laboratory was created and tested with experiments on students<sup>191</sup>. 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<sup>192</sup>. 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. The study found that in order for students to be familiar with the actual processes involved, they should at least watch the operations through a virtual laboratory before doing the practical lesson in a real laboratory. Because some of the chemical experiments are risky and call for a great deal of care and safeguards, this will significantly lower the likelihood of mishaps. A study on the academic performance of students in Chemistry using the Chemistry Virtual Laboratory<sup>193</sup>. 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.

Also, a comparison is made between the effectiveness of a physical Chemistry laboratory and a virtual Chemistry laboratory with respect to science students' understanding of science processes and skills in Chemistry experiments<sup>194</sup>. The Science Processes and Skills Mastery Test (SPST) was the instrument used. The design of the research was quasi-experimental with a non-equivalent control group. A total of 147 people were selected to participate in the study. Science processes and skill

mastery in Chemistry experiments involving confirmatory tests for cations and anions were also effectively addressed by the Virtual Chemistry Laboratory, as evidenced by the two-way ANCOVA analysis that showed higher performance but no significant difference between those taught in physical and virtual Chemistry.

Furthermore, the results indicated that Chemistry learning through the virtual Chemistry laboratory is not influenced by gender. Comparable results from numerous researches on the effectiveness of virtual Chemistry laboratories for teaching practical Chemistry have also been demonstrated<sup>182, 189</sup>. Numerous researches were able to obtain a study about the Virtual Chemistry Laboratory in the Nigerian context<sup>195</sup>. The impact of combining real and virtual Chemistry laboratories was investigated in this study. Chemistry Practical Achievement was the instrument used. Students were asked to perform volumetric analysis and respond to questions. The results showed that students' performance was much higher when they used both virtual and real Chemistry laboratories, as opposed to when they solely used real laboratories. Thus, it is more advantageous to conduct Chemistry practical using a virtual laboratory in addition to a real one in order to improve student comprehension and performance. Thus, in schools having a real Chemistry laboratory and those without, the virtual Chemistry laboratory might be used as a support system and supplement, respectively. Based on the aforementioned studies, it can be concluded that providing virtual Chemistry laboratories to supplement the current laboratories in Nigerian secondary schools would address issues with inadequate space, laboratories overcrowding, student vandalism, and safety concerns when conducting risky experiments.

### **2.3.3 Predict-Observe-Explain Instructional Strategy and Students' Attitude to Physics**

In the field of education, various methods have been embraced with the aim of attaining educational objectives<sup>196</sup>. Instead of teacher-centered traditional approaches, the constructivist approach, in which learners construct knowledge through their own decisions, has been adopted especially in science education<sup>197</sup>. In other words, societies reorganized their educational programs was by implementing

the constructivist approach, in order to adapt to the changes in science and technology<sup>198</sup>. In this respect, great importance has been given to various models for the implementation of the constructivist learning approach in recent years<sup>199</sup>. Predict-Observe-Explain (POE) strategy is one of the methods suitable for constructivist approach and aims to identify and eliminate students' misconceptions and increase the comprehension level of them<sup>196</sup>.

A study investigated the effects of predict-observe-explain strategy on students' academic achievement, scientific process skills and attitude towards science<sup>197</sup>. In this semi-experimental research design, 17 students were in the control group and 15 were in the experimental group, for data collection, three different scales were used. The scales were administered to all participants at the beginning and at the end of the implementation. The experimental group was exposed to POE during their lessons for six weeks and the control group received regular instruction which is suggested by the Turkey Ministry of National Education. The results revealed that students in the experimental group had significantly higher scores than the students in the control group in terms of academic achievement and scientific process skills. However, no difference was observed in their attitude towards science.

Another study investigated, the effect of the Prediction-Observation-Explanation (POE) method on learning of image formation by a plane mirror and pre-service teachers' opinions<sup>198</sup>. The research involved 20 pre-service science teachers studying at the Department of Science Education in Turkey. A one group pretest–posttest design was used. In the teaching process, carried out in accordance with the POE method, the pre-service teachers made their own plane mirror by using glass and mirror-effect spray paint, and then analyzed the image of a cube by using these mirrors. It was found that the POE method is effective in the learning of image formation by a plane mirror. 13 (65%) pre-service teachers expressed only positive opinions about making a plane mirror by using glass and mirror-effect spray paint; seven (35%) pre-service teachers expressed both positive and negative opinions. The entertaining production process (learning by practicing that mirrors can be made from

glass) and gaining experience (like preparing material, learning, and implementing safety rules) were the most common positive opinions, although the irritating smell of the spray paint was the most common negative opinion. 17 (85%) pre-service teachers expressed positive opinions and 3 (15%) pre-service teachers expressed both positive and negative opinions on the organized activity in accordance with the POE method. In consideration of the obtained positive and negative opinions, it was found that teachers could do such activities to provide a better learning environment.

Also, research was carried out on the effects of POE Learning Model and Achievement Motivation on the Spiritual and Social Competence of Madrasah Tsanawiyah (MTs) Students in Social Studies<sup>199</sup>. The study's objectives are to ascertain the impact of the learning models Predict Observe Explain (POE) and achievement motivation, which are used in the experimental class, and Direct Instruction (DI), which is used in the control class, on the material excellence and barriers among students with regard to the social and spiritual competency of Madrasah Tsanawiyah (MTs) students. The research is based on a scientific-based learning model in Social Studies learning to improve the spiritual and social competence of students facing the 21st century. The research was conducted at MTsN 9 Kediri with sampling techniques using simple random sampling. Data collection techniques using questionnaires and observations. The achievement motivation instrument uses LAMB (achievement motivation questionnaire sheet). While the spiritual and social attitude competency instruments use LOKSS-S (observation sheet of spiritual and social attitudes). Research tools using syllabus, RPP, textbooks and LKS. The results of the hypothesis study show: 1) that the significance value that follows the POE and DI learning model is 0.785, which means that it is non-significant. It is evident from this that students who use the DI learning model and those who use the POE learning model have the same level of competency in their spiritual and social attitudes.; 2) a significance value of 0.169 means non-significant. This demonstrates that there is no distinction in the competence of students' spiritual and social attitudes between those who have low achievement motivation and those who have high achievement motivation; and 3) significance value of 0.494

means non-significant. This shows that there is no interaction between learning models (POE and DI) and achievement motivation (low and high) on the competence of students' spiritual and social attitudes. The conclusion of hypotheses 1, 2 and 3 is to accept  $H_0$  and reject  $H_1$ .

The investigation of how a POE-based laboratory teaching affected pre-service science teachers' conceptual knowledge of photosynthesis and plant respiration as well as their views toward general Biology laboratories<sup>200</sup>. Participating in the study were 122 preservice elementary teachers who completed the General Biology Laboratory course. Data were gathered using a two-tier concept test about photosynthesis and respiration in plants as well as an attitude scale about Biology laboratories. The results indicated that employing the POE approach in laboratory instruction proved to be a successful method for enhancing comprehension of concepts and fostering positive attitudes towards Biology laboratory.

A research study explored how pre-service science teachers' attitudes towards teaching science were impacted by engaging in activities focused on plant growth and development using the POE approach<sup>201</sup>. Seventy-four pre-service science teachers in second grade participated in the study. The experimental group engaged in POE activities, while the control group followed a traditional teacher-centered approach. The findings indicated that views about science teaching were significantly different in favor of the experimental group compared to the control group. Additionally, the pre-service science teachers reported that they would incorporate POE activities into their lessons because they were happy, felt better about themselves, and found them to be productive.

The POE activity "Water can be boiled with ice" was developed<sup>202</sup>. A total of 44 pre-service Chemistry teachers participated in this activity. Data was collected through observations and interviews. The results showed that POE activities promoted preservice science teachers' attitudes toward chemistry, their interest and motivation for the subject.

Additionally, an extensive study has been conducted <sup>203</sup>. The POE tasks used in general chemistry lessons concern gases and are designed to correct preservice elementary teachers' alternative concepts and promote their attitudes towards Chemistry lessons. The data collection methods used were a gases concept test, an attitude scale toward chemistry, as well as POE worksheets. A total of eight POE activities were applied for three weeks in the experimental group, and the gases subject was taught using the traditional approach in the control group. The POE was discovered to be a successful strategy for enhancing the academic performance, conceptual grasp of the topic of gases, and attitude toward Chemistry of pre-service elementary teachers.

A study of the understanding and attitudes of Chemistry Laboratory Pre-Service Elementary Teachers regarding the Predict-Observe-Explain tasks was investigated<sup>204</sup>. The purpose of the study was to examine how pre-service elementary teachers' understanding and attitude towards Chemistry lessons and laboratory work were impacted by engaging in predict observe-explain tasks centered on Mixtures, Physical and Chemical Changes, and Acids and Bases. For this objective, the pre-service elementary teachers were assigned at random to the experimental group (N=26) and control (N=30) groups. The participants in the experiment were given laboratory tasks that involved predicting, observing, and explaining, while the control group received traditional laboratory activities designed like a cookbook. This instruction lasted ten weeks. Before and after the instructions, a two-tier concept test, as well as attitude scales for Chemistry lessons and Chemistry laboratories, were used to collect data. The findings revealed that pre-service elementary teachers who underwent training involving laboratory activities centered around the Predict Observe-Explain task achieved significantly higher scores in both their understanding and attitude towards Chemistry lessons and laboratory work compared to those who were taught using the traditional approach. The study also discovered that using the Predict-Observe-Explain method for laboratory tasks was more effective in correcting pre-existing misconceptions.

The effect of Prediction, Observation, and Explanation Supported Project-Based Environmental Education on the levels of attitude and behavior toward the environment was investigated<sup>205</sup>. The study aims to determine the effect of Prediction, Observation, and Explanation Supported Project Based Environmental Education (POESPBEE) on the attitudes and behaviors levels of eighth grade students compared to teacher-centered environmental education. The study used a quasi-experimental research design including pretest posttest and control group. The application step of the study was carried out by the researchers in a 10-week period in 2018-2019 academic year. The study group included 62 students, 34 of whom were in the experimental group and 28 of whom were in the control group. The experimental group was applied the Prediction, Observation, and Explanation supported Project-Based Environmental Education (POESPBEE) and the control group was applied teacher-centered environmental education. Attitude scale toward environment and behavior scale toward environment were administered as pre-test, post-test and follow-up test to evaluate the attitude and behavior levels of the students in the experimental and control groups toward the environment. Data were analyzed using the independent samples t-test and repeated measures ANOVA. The study found that the Prediction, Observation, and Explanation supported Project-Based Environmental Education (POESPBEE) provided a significant development on students' attitude and behavior; however, teacher centered environmental education could not provide a significant development on the students. Based on this result, it can be claimed that the methods like the Prediction, Observation, and Explanation supported Project-Based Environmental Education (POESPBEE), which can change individuals' attitudes and behaviors toward the environment in positive way, should be used in environmental education.

A study indicates that implementing the Predict-Observe-Explain (POE) strategy has a beneficial impact on students' academic performance and their attitude towards Physics<sup>206</sup>. This study used a pretest-posttest experimental research design to examine the impact of the Predict-Observe-Explain (POE) Strategy on students' achievement and attitude toward Physics. In this study, 59

seventh-grade students from two intact heterogeneous classes took part. The significant differences in attitude and achievement between the two groups as well as within each group were found using the t-test. The findings of the study showed a significant difference in the achievement scores of the two groups in the posttest. Furthermore, it was discovered that, although the control group continued to have a neutral attitude toward physics, the experimental group significantly changed their attitude toward the subject and outperformed them in the posttest.

#### **2.3.4 Predict-Observe-Explain Instructional Strategy and Academic Achievement in Physics**

Student achievement is directly correlated with the teaching strategies used in the classroom; therefore, if the subject matter is taught using the most appropriate method, it is likely that students will likewise demonstrate a high level of success in the learning area<sup>207</sup>. The POEI strategy has proven to be highly effective in science education due to its emphasis on hands-on learning. This approach encourages students to actively engage in investigations and develop their own understanding of scientific concepts<sup>208</sup>. Additionally, it is considered a suitable instrument for exploring students' initial thoughts or existing notions<sup>209</sup>. The effectiveness of the conducted studies in reducing students' misunderstandings in chemistry has been confirmed<sup>210, 211</sup>.

Additional research has demonstrated the positive impact of the POE strategy on students' academic success in science<sup>212</sup>. For example, a study focused specifically on the Chemistry achievement of secondary school students found that the implementation of the POE strategy resulted in improved outcomes<sup>213</sup>. The effectiveness of the POE strategy in promoting student engagement and facilitating classroom discussions is well-documented in the study<sup>214</sup>. This confirms its positive impact on enhancing practical skills in Basic Science among elementary students. The research carried out has confirmed the success of using the POEI approach to enhance the abilities and engagement of aspiring science teachers when it comes to conducting experiments in the laboratories<sup>215</sup>.

A recent Physics study found that implementing the POE strategy resulted in enhanced student interest and achievement in the subject<sup>216</sup>. Based on the study, elementary school children' academic performance and attitude toward science are improved when this technique is used<sup>217</sup>. These include the research that demonstrated the value of metacognition in science achievement through the Predict-Explain-Observe-Explain Approach (PEOE) and the study that validated the efficacy of the Predict-Observe-Explain-Explore Strategy (POEE) in general Chemistry instruction<sup>218</sup>.

The POE strategy was found to improve students' academic performance and attitude towards Physics in a study<sup>219</sup>. In this study, a quasi-experimental research design was employed to assess how the POE Strategy influenced students' achievement and attitude in Physics. This study involved the participation of 59 seventh-grade students from two intact heterogeneous classes. The control group was taught using the engage-explore-explain-elaborate-evaluate (5E's) learning cycle, while the experimental group was taught using the POE strategy. The t-test method was employed to identify any notable disparities in achievement and attitude between the two groups, as well as within each individual group. The study revealed indicated a notable disparity in the posttest achievement scores between the two groups. The findings indicated that the participants in the experimental group showed superior performance in the posttest compared to those in the control group. Additionally, the experimental group experienced a notable shift in their attitude towards Physics, transitioning from a neutral perspective to a positive one. In contrast, the control group maintained a neutral attitude throughout the study.

Another research was conducted to examine how the Predict-Observe-Explain and Virtual Laboratory Instructional Strategies impact students' performance in Physics practicals<sup>220</sup>. The research utilized a quasi-experimental approach, specifically the pretest posttest and control group design. The participants consisted of 74 Physics students in their second year of Senior Secondary school. These students were chosen randomly from three co-educational schools in Osun State, using a multistage procedure. The schools were chosen at random to form two experimental groups and one

control group. The participants in the experimental groups were subjected to the Predict-Observe-Explain and Virtual Laboratory Instructional Strategies, whereas the control group received instruction through the traditional laboratory approach. In order to gather pertinent information for this study, the researchers employed the Physics Practical Test (PPT) as their instrument. The PPT involved a practical examination with two simultaneous tests, namely alternative A and alternative B. The hypotheses put forth were examined using various statistical methods, such as, Analysis of Covariance (ANCOVA), Scheffe Post Hoc Analysis, and Multiple Classification Analysis (MCA). The study's results revealed a noticeable impact on the average scores of students' performance in all three groups, indicating a significant teaching effect.

The effects of the Predict-Observe-Explain instructional strategy on students' practical skills in Physics were investigated in another study<sup>221</sup>. For the research, the study utilized a pretest posttest quasi-experimental design. The study involved a sample of 213 SS II Physics students from six senior secondary schools in Ibadan, Nigeria. The Predict-Observe-Explain instruction yielded better results (adjusted mean = 33.37) compared to the traditional practical instruction (adjusted mean = 24.42).

Also, a study on the Influence of Predict Observe Explain (POE) Learning Model on Student Learning Outcomes was investigated<sup>222</sup>. The research was conducted using quasi-experimental design with pretest posttest control group design, the population of the research was XI grade students. The result showed that the learning outcomes of the experimental group 1 was better than control group in terms of cognitive, affective and psychomotor aspects. The results of t-test showed that there was a significant difference of posttest pretest value between experimental and control groups.

The implementation of Predict-Observe-Explain strategy with group investigation effect on students' critical thinking skills and learning achievement was carried out<sup>223</sup>. The study employed quasi-experimental design type control group pretest posttest and its instrument for assessing learning achievement was test, while critical thinking skills were measured with observation sheets. Data analysis techniques used were independent t-test, one tail(right) test, N-gain test, analysis of

observation sheet with checklist formular and Product Moment Correlation test. The outcome indicated that when the POE learning strategy was applied with the GI model, it had a notable impact on the academic performance and critical thinking abilities of the students. Critical thinking skills were also correlated significantly to students' learning achievements.

The study used a one group pretest posttest design to evaluate the effectiveness of the Predict-Observe-Explain Strategy in reducing misconception in Thermochemistry<sup>224</sup>. The sample is 33 students of XI MIA 4 at senior high school Kemala Bhayangkari 3. This research was conducted using three tiers diagnostic test for pretest and posttest. A pretest was conducted after students have a conventional learning process with their teacher. Posttest was conducted after the student had given a treatment using POE strategy. The result shows students' changing conception. Initially, student's conception was 21.03% and student with misconception was 57.12%. After implementation of the learning process using POE strategy the conception changing gradually becomes 93.5% and 4.61%, respectively. The conclusion of the study was that POEI strategy was effective to reduce misconception among the students. Another research done on using POEIS to facilitate changes in students' concepts in Heat energy and Earth energy was carried out<sup>225</sup>. The research used the quasi-experimental method with non-equivalent control group design. The sample comprising of 80 students was selected by using purposive technique sampling. The learning process in the experimental group used POE (Predict-Observe-Explain) based teaching strategy and in the control, group used conventional one. The instruments used are the Thermal Concept Evaluation (TCE) consisting of 20 multiple choice questions to measure students' conceptual understanding and observation sheet to observe the students' activities during the lesson. The conclusion is the POE (Predict-Observe-Explain) based teaching strategy was effective to improve learners' conceptual understanding on Heat and Temperature topics. Other studies conducted suggests that learning by using POE is better than traditional learning to straighten a misconception about salt solubility<sup>226</sup>.

Similarly, studies revealed that POE can improve students' understanding of concepts in Newton's legal material and research also shows that Predict Observe Explain (POE) strategy has effect on the change of mental model of primary pupils<sup>227</sup>. A study carried out to understand the effect of Predict-Observe and Explain (POE) strategy toward students' conceptual change about density of water indicated that conceptual changes in students given treatment using POE strategy were at the construction level 2%( students were able to construct their understanding), revision 84%(students were able to make improvements(revisions) to their initial understanding and static as much 14%(students cannot change their understanding to a better understanding)<sup>228</sup>. The respondents used in the study were 34 students on 5<sup>th</sup> grade pupils in one of the primary schools in Bekasi, while the research method was pre-experimental method and the design was one-group pretest-post- test design. The instrument used to view the level of students' conceptual change was a pretest and post-test with four –tiers diagnostic test. Test responses were modified to reflect the five levels of conceptual change: disorientation, complementation, construction, revision, and static. The results showed that majority of students experience conceptual change after learning the POE strategy

A study was carried out on relative effectiveness of Predict-Observe-Explain (POE) and lecture methods of teaching Basic Science on academic performance of secondary students in Akwa Ibom State, Nigeria<sup>229</sup>. Four research questions and four hypotheses guided the study. The research design was pretest posttest quasi-experimental design. The sample of the study was made up of 300 randomly sampled students from six public secondary schools in the State. The independent t-test statistical instrument was used in analyzing the data at 0.05 levels of significance.

The Predict-Observe-Explain strategy was used to investigate the understanding of electrochemistry concepts<sup>230</sup>. The study deals with freshman students who study at the Department of Science at the Faculty of Education in Amasya University, Turkey. The aim of the study was to investigate the effect of teaching electrochemistry concepts using Predict-Observe-Explain (POE) strategy. The study was quasi-experimental design using 20 students each in the experimental group

(EG) and control group (CG). Two research questions and two null hypotheses guided the study. An Open-Ended Test (OET) and Multiple-Choice Test (MCT) were used as pre and posttest, respectively. Mean ( $\bar{x}$ ) and Standard Deviation (SD) scores were used to answer the research questions, while Analysis of Covariance (ANCOVA) were used to test the hypotheses. The results of the study revealed that using Predict-Observe-Explain strategy significantly enhance students understanding in electrochemistry concepts than lecture method.

The effect of Predict-Observe-Explain (POE) technique on the understandings of grade 11 Chemistry students about the Gases in Trabzon was investigated<sup>231</sup>. Quasi-experimental research design was adopted in the study. Two classes in Anatolian high school in Trabzon were randomly selected for the study. One of the classes was randomly assigned as experimental group (N=36), the other was determined as control group (N=37). Gases Concept Test (GCT) consisting of 20 multiple choice items was used. Eight activities based on POE technique were developed and applied to the experimental group students. On the other hand, the control group students were taught by traditional approach. Mean and Standard Deviation score was used to answer the research question and ANCOVA was used to test the null hypothesis. The results indicated that the students in experimental group taught using Predict-Observe-Explain technique showed a higher success than the control group students.

The effects of Predict-Observe-Explain (POE) approach on Students' achievement and attitudes towards science was carried out<sup>232</sup>. This study was conducted in Gonzalo Gatchalian Elementary School in Las Piñas City. The participants of the study consisted of 220 in Gonzalo Gatchalian Elementary School in Las Piñas City. The instruments used for data collection were Science Achievement Test (SAT) and Learning Science Attitude Inventory (LSAI). The study was guided by three null hypotheses. The study employed the repeated measures two factors design. The dependent t-test was used for data analysis. The results revealed that the gain scores in the achievement and

attitude of students in the experimental group (POE approach) performed better than the control group (lecture method).

While previous studies have demonstrated the efficacy of the POE strategy in enhancing students' performance in science, the majority of these studies have primarily examined its effectiveness in Chemistry and elementary level Science. This study primarily sought to determine the effects of Predict-Observe-Explain and Virtual laboratory strategies on secondary school Physics students' attitude and achievement in Simple Harmonic Motion (SHM) in Ogun State. The Predict-Observe-Explain strategy can be a valuable tool for science teachers. By implementing this strategy, teachers can effectively engage their students in Physics classes, leading to greater success in the subject<sup>233</sup>. Additionally, this approach provides an opportunity for students to develop a genuine interest in Physics<sup>233</sup>.

### **2.3.5 Gender and Students' Attitude to Physics**

Attitudes toward science may also be influenced by gender, according to research in science education. A study has revealed that, of all the factors that could affect people's attitude about science, gender has consistently been found to have an impact<sup>234</sup>. Studies show that boys have more positive attitudes than girls when it comes to science, rather than a specific field<sup>235</sup>.

In many nations, there has been a problem with the attitudes that boys and girls have about Physics. In response to this, many researches have been carried out with mixed reports. An investigation has been conducted on the attitudes of secondary school students from various school types in Chennai, India toward learning science and their accomplishment in the subject<sup>237</sup>. Science attitudes were assessed using the attitude toward learning science scale, and marks were obtained from their half-year performance in Science<sup>237</sup>.

A study was carried out on, the effects of gender on students' attitude in Physics in senior secondary schools in Oyo State, Nigeria<sup>238</sup>. It was found that there was a slight difference in attitude among the students in favour of females in Physics. In the study to identify the relationship between

students' attitude towards Physics with their achievements in Physics<sup>239</sup>. The results showed that there is a relationship between attitude and achievement for female students but not for male students and also showed that there is no difference in attitude between male and female students towards Physics.

A study showed that male and female students who achieved high grades in Mathematics do not differ in terms of their attitudes towards Mathematics<sup>240</sup>. For Physics, female students who showed positive attitude obtained better results compared to male students. A study found that students' attitude towards science, especially the female students, decreased when they entered secondary schools<sup>241</sup>. Female students' attitude towards Physics was found to be below and that learning Biology was more enjoyable<sup>242</sup>. A study showed that there is a difference in terms of attitude dimension between male and female students<sup>243</sup>. Based on findings from the study of attitudes and achievement in Mathematics among indigenous African students majoring in Mathematics, there is no difference between attitude and gender<sup>244</sup>.

A study of exploring students' attitudes towards Physics and their association with gender was carried out<sup>245</sup>. The purpose of this study was to analyze gender differences in the attitudes towards Physics in the framework of the Semiotic Cultural Psychological Theory (SCPT). A view-of-Physics questionnaire was used as instrument to collect data with 1562 (723 females) high school students. Using multiple correspondence analysis and cluster analysis, four generalized meanings of Physics were identified: (a) interesting and important for society; (b) a quite interesting, but badly taught subject at school and not completely useful for society; (c) difficult to study and irrelevant for society; and (d) a fascinating and protective niche from society. The association between gender and the identified cluster was assessed by a chi-square test and it was reported that female high school students were more likely to view Physics as difficult and irrelevant to society. A study to Enhancing secondary school students' attitudes toward Physics by using computer simulations was investigated<sup>246</sup>. The study seeks to determine whether Computer Simulations could improve the attitudes of

Emirati secondary school students toward Physics. The study employed a quasi-experimental design that included 90 UAE 11th-grade students from two public schools in the City of Al Ain. The intervention included student engagement in the PhET interactive simulation of Newton's second law of motion. The study employed the Test of Science-Related Attitudes (TOSRA) questionnaire to collect data before and after the intervention for the experimental and control groups. The findings demonstrated statistically significant differences between experimental and control groups in students' attitudes toward scientific inquiry, enjoyment of science lessons, and career interest in physics/science. Furthermore, results showed a significant difference in attitudes perceived in these scales, with males having a more significant effect size than female students in all three scales. In a study of scientific attitudes: gender differences, impact on Physics scores and choices to study Physics at higher levels among pre-college STEM students<sup>247</sup>. The study examined the relationships between gender, scientific attitude (in terms of rationality, open-mindedness, confidence in the scientific method, curiosity, and aversion to superstition), Physics scores and students who chose to study college Physics. The study involved 641 K12 pre-college STEM students in India. The results revealed that girls have lower Physics scores and scientific attitude than boys. The Physics scores and scientific attitude have a strong correlation for girls compared to boys. Also, in a study of Impact of traditional or evidence-based active-engagement instruction on introductory female and male students' attitudes and approaches to Physics problem solving<sup>248</sup>. It was found that evidence-based active engagement instruction leads to better student attitudes towards Physics problem solving compared to traditional lecture, and female students exhibit less decline in these attitudes than male. The study of epistemological beliefs and attitudes towards Physics and Physics Learning among Malaysian STEM Students in Selangor was investigated<sup>249</sup>. The purpose of this study is to evaluate the epistemological beliefs and learning attitudes among Malaysian STEM students in Selangor towards Physics and Physics learning. The study identified 120 Malaysian STEM students who undertook Physics from a few schools in Selangor to participate in this research. This is descriptive

quantitative research. The Physics Epistemological Beliefs & Attitudes Test were developed. The findings of the study indicated that Malaysian STEM students possess highly sophisticated epistemological beliefs with the mean score of 72.61% and were favourable in learning Physics with the mean score of 74.29%, substantial differences in both tests were absent in between male and female students. However, significant differences between Form 4 and Form 5 students in epistemological beliefs as well as learning attitudes existed. Pearson correlation gathered shows that the relationships between the epistemological beliefs and learning attitudes among the students were high, positive and very significant.

A multidimensional study that involved approximately 4,000 students in Grades 6 through 10 found that boys exhibited significantly more positive attitudes about science than girls<sup>234</sup>. Within each grade level, this was true. Study results indicate that girls have more negative attitudes toward science than boys, but still have higher science grades<sup>250</sup>. A study of 1,200 students in Grades 4, 5, and 6 found that most students had a positive attitude toward science<sup>251</sup>. All grade levels experienced this. The experimental and control groups showed different attitudes toward sex<sup>252</sup>. It was found that boys had more positive attitudes toward science than girls in both groups. It was also reported that no gender differences with regard to attitudes toward science with gifted and average students<sup>253</sup>. It was found that girls showed less interest in physical science concepts<sup>254</sup>. It was explained that self-variables accounted for 38% to 55% of the variance in student's attitude toward science; family variables accounted for 13% to 19% of variance; and classroom environment variables accounted for 46% to 73% of the variance<sup>255</sup>. It has shown that students' attitudes and feelings toward science remain positive until the 6th or 7th grade<sup>256</sup>.

A study was carried out on students' attitudes toward Introductory Physics Course<sup>257</sup>. In the study, there were 176 students, and they were selected through convenience sample technique from Florida Institute of Technology, Melbourne, Florida of 125 male students, and 51 female students. The instrument used had 18 statements relating to measure students' attitude toward Physics. It was

found that there was a significance difference between male and female students' attitude toward Physics. Male students have more positive attitude toward Physics than female students. Also, the result revealed that there was a significance difference among the students' attitude toward Physics. A significant difference in gender between the cooperative and the noncooperative groups, with boys having more positive attitudes than girls, was found in the effects of cooperative learning on students' attitudes towards laboratory work<sup>258</sup>. The general view is that boys have a more favourable attitude towards science, than females. However, it is not always the case when studying specific scientific fields. Girls are said to have a more positive attitude toward Biology, while guys are said to be more favorable toward Physics and Chemistry<sup>259</sup>.

A study was conducted to investigate the impact of Biology laboratory experiences on high school students. The findings revealed a slight but unfavorable correlation between gender and attitude towards these experiences. In other words, it was observed that girls tend to possess a more positive attitude compared to boys<sup>260</sup>. A similar study was conducted in which the attitudes of middle school pupils from Kuwait to Science laboratory work were evaluated<sup>261</sup>. Girls were found to have more positive attitudes towards science laboratory work than boys<sup>261</sup>. However, in another study, it was found that male students recorded a much higher positive attitude compared to female students<sup>262</sup>. Male students, consistently, have a more positive attitude towards science compared to female students. This situation is prominent in Physics compared to in Biology<sup>263</sup>.

A study conducted at that Matriculation College showed that there is no gender difference in attitude towards teaching and learning of Mathematics<sup>264</sup>. It was found that female students lack interest in Physics compared to male students<sup>265</sup>. Compared to males, females have a more unfavourable attitude toward Physics. The female students argued that Physics is difficult for them because it tends to favour the male gender. Differences in attitudes between male and female students will lead to differences in achievement and readiness for attaining the educational objective<sup>266</sup>. The study conducted revealed that Physics and Mathematics are believed to differ from the innate

qualities associated with females, which are commonly associated with femininity<sup>267</sup>. Compared to female students, who are more favorable toward courses that are more feminine, like Biology, male students demonstrated a more positive attitude toward subjects that are perceived more masculine. Compared to female students, male students generally exhibit a more positive attitude toward Physics. They also have the inclination to choose a science and technical related career<sup>268</sup>.

Female students exhibit a more negative attitude than male pupils, based on a San Diego science study that included 148 students<sup>269</sup>. Male students are more likely to use science equipment and participate in science activities<sup>270</sup>. The results showed a negative view of science and careers in science by a higher proportion of female students<sup>271</sup>. The majority of female students believe that science classes are boring, and they only need to memorize facts to get good grades, whereas careers in science are thought to require a lot of work. Contrary to what has been known, no gender differences were found with regard to attitudes towards science among talented and average high school students<sup>272</sup>. It is difficult to determine whether there are gender differences in students' attitudes towards science, or whether there are gender differences in correlation between attitudes towards science and achievement in science, given the conflicting results from different studies. Hence, the need to examine the effect of gender on students' attitude in Physics

### **2.3.6 Gender and Students' Academic Achievement in Physics**

A number of research reports found divergent results regarding the influence of gender on males' and females' achievement in science. A study has been conducted to examine the impact of gender on junior secondary school students' academic achievement in Basic Science using cooperative learning teaching strategies<sup>273</sup>. The study involved 120 students selected from intact classes in three selected Junior Secondary Schools in three selected local government areas in Ogun State, South West, Nigeria. A quasi -experimental design was used for the study. In this study, the Achievement Test for Basic Science Students (ATBSS) was used to collect relevant data. In order to analyze the collected data, descriptive and independent sample t-test statistical methods were used.

The findings of this study indicate that there are no significant differences in academic achievement between male and female students at the pre-test, post-test, and delayed post-test levels.

Moreover, a study was conducted in Anambra State Secondary Schools to investigate the effect of gender and school location on students' Chemistry achievement<sup>274</sup>. Three research questions and three hypotheses guided the study. A total of 1889 responded were included in the study, including 844 males and 1045 females. Multistage sampling procedures were used to draw the sample. In answering the research questions, mean and standard deviation were used, while ANOVA was used to test the null hypotheses. For a step-by-step comparison of the means, a Scheffe test was also performed. The results of the study indicated that female students achieved more than male students, however the difference was not statistically significant. Students in senior secondary school participated in a study to examine gender disparities in computational Chemistry tasks<sup>275</sup>. A set of achievement test items, consisting of multiple-choice questions, was developed based on three topics covered in the experiment. A test was given to 400 SSII students who were selected at random from 20 secondary schools located in four local government areas of Delta State. Using the t-test at the 0.05 level of significance, two hypotheses were formulated and tested. Following a thorough analysis of the data, it was discovered that male students did not perform appreciably better than female students in computational problems in Chemistry.

A study on the impact of a constructivist teaching approach on the Physics achievement and self-efficacy of senior secondary school students was conducted<sup>276</sup>. One hundred and eighty-four students from four secondary schools, two boys and two girls, respectively, were employed in the study. A modified non-equivalent control group design was used. Five research inquiries were delineated and the study was directed by three null hypotheses. The research questions were answered using the mean and standard deviation, and the hypotheses were tested using ANCOVA. The academic achievement of students in Physics was discovered to be significantly impacted by their gender.

A study was conducted in the western senatorial district of Nassarawa State, Nigeria, to investigate the effects of gender and school location on the accomplishment of Science and Mathematics pupils<sup>277</sup>. The study was descriptive in nature and used a survey method to obtain information. Students in senior secondary schools in Nasarawa State made up the study's population. One hundred and ninety-eight (198) students made up the study's sample, and they were chosen at random using the random sampling technique. The study employed a questionnaire and achievement test as its instruments. Using frequency counts and t-test analyses, the data collected in the main study were analyzed. The significance level for testing the hypotheses was 0.05. The study's findings demonstrated that male and female pupils' academic performance in Science and Mathematics differed significantly.

An additional investigation was conducted to examine the disparities in gender when it comes to undergraduate students' use of information and communication technology (ICT)<sup>278</sup>. The study was guided by one research question and one hypothesis. The sample consisted of 100 male and female students from the University of Nigeria Nsukka's Faculty of Education. The t-test statistics and mean scores were employed in the data analysis. The findings indicated that students' ICT usage differed by gender and that males used it more frequently than females. Furthermore, the hypothesis demonstrated a statistically significant difference in the mean scores of male and female students regarding their use of ICT for academic purposes, suggesting that male students use ICT more frequently than female students.

Another study, similar to the previous one, showed that students learning science from gender sensitized teachers performed significantly better than those taught by non-gender sensitized Teachers<sup>279</sup>. In science classroom, it has been proven that learning environments using various strategies and teaching methods which address a variety of approaches to learning have encouraged women's success<sup>280</sup>. In India's class VII high school, girls outperformed males in the knowledge-based scientific subjects when the activity-based approach was used to teach them<sup>281</sup>.

A t-test comparison of the academic achievement of 300 male and 300 female secondary school students from various socioeconomic backgrounds in the Pakistani metropolis took place in the ninth-grade annual examination (conducted by the Board of Intermediate and Secondary Education, Lahore)<sup>282</sup>. In English and mathematics, it was noted that girls had significantly higher average scores in both subjects as well as overall performance compared to boys. In science, it has also been reported that female students have performed significantly better than their male counterparts<sup>283</sup>. Trends in International Mathematics and Science Study TIMSS reported that in 2007, males performed significantly better than females in all areas of science, with higher scores in Biology, Physics, and earth sciences. Additionally, the TIMSS revealed no discernible difference between the average scientific scores in Chemistry for male and female students in the United States' eighth grade. These findings supported the TIMSS findings from 1995, 1999, and 2003, which showed that men outperformed women in science<sup>284</sup>.

Numerous researches revealed that there is no significance difference between male and female academic achievement in science. In particular, there was no difference in the performance of male and female tenth-grade Biology students who participated in a simulated experiment<sup>285</sup>. Students at private secondary schools in Oyo town and Ibadan city, Nigeria, who were taught utilizing the CAI method did not exhibit gender-sensitive Biology achievement<sup>286</sup>. An analysis of secondary school pupils exposed to online CAI as a science supplemental technique found no statistically significant gender differences in achievement<sup>286</sup>. Eighth-standard Iranian primary school children in Ahwaz City who were taught science courses using the CAI software package did not perform differently based on their gender<sup>287</sup>. The mean performance of male and female Junior Secondary three (JSIII) students exposed to Computer Assisted Instruction (CAI) in Basic Science and Technology did not differ significantly<sup>288</sup>.

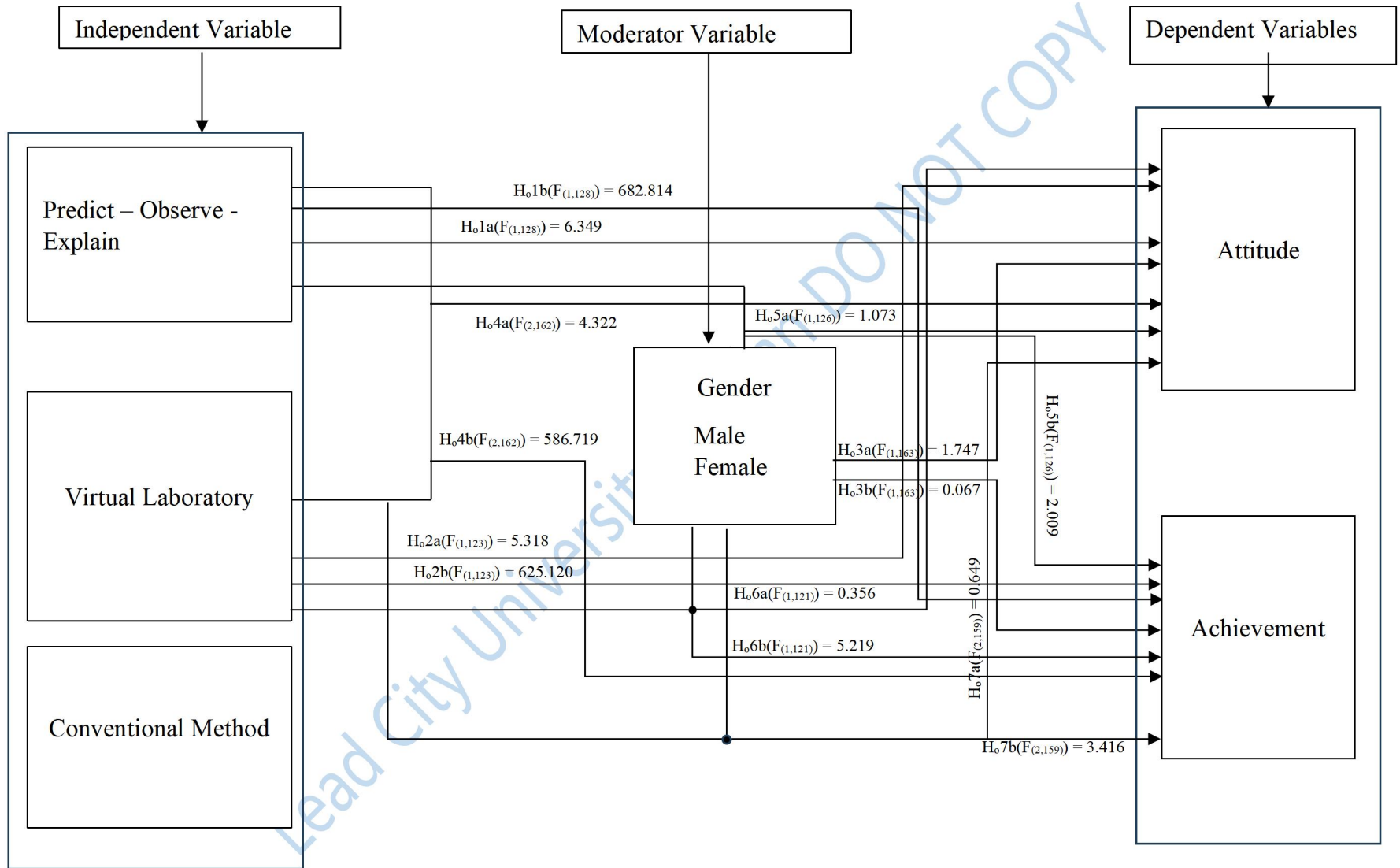
A quasi-experimental pretest-posttest control group design was employed to examine the impact of problem-solving instructional strategies and Computer Assisted Instruction (CAI) on

students' performance in Basic Science<sup>289</sup>. It was found that the Basic Science achievement of 120 randomly selected male and female Osun State Junior Secondary II pupils did not significantly differ<sup>289</sup>. Given the findings of these studies, it is obvious that there is still a lack of consensus as to whether gender has an effect on science achievement or not. While some scholars believe that males are superior to females, others support females, and still others have no view at all. In the light of these controversies, the impact of gender on academic achievement in Physics will be further explored in this study.

#### **2.4 Conceptual Framework**

A conceptual framework for the study is shown in figure 2.3. The following conceptual framework explains the process by which the study will be carried out. The independent variable is the treatment which can be manipulated at three levels; Predict-Observe-Explain Strategy (POES), Virtual Laboratory Instructional Strategy (VLS) and Conventional Method (CM). The dependent variables are the learning outcomes in terms of attitude to and achievement in Physics, while the moderating variable is gender at two levels; male and female.

### Conceptual Model



**Fig 2.3:** Conceptual Model of Predict-Observe-Explain and Virtual Laboratory strategies on attitude and achievement in Simple Harmonic Motion

**Source:** Field Survey, 2024

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## 2.5 Summary of Literature Reviewed

The literature review was organized into four sections: conceptual framework, theoretical framework, empirical review, and summary of the literature review. The concepts of attitude, academic achievement, gender, the Predict-Observe-Explain strategy, the Virtual Laboratory strategy, Simple Harmonic Motion, and Mechanics were all reviewed in the conceptual framework.

From the review, the present study was based on a review of theories of educational learning. Constructivist learning theory is examined in the review. This theory describes the active nature of learning which involves three key principles, personal experience, active learning and social interactions. This theory is relevant to this study with its emphasis on learners' active participation in a learning environment. Predict-Observe-Explain and Virtual laboratories instructional strategies are in line with this theory as the strategies provide opportunities for learners to actively engage in a learning environment and develop the ability to think and make meanings as they interact and collaborate in the learning environment with others

It also helps the researcher to arrange the materials sequentially from known to unknown so that the teaching of productive skills in Simple Harmonic Motion through the application of Constructivist-based learning will enhance effective teaching and learning processes and improve the performance of students of Physics in Senior Secondary Schools and also, since the study is building on the prior knowledge of students to make learning meaningful.

Furthermore, there are reviews of some empirical studies on the Virtual Laboratory and students' attitudes towards Physics, Virtual Laboratory and Students academic achievement in Physics, Predict-Observe-Explain Instructional strategy and students attitude in Physics, Predict-Observe-Explain Instructional strategy and students' academic achievement in Physics , gender and students attitude in Physics and gender and students' academic achievement in Physics as well as

empirical model but the literature review identifies few research findings on Predict-Observe-Explain Instructional strategy. Thus, a strong instructional approach and effective strategies for conducting practical are needed in order to enhance students' attitude and achievement in Physics

The review showed that there have been studies on influence of gender on students' achievement and attitudes in different science subjects using different instructional models and approach, research findings showed that males performed better than females, females achieved more than males and no gender disparity in students' achievement in science, but the findings of these studies have been inconclusive. Hence, the divergent reports necessitated further research on gender effects on learning outcomes in Physics. This study investigated effects of Predict-Observe-Explain and Virtual Laboratory strategies on secondary school Physics students' attitude to and achievement in Simple Harmonic Motion in Ogun State. This study also determined the influence of gender on students' attitude and achievement.

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## **Chapter Three**

### **Methodology**

This chapter discusses procedures employed in carrying out the study. These are discussed under the following sub headings: Research Design, Population, Sample and Sampling Techniques, Research Instruments, Validation and Reliability of Research Instruments, Procedure for Data collection, and Data Analysis Techniques

#### **3.1 Research Design**

The study adopted the pretest- posttest control group quasi-experimental design. The variables (independent and moderator) were crossed in a 3x2 factorial matrix (two treatment groups: Predict-Observe-Explain (POES) and Virtual Laboratory Strategies (VLS) and conventional method as

control group; two levels of gender groups-male and female). The dependent variables were students' attitudes towards and academic achievement in Physics.

**Table 3.1: Layout of the 3x2 Factorial Matrix of the Study Design**

<b>Treatment Condition</b>	<b>Gender</b>
<b>X<sub>1</sub></b> : Predict-Observe-Explain Instructional Strategy (POEIS)	Male
	Female
<b>X<sub>2</sub></b> : Virtual Laboratory Instructional Strategy	Male
	Female
<b>X<sub>3</sub></b> : Conventional Method	Male
	Female

The factorial design had been adopted for this study because of the experimental nature of the study. Furthermore, the independent variable (instruction) is being manipulated at three levels and were varied independently and also interacted with moderator variable so that their effects can be observed on the dependent variables (attitudes and achievement).

#### Model Specification

O<sub>1</sub> X<sub>1</sub> O<sub>2</sub>

O<sub>3</sub> X<sub>2</sub> O<sub>4</sub>

O<sub>5</sub> X<sub>3</sub> O<sub>6</sub>

O<sub>1</sub>= Pre-test scores in the experimental group I

O<sub>2</sub>=Post-test scores in the experimental group I

O<sub>3</sub>=Pre-test scores in the experimental II

O<sub>4</sub>=Post-test scores in the experimental group II

O<sub>5</sub>=Pre-test scores in the control group

O<sub>6</sub>= Post-test scores in the control group

X<sub>1</sub>= Predict-Observe-Explain Instructional Strategy (POIES)

X<sub>2</sub>= Virtual Laboratory Instructional Strategy (VLIS)

X<sub>3</sub>= Conventional Method

### **3.2 Population of the Study**

The target population for this study was all the SSII students offering Physics in public schools of Ogun Central Senatorial district of Ogun State, Nigeria. This comprised all the senior secondary schools that exist in the six (6) Local Government Areas. There are about 21,694 students (10,687 males and 11,007 females) in SSI in the Senatorial district and 67 senior secondary schools in the area in 2022/2023 academic session who were promoted to SSII in the first term of the succeeding academic session (2023/2024) when the field work was carried out<sup>1</sup>. The reason for chosen SS2 for the study is because the students have attained some level of adequate knowledge of Physics concepts which are mostly in SSII scheme of work and they do not have any external examination that could easily distract their desirable active participation.

### **3.3 Sample and Sampling Technique**

The sample consisted of only three public Senior Secondary schools which are government owned (for purpose of uniform standard) and which offer Physics up to the Senior Secondary School Certificate (SSSC) level, using multi-stage sampling procedure.

Stage one: Three LGAs were selected through simple random technique, where all the LGAS were given numbers and three were selected randomly.

Stage two: One school among those that meet inclusive criteria was also chosen through purposeful sampling technique.

Stage three: In each of the selected schools, one intact class was selected through random technique if such school had more than one intact class.

In each of the selected schools, the Physics teacher teaching the intact class was chosen as research assistants. Altogether, three research assistants were enlisted and the total number of students was 166 Physics students.

The schools selected for the study satisfied the following conditions:

- i. They have well- equipped Physics and Computer laboratories
- ii. They are public co-educational school with good number of male and female students because of the inclusion of gender as moderator variable in the study
- iii. They have evidence of completion of topics that serve as prerequisite to the understanding of the topic under consideration
- iv. Having professionally qualified and experienced Physics teachers, that is Physics teacher with a minimum of B.Sc (Ed), B.Sc and PGDE
- v. They have been consistently presenting candidates for Senior Secondary Certificate Examination (SSCE) Physics in the last past five consecutive years.

A simple random sampling technique was used by rolling three (3) papers to allocate the schools to specific strategy. A total of 166 students offering Physics (75) in the experimental group and (91) in the control group participated in the study. This consisted of (70) males and (96) females having the mean age of 15-16 years and the range was 12-17 years and above constituted the sample for the study. The sample size in each school and the strategy used are shown in Table 3.2

**Table 3.2: The Distribution of Samples into Strategies**

School	Male	Female	Total	Strategy used
School I	20	15	35	Predict - Observe - Explain Strategy
School II	10	30	40	Virtual laboratory Strategy
School III	40	51	91	Conventional Method (CM)

### 3.4 Description of the Research Instruments

The following instruments were used for the study:

- Physics Achievement Test (PAT)
- Physics Attitude Scale (PAS)
- Teachers' Instructional Guides (TIG)

#### 3.4.1 Physics Achievement Test (PAT)

This instrument consisted of 30 multiple-choice questions. The instrument was modified by the researcher and some of the items in the PAT were adopted from previous West Africa Examination Council (WAEC) and National Examination Council (NECO) senior School Certificate Examination past questions based on the Physics contents taught in the study. This was to basically determine the students' cognitive domain namely; knowledge, comprehension and application levels. A pool of 70 multiple-choice PAT was constructed. The 70 items were then subjected to item analysis to obtain its discriminating and difficulty index. Thirty items with difficulty index range between 0.40-0.80 and discrimination index of 0.4 were selected for the study.

**Table 3.3: Table of Specification for Physics Achievement Test (PAT)**

Concepts	Knowledge	Comprehension	Application	Total
Experiment on verification of Hooke's Law	(3) 1;5;6	(2) 3;7	(2) ;2;6	7
Determination of force constant of a spring	(2) 9;12	(2) 10;11	(2) 15;16	6

Determination of effective mass of a spiral spring by oscillation method	(3) 12;13	(1) 18	(1) 20	5
Determination of acceleration due to gravity by means of the Simple Pendulum	(1) 24	(2) 17;19	(1) 21	4
Acceleration due to gravity by means of the simple pendulum from inaccessible height	(3) 20;28;29	(3) 22;26;27	(2);23;24	8
<b>Total</b>	12	10	8	30

### 3.4.2 Physics Attitude Scale (PAS)

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 Physics. The questionnaire contains two sections A and B.

Section A contained personal information and section B contains 20 attitude items towards Physics 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. The constructed item was presented to two experts to examine the suitability and the language used in terms of clarity. The observations were noted and used to improve the scale. In scoring the attitude of the students towards Physics, Strongly Agree (SA) rated 4marks, Agree (A) rated 3marks, Disagree (D) rated 2 marks and Strongly Disagree (SD) rated 1 mark for positive worded items, while negative worded items rated as

follows Strongly Agree (SA) rated 1mark, Agree (A) rated 2marks, Disagree (D) rated 3 marks and Strongly Disagree (SD) rated 4 marks.

### **3.4.3 Teachers' Instructional Guides (TIG)**

These are different instructional guides uniformly used by the groups to teach the content so that the teachers would not deviate from the procedures as outlined by the researcher. The instructional guides are designed as control for the research assistant to effect. These guides were given to the experts in the Physics department, Science Educators in Science and Technology Education department and practicing senior Physics teachers for the corrections and observations. These guides consisted of notes of lesson in which the major roles of individuals participating in the study (research assistant and Students) were clearly stated. Specific in the notes of lesson are the following items: subject, class, topic, instructional materials, objectives to be achieved, previous knowledge, presentation and assessment.

#### **3.4.3.1 Instructional Guide on Predict-Observe-Explain Instructional Strategy (POEIS)**

This instructional guide was used for experimental group I. It is an instructional guide made up of four procedural steps. It includes the Introduction, Prediction, Observation, and Explanation phases. The researcher prepared this instructional guide and presented it to experts in Physics education and experienced secondary school Physics teachers for critique, suitability of the content and instructional steps, language of presentation and workability of the steps.

#### **3.4.3.2 Instructional Guide on Virtual Laboratory Instructional Strategy (VLIS)**

This instructional guide was used for experimental group II. There are web sites, where developed virtual laboratory experiments on different topics of Physics are available. One of such sites is Physics Education Technology (PhET) website which was created by the University of Colorado. The researcher of the present study has gone through this website and found a virtual lab experiment on Simple Harmonic Motion (SHM) fitting in to the purpose of the study and therefore, decided to employ the same. The VLP contained five Physics topics, namely: experiment on verification of

Hooke's law (lesson 1), determination of force constant of a spring (lesson 2); determination of effective mass of a spiral spring by oscillation method (lesson 3), determination of acceleration due to gravity by means of the simple pendulum (lesson 4) and acceleration due to gravity by means of the simple pendulum from inaccessible height (lesson 5). The main menu of the package consisted of teaching resources, activities, topics, sample learning goals and system requirements. The VL is divided into three sections, namely: Lesson Note section, where students read the experimental procedures; Video section, where the students watch a practical demonstration of the experiment; and virtual laboratory section, where the students perform the experiment. This simulation allows students to control inputs such as masses, length, and force, period and among others and it allows them to receive immediate feedback on the results of changes to the experimental set-up. With proper guidance, students can use the simulation to construct a mental model of the experiment. This simulation also allows students to interactively construct the graphs commonly found in textbooks, such as load vs. extension, length vs. period, and speed vs. square of time. By seeing these graphs created in real time as they change the controls on the experiment, students were able to see the relationship between the graphs and the experiment more clearly than they see when viewing static images. The figures 3.1-3.4 are the virtual laboratories used for the Simple Harmonic Motion taught the experimental group II

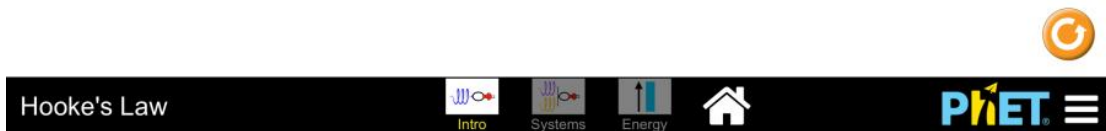
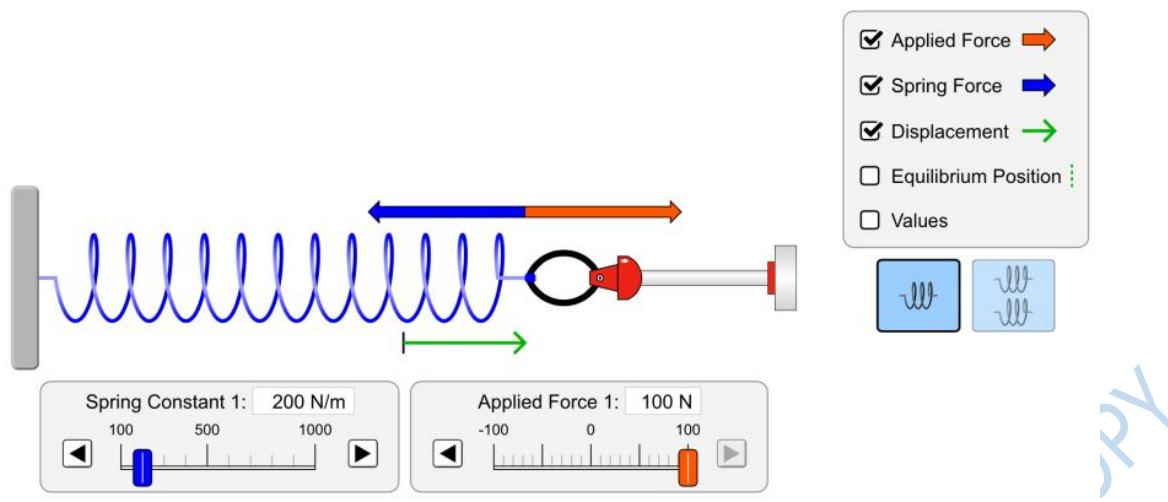


Fig 3.1 virtual laboratory for experiment on verification of Hooke's Law  
 Source: <https://phet.colorado.edu>

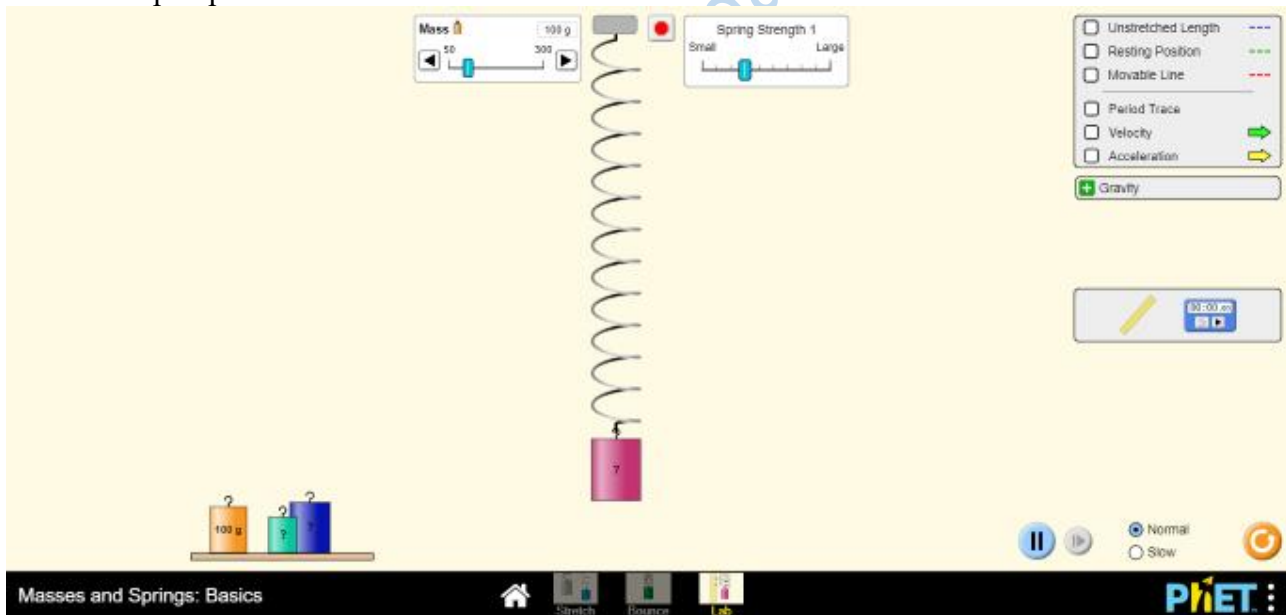


Fig 3.2 virtual laboratory for determination of force constant of a spring  
 Source: <https://phet.colorado.edu>

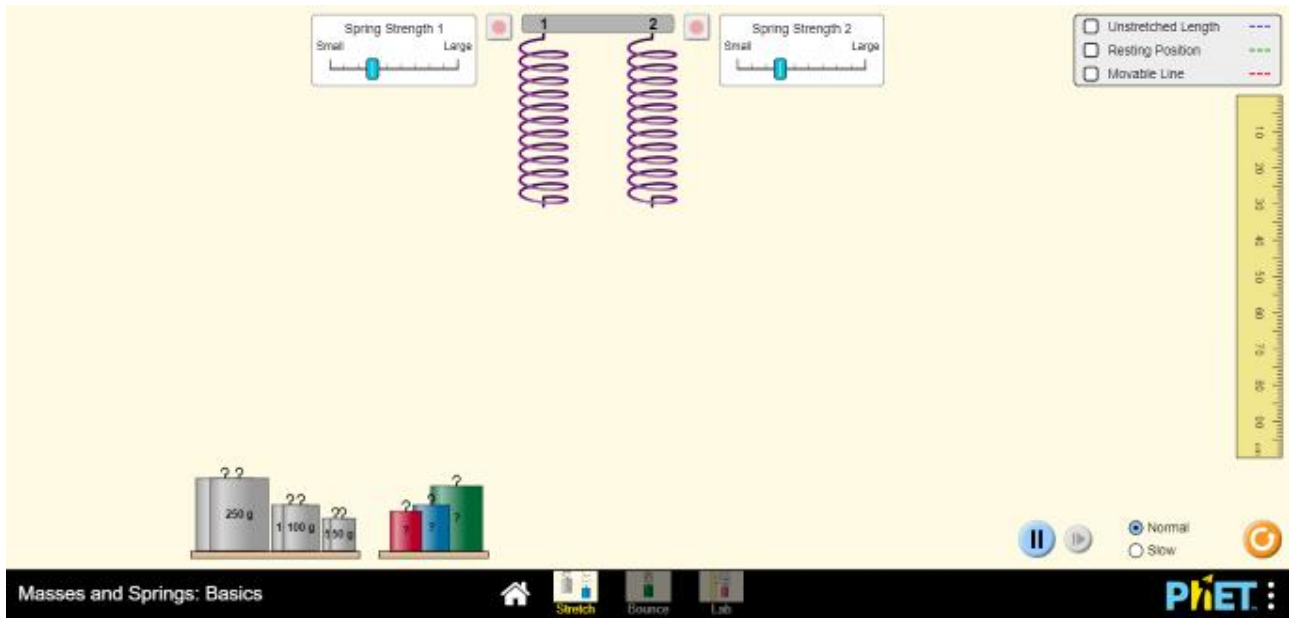


Fig 3.3 virtual laboratory for determination of effective mass of a spiral spring by oscillation method  
 Source: <https://phet.colorado.edu>

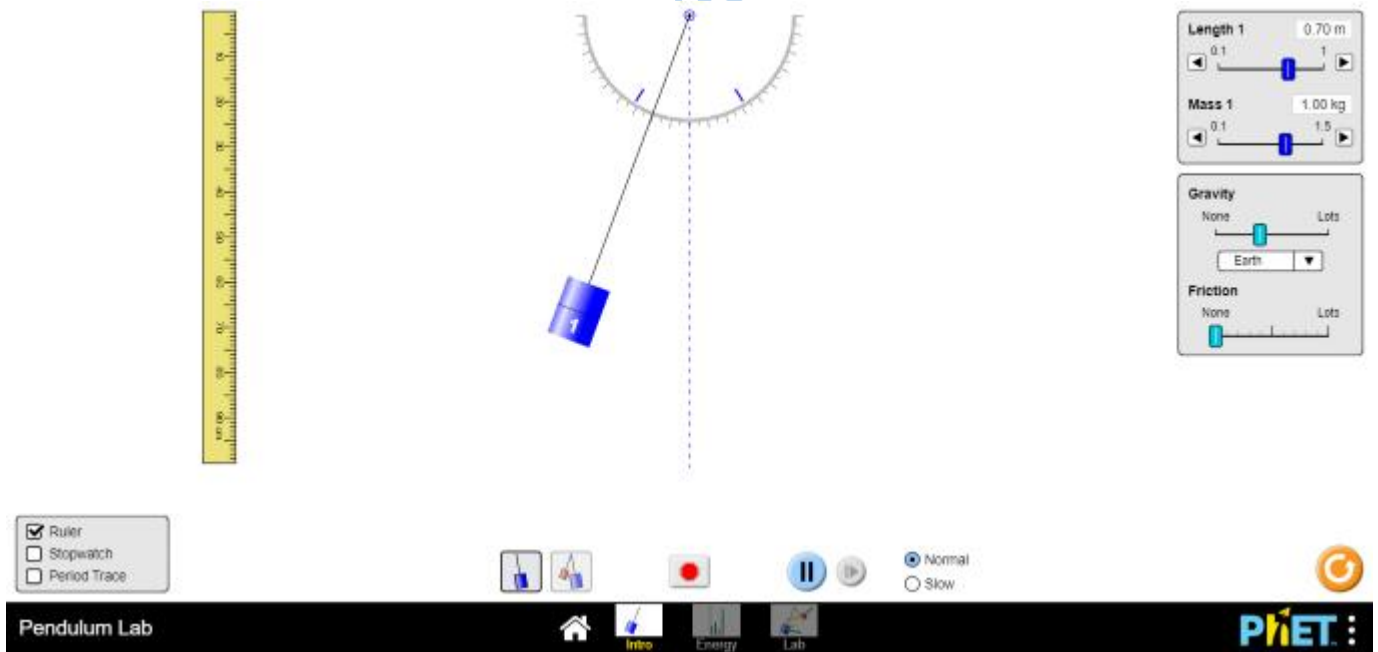


Fig 3.4 virtual laboratory for determination of acceleration due to gravity by means of the simple pendulum and acceleration due to gravity by means of the simple pendulum from inaccessible height  
 Source: <https://phet.colorado.edu>

### **3.4.3.3 Instructional Guide on Conventional Method (CM)**

This guide describes the steps of the teaching/learning process by the teacher. Conventional Method (CM) instructional guide is a step-by-step instruction given to the participants in control group. The teacher taught the students using the conventional method (teacher-centred) of chalk and talk

The control group used this instrument, which is the most commonly used teaching approach in Nigerian schools for practical science teaching. The strategy involves the following steps: The teacher introduces the concept to be learnt and asks questions on Learners' prior knowledge. Learners sit down facing the chalkboard, while the teacher writes on the chalkboard. The teacher explains the new concept, while learners listen to the teacher. The teacher demonstrates, solves numerical and non-numerical problems and performs experiment using relevant procedural steps. The instructional guide was peer and expert reviewed and their reactions, suggestions and advice were used to improve the instrument.

## **3.5 Validity of Research Instruments**

### **3.5.1 Physics Achievement Test (PAT)**

The researcher ensured that the instrument "PAT" satisfies the necessary psychometric properties. In order to ensure the validity of the instrument it was given to two senior secondary II Physics teachers for scrutiny to peruse in order to ensure that the items actually measure what it intends to measure. The researcher initially generated a total of (70) test items, based on the content of the topic selected for the study. In the course of validation, these experts subjected the items to criticism and vetting as requested by the researcher. The criteria for this were with respect to relevance, suitability, content areas identified, repetitions, set objectives, use of language, ambiguity and any other criticism. All the observations and corrections were put into consideration in developing the final draft.

### **3.5.2 Physics Attitude Scale (PAS)**

50 items were drawn at the initial stage. This instrument was then given to the researcher's supervisor and two experienced Physics teachers in secondary schools to assess the face validity in respect of the language used in presenting, clarification of the ideas and their applicability to the investigation. Their observations and suggestions were then applied in modification and production of the final copy. The final scale consisting of 20 items was then administered on a sample of (30) SS2 students outside the main study but similar in characteristics to the students for whom the instrument was intended in order to establish its reliability for the study.

### **3.6 Reliability of the Research Instruments**

#### **3.6.1 Physics Achievement Test (PAT)**

The final draft was trial-tested using a sample of (30) students not participating in the main study but similar in attributes with the participating students. KR-20 was used to analyze responses and a value of 0.81 was obtained for its reliability. For the Physics Achievement Test (PAT), one point (1) was given for every correct answer and no points (0) were given for incorrect answers. The Physics Achievement Test (PAT) has a total score of (30).

#### **3.6.2 Physics Attitude Scale (PAS)**

The final scale consisting of 20 items was then administered on a sample of (30) SS2 students outside the main study but similar in characteristics to the students for whom the instrument was intended in order to establish its reliability for the study. A reliability coefficient of 0.73 was obtained using Cronbach alpha coefficient. In scoring the attitude of the students towards Physics, Strongly Agree (SA) rated 4marks, Agree (A) rated 3marks, disagree (D) rated 2 marks and Strongly Disagree (SD) rated 1 mark for positive worded items, while negative worded items were rated as follows Strongly Agree (SA) rated 1marks, Agree (A) rated 2marks, Disagree (D) rated 3 marks and Strongly Disagree (SD) rated 4 marks.

### **3.7 Method of Data Collection**

The researcher visited and sought permission from the principals of the selected schools and their respective Physics teachers with the introduction letter from the Department of Science Education. The teachers were trained to intimate them with the strategies and design. In the process, the purpose of the study and the procedural steps involved in the study were fully discussed.

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

### **Week One**

#### **Training of Research Assistants**

The first week was for the training of research assistants on the strategies selected for the topic under consideration

### **Week Two**

#### **Administration of Pre-test**

All the SSII Physics students in each of the three selected schools for the study were exposed to Physics Achievement Test (PAT), as a pre-test and also the questionnaire on students' attitude towards Simple Harmonic Motion in Physics were administered. This exercise lasted a week

### **Week Three-Seven**

The treatment was carried out on the experimental and the control groups. During this period, the researcher and the research assistants taught their students in their respective schools using the lesson notes prepared for experimental I, experimental II and control groups

### **Instructional Procedure:**

#### **a) Instructional Procedure for Experimental Group I (Predict-Observe-Explain Strategy)**

##### **Step 1: Introduction**

Activity i: Arouse students' interest and motivates them to learn by probing into their prior knowledge through questioning

Activity ii: Makes known to the students the teaching technique and its demand on them

Activity iii: Divides the students into groups of 4-7 ask them to assume the role of captain, recorder, time -keeper and so on

Activity iv: Introduces the experiment to the students

### **Step 2: Prediction**

Activity i: students attempt individual predictions of the outcome of the experiment

Activity ii: Students write down their predictions on a sheet of paper or a prediction sheet based on the experiment

### **Step 3: Observation**

Activity i: Instruct the students to carry out the laboratory activities

Activity ii: students record their observation

### **Step 4: Explaining the Observation**

Activity i: The teacher asks the students to write out their explanation for their observation on the Predict-Observe-Explain worksheet

Activity ii: The students compare individual explanations and collectively brainstorm to come out with group explanation to observation

Activity iii: Teacher goes round the various groups to supervise the activities

Activity iv: teacher engages the students to correlate their prediction with their observations

### **Step 5: Summary**

Activity i: The teacher summarizes the important points of the topic on the board

Activity ii: students copy the important points into their notebooks

### **Step 6: Assignment**

Students are given take-home assignment

## **b) Instructional Procedure for Experimental Group II (Virtual Laboratory Strategy)**

### **Step 1: Introduction**

Activity i: The teacher introduces the lesson with the provision of relevant instructional materials.

Activity ii: Makes known to the students the teaching technique and its demand on them

### **Step 2: Presentation**

Activity i: The teacher introduces the virtual laboratory software to the students where the experimental rules, laboratory equipment and materials are stated as shown in figures 3.1-3.4 above

Activity ii: The procedures to perform experiment on Simple Harmonic Motion in the virtual laboratory are introduced to the students

Activity iii: Students are assisted with step-by-step descriptions and screen capture images of the simulation software as illustrated in figures 3.1-3.4 above

### **Step 3: Task Performance by Students**

Activity i: Students select an experiment from the pull-down menu.

step descriptions and screen capture images of the simulation software as illustrated

### **Step 5: Evaluation**

Activity i: The teacher gives a quiz on the material so that students can quickly come to realize that their sessions are not just for fun and games but really count.

Activity ii: Teachers take note of the students' responses.

### **Step 6: Summary**

Activity i: The teacher summarizes the important points after which the students copy them into their notes.

### **Step 7: Assignment**

Activity i: Students are given take-home assignment on related questions.

## **c) Instructional Procedure for Control Group (Conventional Learning Strategy)**

### **Step 1: Introduction**

Activity i: The teacher writes the topic on the board

Activity ii: The teacher asks questions requesting information on their prior knowledge of the topic.

Activity iii: The students respond to the questions asked by the teacher.

Activity iv: The teacher establishes a link between their appropriate responses and the lesson for the day.

### **Step 2: Presentation**

Activity i: The teacher describes/defines/ explains the new concept for the day to students.

Activity ii: The teacher demonstrates to the students the processes of each concept

Activity iii: The students observe teacher's demonstration and make comments on their observations.

### **Step 3: Evaluation**

Activity i: The teacher examines students on the concepts taught.

### **Step 4: Summary**

Activity i: The teacher dictated the note to the students for them to copy

### **Step 5: Assignment**

Activity i: The students are given take-home assignments against next lesson.

## **Week Eight**

### **Administration of Post Test**

Physics Achievement Test (PAT) was administered as post-test on the subjects as well as the questionnaire on students' attitude towards Physics was administered at the end of the treatment for the groups.

### **3.7.1 Data Administration of the Research Instruments**

The researcher trained the research assistants which comprises the Physics Teachers of the schools that were selected for the study. The researcher trained the Physics teachers using the lesson plans prepared by the researcher. The teachers were trained on how to guide the students in the experimental group I in using Predict-Observe-Explain Strategy (POES), which was used for teaching the students in the experimental group I, experimental group II was taught using Virtual Laboratory Strategy (VLIS), while the teachers for the control group used Conventional Method (CM). Students in the treatment and control group received the same instruction using the same length of time (period). Each of the schools were taught using double periods every week for five weeks. After the training, the researcher assessed the research assistants (teachers) by allowing them to demonstrate what they have been taught in the training for 30 minutes. The research assistants were carried on with the experiment based on the earlier discussion. Pretest was administered to the students before the commencement of the experiment. The researcher also monitored the assistants during the experiment. At the end of these actual teaching periods, the pre-PAT and pre-PAS were reshuffled and administered as post-test which lasted for one week and the post test was marked by the researcher using the marking scheme developed by the researcher. The pre-test score constituted the covariates to the post-test scores.

### **3.8 Method of Data Analysis**

The procedure for data analysis in this study involved the use of descriptive and inferential statistics. Frequency and percentage are the descriptive statistics used for the study to show socio-demographic

characteristics of the participants. The hypotheses formulated were analyzed using Analysis of Covariance (ANCOVA) with pre-test scores as covariates. The analysis was done at 0.05 level of significance. Estimated Marginal Means was also used to explain the magnitude of the post-test mean achievement in and attitude towards Simple Harmonic Motion (SHM) in Physics scores across the different levels of strategy and gender.

#### **Endnote**

1. Ogun State Ministry of Education, Science & Technology, Department of Curriculum Development and Evaluation, 2023

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## Chapter Four

### Results and Discussion of Findings

This chapter presents results of the analyses and discussion of findings. The results and discussion of findings are presented based on demographic characteristics of the participants and hypotheses as follow:

#### 4.1 Demographic Data Analysis

Table 4.1-4.3 are the socio-demographic characteristics of the participants.

**Table 4.1: Distribution of the Participants by Gender**

Gender	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 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 4.2 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 4.3: Distribution of the Participants by Groups**

Treatment Groups	Frequency	Percent
Predict-Observe-Explain (Experimental Group 1)	40	24.0
Virtual Laboratory Strategies (Experimental Group 2)	35	21.0
Control Group	91	55.0
Total	166	100.0

**Source:** Field Survey, 2024

Table 4.3 reveals that forty (40) (24.0%) of the participants were exposed to Predict-Observe-Explain, thirty-five (35) (21.0%) were Virtual Laboratory Strategies on Students'; while ninety-one (91) (55.0%) participants were in control group. This means that, most of the participants were in control group, while participants exposed to Virtual Laboratory Strategies were the least.

## 4.2 Presentation of Data

The following hypotheses were tested in this study.

**H<sub>01a</sub>:** There will be no significant main effect of Predict-Observe-Explain strategy on students' attitude towards Physics in secondary schools in Ogun State

**Table 4.4.1: Analysis of Covariance of Main Effect of Predict-Observe-Explain Strategy on Students' Attitude towards Physics**

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	272.067	2	136.034	3.485	0.034	0.052
Intercept	5097.099	1	5097.099	130.574	0.000	0.505
Pretest	13.492	1	13.492	0.346	0.558	0.003
Treatment	247.822	1	247.822	6.349	0.013*	0.047
Error	4996.635	128	39.036			
Total	423171.000	131				
Corrected Total	5268.702	130				

**Source:** Field Survey, 2024 \* denotes significance at  $p \leq 0.05$

Table 4.4.1 shows that there was a significant main effect of Predict-Observe-Explain strategy (treatment) on students' attitude towards Physics in secondary school in Ogun State ( $F_{(1,128)}=6.349$ ,  $p<0.05$ , partial  $\eta^2=0.047$ ). The null hypothesis was therefore rejected. This implies that the treatment was effective on

students' attitude towards Physics in secondary school in Ogun State. Also, the partial eta square value of 0.047 shows the contributing effect size of 4.7%.

**Table 4.4.2: Estimated Marginal Means of Predict-Observe-Explain Strategy on Students' Attitude towards Physics**

Treatment Groups	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Predict-Observe-Explain Strategy	58.562	0.990	56.603	60.521
Control	55.566	0.656	54.269	56.863

**Source:** Field Survey, 2024

Table 4.4.2 shows that participants exposed to Predict-Observe-Explain Strategy (treatment group) had higher posttest mean ( $\bar{x}$ ) score of 58.562 on students' attitude towards Physics in secondary school in Ogun State, than their counterparts in the control group with posttest mean score of 55.566. This means that participants exposed to Predict-Observe-Explain Strategy (treatment group) performed better than those in the control group. It implies that Predict-Observe-Explain Strategy was an effective method that improved students' attitude towards Physics in secondary schools in Ogun State.

**H<sub>01b</sub>:** There will be no significant main effect of Predict-Observe-Explain strategy on students' achievement in Simple Harmonic Motion in Physics in secondary schools in Ogun State.

**Table 4.5.1: Analysis of Covariance of Main Effect of Predict-Observe-Explain Strategy on Students' Achievement in Simple Harmonic Motion in Physics**

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	8694.278	2	4347.139	346.357	0.000	0.844
Intercept	5501.730	1	5501.730	438.349	0.000	0.774
Pretest	1.277	1	1.277	0.102	0.750	0.001
Treatment	8570.010	1	8570.010	682.814	0.000*	0.842
Error	1606.531	128	12.551			
Total	39926.000	131				

Table 4.5.1 shows that that there was a significant main effect of Predict-Observe-Explain strategy (treatment) on students’ achievement in Simple Harmonic Motion in Physics in secondary school in Ogun State ( $F_{(1,128)}=682.814, p<0.05, \text{partial } \eta^2=0.842$ ). The null hypothesis was therefore rejected. This implies that the treatment was effective on students’ achievement in Simple Harmonic Motion in Physics in secondary school in Ogun State. Also, the partial eta square value of 0.842 shows the contributing effect size of 84.2%.

**Table 4.5.2: Estimated Marginal Means of Predict-Observe-Explain Strategy on Students’ Achievement in Simple Harmonic Motion in Physics**

Treatment Groups	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Predict-Observe-Explain Strategy	27.345	0.564	26.230	28.460
Control	9.629	0.372	8.892	10.365

Source: Field Survey, 2024

Table 4.5.2 shows that participants exposed to Predict-Observe-Explain Strategy (treatment group) had higher posttest mean ( $\bar{x}$ ) score of 27.345 on students’ achievement in Simple Harmonic Motion in Physics in secondary school in Ogun State, than their counterparts in the control group with posttest mean score of 9.629. This means that participants exposed to Predict-Observe-Explain Strategy (treatment group) performed better than those in the control group. It implies that Predict-Observe-Explain Strategy was an effective approach that improved students’ achievement in Simple Harmonic Motion in Physics in secondary schools in Ogun State.

**H<sub>0</sub>2a:** There will be no significant main effect of Virtual Laboratory strategy on students’ attitude towards Physics in secondary schools in Ogun State.

**Table 4.6.1: Analysis of Covariance of Main Effect of Virtual Laboratory Strategy on Students’ Attitude towards Physics**

Source	Type III Sum of	df	Mean Square	F	Sig.	Partial Eta Squared
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	Squares					
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

\* denotes significance at  $p \leq 0.05$

Table 4.6.1 shows that there was a significant main effect of Virtual Laboratory strategy (treatment) on students' attitude towards Physics in secondary school in Ogun State ( $F_{(1,123)}=5.318$ ,  $p<0.05$ , partial  $\eta^2=0.041$ ). The null hypothesis was therefore rejected. This implies that the treatment was effective on students' attitude towards Physics in secondary school in Ogun State. Also, the partial eta square value of 0.041 shows the contributing effect size of 4.1%.

**Table 4.6.2: Estimated Marginal Means of Virtual Laboratory Strategy on Students' Attitude towards Physics**

Treatment Groups	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Virtual Laboratory Strategy	58.373	1.029	56.336	60.410
Control	55.527	0.618	54.304	56.750

Source: Field Survey, 2024

Table 4.6.2 shows that participants exposed to Virtual Laboratory Strategy (treatment group) had higher posttest mean ( $\bar{x}$ ) score of 58.373 on students' attitude towards Physics in secondary school in Ogun State, than their counterparts in the control group with posttest mean score of 55.527. This means that participants exposed to Virtual Laboratory Strategy (treatment group) performed better than those in the control group. It implies that Virtual Laboratory Strategy was an effective strategy that improved students' attitude towards Physics in secondary schools in Ogun State.

**H<sub>0</sub>2b:** There will be no significant main effect of Virtual Laboratory strategy on students' achievement in Simple Harmonic Motion in Physics in secondary schools in Ogun State.

**Table 4.7.1: Analysis of Covariance of Main Effect of Virtual Laboratory Strategy on Students' Achievement in Simple Harmonic Motion in Physics**

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	8471.512	2	4235.756	318.115	0.000	0.838
Intercept	5805.328	1	5805.328	435.994	0.000	0.780
Pretest	1.153	1	1.153	0.087	0.769	0.001
Treatment	8323.577	1	8323.577	625.120	0.000*	0.836
Error	1637.765	123	13.315			
Total	37419.000	126				
Corrected Total	10109.278	125				

Source: Field Survey, 2024

\* denotes significance at  $p \leq 0.05$

Table 4.7.1 shows that there was a significant main effect of Virtual Laboratory strategy (treatment) on students' achievement in Simple Harmonic Motion in Physics in secondary school in Ogun State ( $F_{(1,123)}=625.120$ ,  $p<0.05$ , partial  $\eta^2=0.836$ ). The null hypothesis was therefore rejected. This implies that the treatment was effective on students' achievement in Simple Harmonic Motion in Physics in secondary school in Ogun State. Also, the partial eta square value of 0.836 shows the contributing effect size of 83.6%.

**Table 4.7.2: Estimated Marginal Means of Virtual Laboratory Strategy on Students' Achievement in Simple Harmonic Motion in Physics**

Treatment Groups	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Virtual Laboratory strategy	27.965	0.621	26.735	29.195
Control	9.629	0.384	8.869	10.388

Source: Field Survey, 2024

Table 4.7.2 shows that participants exposed to Virtual Laboratory strategy (treatment group) had higher posttest mean ( $\bar{x}$ ) score of 27.965 on students' achievement in Simple Harmonic Motion in Physics in secondary school in Ogun State, than their counterparts in the control group with posttest mean score of 9.629. This means that participants exposed to Virtual Laboratory Strategy (treatment group) performed better than those in the control group. It implies that Virtual Laboratory Strategy was an effective approach that improved students' achievement in Simple Harmonic Motion in Physics in secondary schools in Ogun State.

**H<sub>03a</sub>:** There will be no significant main effect of gender on students' attitude towards Physics in secondary schools in Ogun State.

**Table 4.8.1: Analysis of Covariance of Main Effect of Gender on Students' Attitude towards Physics**

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	131.286	2	65.643	1.803	0.168	0.022
Intercept	7745.878	1	7745.878	212.706	0.000	0.566
Pretest	51.806	1	51.806	1.423	0.235	0.009
Gender	63.615	1	63.615	1.747	0.188*	0.011
Error	5935.799	163	36.416			
Total	542896.000	166				
Corrected Total	6067.084	165				

**Source:** Field Survey, 2024 \* denotes significance at  $p \leq 0.05$

Table 4.8.1 shows that there was no significant main effect of gender on students' attitude towards Physics in secondary school in Ogun State ( $F_{(1,163)}=1.747$ ,  $p>0.05$ , partial  $\eta^2=0.011$ ). The null hypothesis was therefore not rejected. This implies that gender had no significant effect on students' attitude towards Physics in secondary school in Ogun State. Also, the partial eta square value of 0.011 shows the contributing effect size of 1.1%.

**Table 4.8.2: Estimated Marginal Means of Gender on Students' Attitude towards Physics**

Gender	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Male	56.137	.724	54.707	57.567
Female	57.400	.618	56.180	58.620

**Source:** Field Survey, 2024

Table 4.8.2 shows that female participants had a higher posttest mean score (57.400) than their male (56.137) counterparts. This implied that female gender had a better effect on students' attitude towards Physics than their male counterparts.

**H<sub>03b</sub>:** There will be no significant main effect of gender on students' achievement in Simple Harmonic Motion in Physics in secondary schools in Ogun State.

**Table 4.9.1: Analysis of Covariance of Main Effect of Gender on Students' Achievement in Simple Harmonic Motion in Physics**

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	219.092	2	109.546	1.200	0.304	0.015
Intercept	5042.005	1	5042.005	55.212	0.000	0.253
Pretest	208.336	1	208.336	2.281	0.133	0.014
Gender	6.121	1	6.121	0.067	0.053*	0.000
Error	14885.269	163	91.321			
Total	67458.000	166				
Corrected Total	15104.361	165				

**Source:** Field Survey, 2024 \* denotes significance at  $p \leq 0.05$

Table 4.9.1 shows that there was no significant main effect of gender on students' achievement in Simple Harmonic Motion in Physics in secondary school in Ogun State ( $F_{(1,163)}=0.067$ ,  $p>0.05$ , partial  $\eta^2=0.000$ ). The null hypothesis was therefore not rejected. This implies that gender had no significant effect on students' achievement in Simple Harmonic Motion in Physics in secondary school in Ogun State. Also, the partial eta square value of 0.000 shows the contributing effect size of 0.0%.

**Table 4.9.2: Estimated Marginal Means of Gender on Students' Achievement in Simple Harmonic Motion in Physics**

Gender	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Male	17.984	1.143	15.727	20.242
Female	17.595	0.976	15.668	19.522

**Source:** Field Survey, 2024

Table 4.9.2 shows that male participants had a higher posttest mean score (17.984) than their female (17.595) counterparts. This implied that gender had a better effect on students' achievement in Simple Harmonic Motion in Physics than their female counterparts.

**H<sub>0</sub>4a:** There will be no significant main effect of treatment: Predict-Observe-Explain and Virtual Laboratory strategies on students' attitude towards Physics in secondary schools in Ogun State.

**Table 4.10.1: Analysis of Covariance of main Effect of treatment: Predict-Observe-Explain and Virtual Laboratory Strategies on Students' Attitude towards Physics**

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	371.596	3	123.865	3.523	0.016	0.061
Intercept	7071.414	1	7071.414	201.136	0.000	0.554
Pretest	20.182	1	20.182	0.574	0.450	0.004
POES*VLS (Treatment)	303.925	2	151.962	4.322	0.015*	0.051
Error	5695.488	162	35.157			
Total	542896.000	166				
Corrected Total	6067.084	165				

**Source:** Field Survey, 2024 \* denotes significance at  $p \leq 0.05$

Table 4.10.1 shows that there was a significant main effect of treatments (Effect of Predict-Observe-Explain and Virtual Laboratory Strategies) on students' attitude towards Physics in secondary school in Ogun State ( $F_{(2,162)}=4.322$ ,  $p<0.05$ , partial  $\eta^2=0.047$ ). The null hypothesis was therefore rejected. This implies that the combined treatment of (Effect of Predict-Observe-Explain and Virtual Laboratory Strategies) was effective on students' attitude towards Physics in secondary school in Ogun State. Also, the partial eta square value of 0.051 shows the contributing effect size of 5.1%.

**Table 4.10.2: Estimated Marginal Means of Predict-Observe-Explain and Virtual Laboratory Strategies on Students' Attitude towards Physics**

Treatment Groups	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Predict-Observe-Explain Strategy (Experimental 1)	58.616	0.938	56.764	60.468
Virtual Laboratory Strategy (Experimental 2)	58.102	1.041	56.046	60.157
Control	55.624	0.629	54.381	56.867

**Source:** Field Survey, 2024

Table 4.10.2 shows that after controlling for the effect of treatments on students' attitude towards Physics, the participants exposed to Predict-Observe-Explain strategy had the highest mean score (58.616), followed by those exposed to Virtual Laboratory strategy (58.102), while the control group had a mean score of 55.624. This implies that Predict-Observe-Explain strategy was more potent in relation to students' attitude towards Simple Harmonic Motion in Physics in secondary schools in Ogun State.

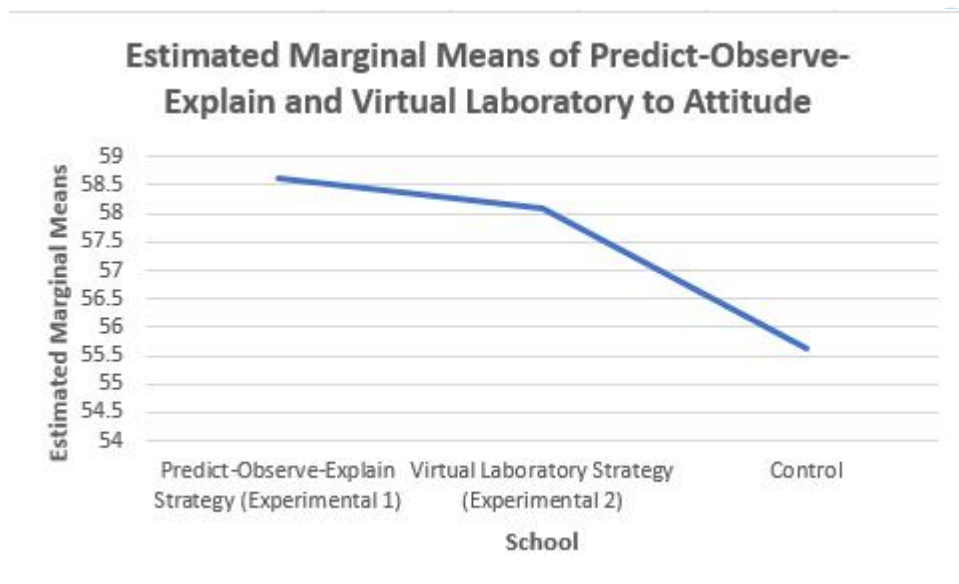


Figure 4.1: Graphical illustration of the 2-way interaction effect of Predict-Observe-Explain and Virtual Laboratory to Attitude

**Table 4.10.3: Scheffe Pair-wise Comparisons of Attitude on Strategy**

Treatment Groups	Mean	Predict-Observe-Explain	Virtual Laboratory	Conventional Method
Predict-Observe-Explain (Exp.1)	58.616			*
Virtual Laboratory (Exp.2)	58.102			*
Control	55.624	*	*	

\* denotes pairs of groups that are significantly different at  $p \leq 0.05$

The Result in table 4.10.3 shows that the obtained significant differences in strategy is accounted for by the significant difference in the post-test mean attitude scores of the students exposed to the pairs of Predict-Observe-Explain and Conventional Method on the one hand as well as Virtual Laboratory and Conventional Method on the other. This implied that the difference between the post-test mean attitude scores of the students exposed to the pairs of Predict-Observe-Explain strategy and Conventional Method as well as Virtual Laboratory and Conventional Method are statistically significant at 0.05 level of significance. However, the difference between the post-test means attitude scores of the students exposed to the other possible pairs (Predict-Observe-Explain and Virtual Laboratory) is not statistically significant. Therefore, the significant difference in the post-test mean attitude scores of the students exposed to the pairs of Predict-Observe-Explain and Conventional Method as well as Virtual Laboratory and Conventional Method are responsible for the obtained significant main effect of instructional strategy on attitude to Physics

**H<sub>04b</sub>:** There will be no significant main effect of treatment: Predict-Observe-Explain and Virtual Laboratory strategies on students' achievement in Simple Harmonic Motion in Physics in secondary schools in Ogun State.

**Table 4.11.1: Analysis of Covariance of main Effect of treatment: Predict-Observe-Explain and Virtual Laboratory Strategies on Students' Achievement in Simple Harmonic Motion in Physics**

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	13297.909	3	4432.636	397.512	0.000	0.880
Intercept	10187.893	1	10187.893	913.635	0.000	0.849
Pretest	5.241	1	5.241	0.470	0.494	0.003
Treatment	13084.938	2	6542.469	586.719	0.000*	0.879
Error	1806.452	162	11.151			
Total	67458.000	166				
Corrected Total	15104.361	165				

**Source:** Field Survey, 2024 \* denotes significance at  $p \leq 0.05$

Table 4.11.1 shows that there was a significant main effect of treatment (Effect of Predict-Observe-Explain and Virtual Laboratory Strategies) on students' achievement in Simple Harmonic Motion in Physics in secondary school in Ogun State ( $F_{(2,162)}=586.719$ ,  $p<0.05$ , partial  $\eta^2=0.047$ ). The null hypothesis was

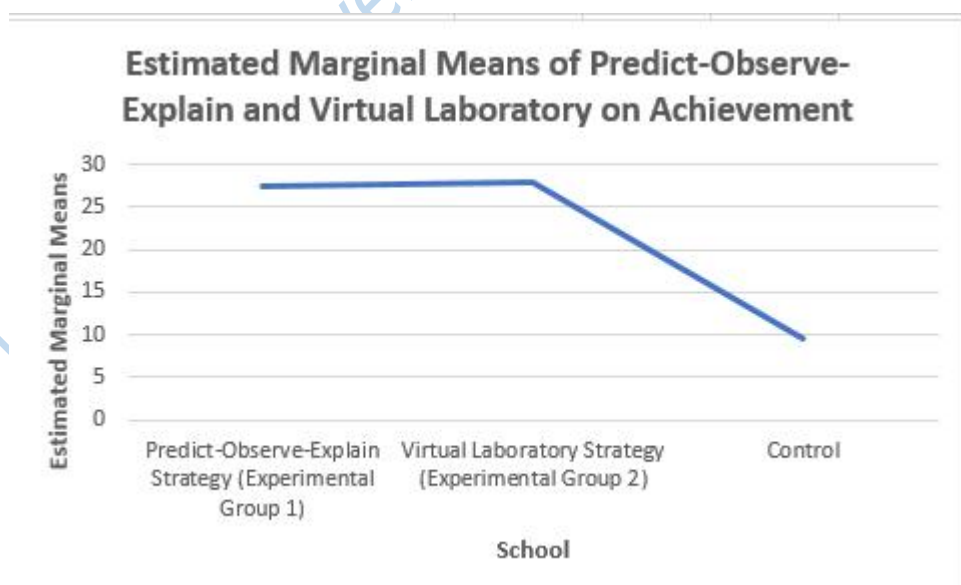
therefore rejected. This implies that the combined treatment of (Effect of Predict-Observe-Explain and Virtual Laboratory Strategies) was effective on students' achievement in Simple Harmonic Motion in Physics in secondary school in Ogun State. Also, the partial eta square value of 0.879 shows the contributing effect size of 87.9%.

**Table 4.11.2: Estimated Marginal Means of Predict-Observe-Explain and Virtual Laboratory Strategies on Students' Achievement in Simple Harmonic Motion in Physics**

Treatment Groups	Mean	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
Predict-Observe-Explain Strategy (Experimental Group 1)	27.350	0.529	26.305	28.395
Virtual Laboratory Strategy (Experimental Group 2)	27.976	0.567	26.858	29.095
Control	9.614	0.352	8.919	10.308

**Source:** Field Survey, 2024

Table 4.11.2 shows that after controlling for the effect of treatment on students' achievement in Simple Harmonic Motion in Physics, the participants exposed to Virtual Laboratory strategy had the highest mean score (27.976), followed by those exposed to Predict-Observe-Explain strategy (27.350), while the control group had a mean score of 9.614. This implies that Virtual Laboratory strategy was more potent in relation to students' achievement in Simple Harmonic Motion in Physics in secondary schools in Ogun State.



**Figure 4.2: Graphical illustration of the 2-way interaction effect of Predict-Observe-Explain and Virtual Laboratory on Achievement**

**Table 4.11.3: Scheffe Pair-wise Comparisons of Achievement on Strategy**

Treatment Groups	Mean	Predict-Observe-Explain	Virtual Laboratory	Conventional Method
Predict-Observe-Explain (Exp.1)	27.350		*	
Virtual Laboratory	27.976	*		*
Control	9.614		*	

\* denotes pairs of groups that are significantly different at  $p \leq 0.05$

The result in Table 4.11.3 shows that the obtained significant difference in strategy was accounted for by the significant difference in the mean achievement scores of the students exposed to the pairs of Predict-Observe-Explain versus Virtual Laboratory and Virtual Laboratory versus conventional method. This implies that the difference between the mean achievement scores of the students exposed to the pairs of Predict-Observe-Explain and Virtual Laboratory as well as Virtual Laboratory and conventional method are statistically significant at the 0.05 level of significance. However, the difference between the mean achievement scores of the students exposed to Predict-Observe-Explain versus conventional method is not statistically significant. Therefore, the significant difference in the mean achievement scores of the students exposed to the pairs of Predict-Observe-Explain versus Virtual Laboratory and Virtual Laboratory versus conventional method are responsible for the obtained significant effect of instructional strategy on the achievement in Simple Harmonic Motion

**H<sub>05a</sub>:** There will be no significant interaction effect of Predict-Observe-Explain and gender on students' attitude towards Physics in secondary schools in Ogun State.



male participants who were exposed to Predict-Observe-Explain strategy than their female counterparts. In the control group, the female participants had a higher mean score (56.488) than their male (54.371) counterparts. This implies that the interaction of Predict-Observe-Explain and gender had a better effect on students' attitude towards Physics in secondary schools in Ogun State among female participants in the control group than their male counterparts.

The overall comparison shows that male participants in treatment group had the higher mean score (59.056), followed by female participants in treatment group with a mean score of 58.423, while the male participants in control group had the least mean score (54.371). It implies the interaction of Predict-Observe-Explain and gender had a better effect on students' attitude towards Physics in secondary schools in Ogun State among male participants who were exposed to Predict-Observe-Explain strategy than their female counterparts; and other participants in the control group, respectively.

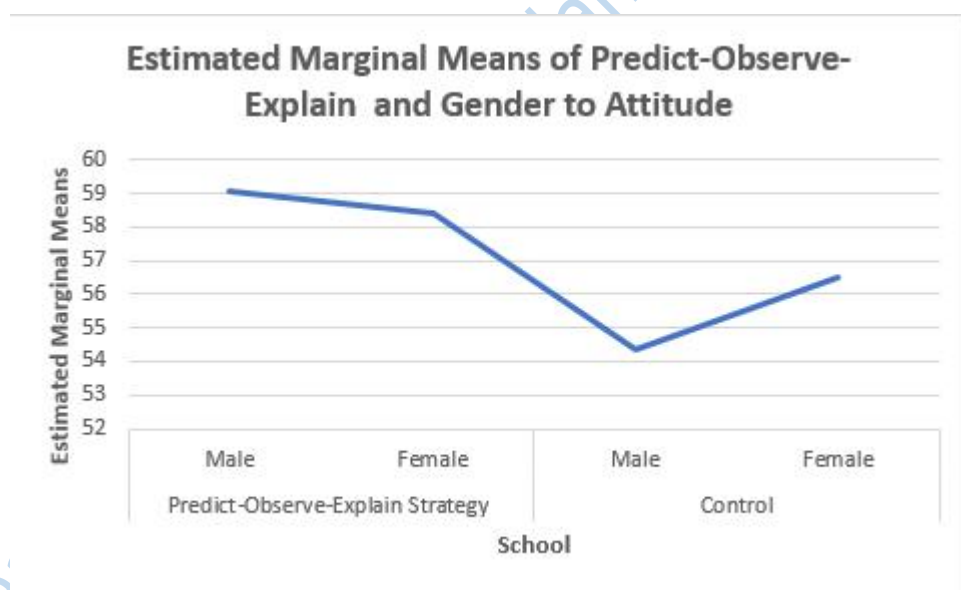


Figure 4.3: Graphical illustration of the 2-way interaction effect of Predict-Observe-Explain and Gender to Attitude

**H<sub>05b</sub>:** There will be no significant interaction effect of Predict-Observe-Explain and gender on students' achievement in Simple Harmonic Motion in Physics in secondary schools in Ogun State.

**Table 4.13.1: Analysis of Covariance of Interaction Effect of Predict-Observe-Explain Strategy and Gender on Students' Achievement in Simple Harmonic Motion in Physics**

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	8817.759	4	2204.440	187.289	0.000	0.856
Intercept	5153.772	1	5153.772	437.865	0.000	0.777
Pretest	1.373	1	1.373	0.117	0.733	0.001
Treatment	6807.717	1	6807.717	578.384	0.000	0.821
Gender	38.293	1	38.293	3.253	0.074	0.025
Treatment * Gender	23.650	1	23.650	2.009	0.159*	0.016
Error	1483.051	126	11.770			
Total	39926.000	131				
Corrected Total	10300.809	130				

Source: Field Survey, 2024

\* denotes significance at  $p \leq 0.05$

Table 4.13.1 shows that there was no significant interaction effect of Predict-Observe-Explain (treatment) and gender on students' achievement in Simple Harmonic Motion in Physics in secondary schools in Ogun State ( $F_{(1,126)}=2.009$ ,  $p>0.05$ , partial  $\eta^2=0.016$ ). The null hypothesis was therefore not rejected. This implied that Predict- Observe-Explain and gender had no significant interaction effective on the students' achievement in Simple Harmonic Motion in Physics in secondary schools in Ogun State. The partial eta square value of 0.016 shows the contributing effect size of 1.6%.

**Table 4.13.2: Estimated Marginal Means of Predict-Observe-Explain Strategy and Gender on Students' Achievement in Simple Harmonic Motion in Physics**

Treatment	Gender	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Predict-Observe-Explain Strategy	Male	27.556	1.097	25.385	29.727
	Female	27.276	0.627	26.035	28.516
Control	Male	10.940	0.543	9.866	12.015
	Female	8.599	0.481	7.647	9.551

Source: Field Survey, 2024

Table 4.13.2 shows that male participants in the Predict-Observe-Explain group had a higher mean score (27.556) than their female (27.276) counterparts. This implies that the interaction of Predict-Observe-

Explain and gender had a better effect on students' achievement in Simple Harmonic Motion in Physics in secondary schools in Ogun State among male participants who were exposed to Predict-Observe-Explain strategy than their female counterparts. In the control group, the male participants had a higher mean score (10.940) than their female (8.599) counterparts. This implies that the interaction of Predict-Observe-Explain and gender had a better effect on students' achievement in Simple Harmonic Motion in Physics in secondary schools in Ogun State among male participants in the control group than their female counterparts.

The overall comparison shows that male participants in Predict-Observe-Explain group had the higher mean score (27.556), followed by male participants in treatment group with a mean score of 27.276, while the female participants in control group had the least mean score (8.599). It implies the interaction of Predict-Observe-Explain and gender had a better effect on students' achievement in Simple Harmonic Motion in Physics in secondary schools in Ogun State among male participants who were exposed to Predict-Observe-Explain strategy than their female counterparts; and other participants in the control group respectively.

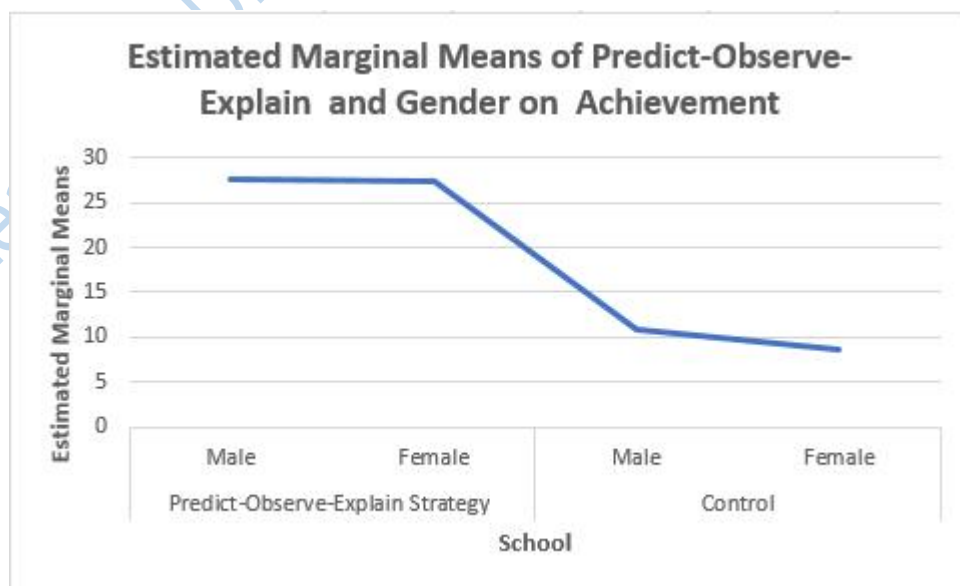


Figure 4.4: Graphical illustration of the 2-way interaction effect of Predict-Observe-Explain and Gender on Achievement

**H<sub>06a</sub>:** There will be no significant interaction effect of Virtual Laboratory and gender on students’ attitude towards Physics in secondary schools in Ogun State.

**Table 4.14.1: Analysis of Covariance of Interaction Effect of Virtual Laboratory Strategy and Gender on Students’ Attitude towards Physics**

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	317.552	4	79.388	2.417	0.052	0.074
Intercept	3487.655	1	3487.655	106.199	0.000	0.467
Pretest	12.704	1	12.704	.387	0.535	0.003
Treatment	221.315	1	221.315	6.739	0.011	0.053
Gender	63.009	1	63.009	1.919	0.169	0.016
Treatment*Gender	11.697	1	11.697	0.356	0.352*	0.003
Error	3973.750	121	32.841			
Total	403920.000	126				
Corrected Total	4291.302	125				

**Source:** Field Survey, 2024                      \* denotes significance at  $p \leq 0.05$

Table 4.14.1 shows that that there was no significant interaction effect of Virtual Laboratory strategy (treatment) and gender on students’ attitude towards Physics in secondary schools in Ogun State ( $F_{(1,121)}=0.356, p>0.05, \text{partial } \eta^2=0.003$ ). The null hypothesis was therefore not rejected. This implies that Virtual Laboratory and gender had no significant interaction effect on the students’ attitude towards Physics in secondary schools in Ogun State. The partial eta square value of 0.003 shows the contributing effect size of 0.3%.

**Table 4.14.2: Estimated Marginal Means of Virtual Laboratory Strategy and Gender on Students’ Attitude towards Physics**

Treatment Groups	Gender	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound

Virtual Laboratory Strategy	Male	58.112	1.294	55.550	60.674
	Female	59.073	1.577	55.950	62.196
Control	Male	54.159	0.945	52.289	56.029
	Female	56.496	0.803	54.907	58.085

**Source:** Field Survey, 2024

Table 4.14.2 shows that female participants in the Virtual Laboratory group had a higher mean score (59.073) than their male (58.112) counterparts. This implies that the interaction of Virtual Laboratory and gender had a better effect on students' attitude towards Physics in secondary schools in Ogun State among female participants who were exposed to Virtual Laboratory strategy than their male counterparts. In the control group, the female participants had a higher mean score (56.496) than their male (54.159) counterparts. This implies that the interaction of Virtual Laboratory and gender had a better effect on students' attitude towards Physics in secondary schools in Ogun State among female participants in the control group than their male counterparts.

The overall comparison shows that female participants in Virtual Laboratory group had the higher mean score (59.073), followed by male participants in Virtual Laboratory group with a mean score of 58.112, while the male participants in control group had the least mean score (54.159). It implies the interaction of Virtual Laboratory and gender had a better effect on students' attitude towards Physics in secondary schools in Ogun State among female participants who were exposed to Predict-Observe-Explain strategy than their male counterparts; and other participants in the control group, respectively.

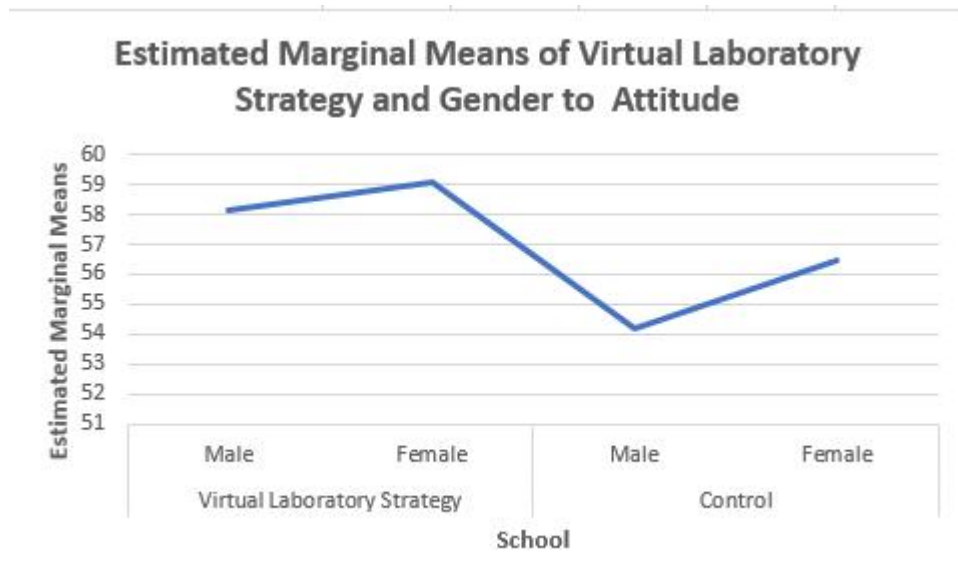


Figure 4.5: Graphical illustration of the 2-way interaction effect of Virtual Laboratory and Gender to Attitude

**H<sub>06b</sub>:** There will be no significant interaction effect of Virtual Laboratory and gender on students' achievement in Simple Harmonic Motion in Physics in secondary schools in Ogun State.

**Table 4.15.1: Analysis of Covariance of Interaction Effect of Virtual Laboratory Strategy and Gender on Students' Achievement in Simple Harmonic Motion in Physics**

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	8601.351 <sup>a</sup>	4	2150.338	172.549	0.000	0.851
Intercept	5841.250	1	5841.250	468.717	0.000	0.795
Preach	.813	1	.813	.065	0.799	0.001
Treatment	8110.455	1	8110.455	650.804	0.000	0.843
Gender	12.850	1	12.850	1.031	0.312	0.008
Treatment * Gender	65.045	1	65.045	5.219	0.024*	0.041
Error	1507.927	121	12.462			
Total	37419.000	126				
Corrected Total	10109.278	125				

Source: Field Survey, 2024

\* denotes significance at  $p \leq 0.05$

Table 4.15.1 shows that that there was a significant interaction effect of Virtual Laboratory strategy (treatment) and gender on students' achievement in Simple Harmonic Motion in Physics in secondary

schools in Ogun State ( $F_{(1,121)}=5.219, p<0.05, \text{partial } \eta^2=0.041$ ). The null hypothesis was therefore rejected. This implies that Virtual Laboratory and gender had a significant interaction effect on the students' achievement in Simple Harmonic Motion in Physics in secondary schools in Ogun State. The partial eta square value of 0.041 shows the contributing effect size of 4.1%.

**Table 4.15.2: Estimated Marginal Means of Virtual Laboratory Strategy and Gender on Students' Achievement in Simple Harmonic Motion in Physics**

Treatment Groups	Gender	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Virtual Laboratory Strategy	Male	27.576	0.796	26.000	29.151
	Female	28.476	0.912	26.670	30.282
Control	Male	10.942	0.559	9.836	12.049
	Female	8.601	0.495	7.621	9.581

**Source:** Field Survey, 2024

Table 4.15.2 shows that female participants in the Virtual Laboratory group had a higher mean score (28.476) than their male (27.576) counterparts. This implies that the interaction of Virtual Laboratory and gender had a better effect on students' achievement in Simple Harmonic Motion in Physics in secondary schools in Ogun State among female participants who were exposed to Virtual Laboratory strategy than their male counterparts. In the control group, the male participants had a higher mean score (10.942) than their female (8.601) counterparts. This implies that the interaction of Virtual Laboratory and gender had a better effect on students' achievement in Simple Harmonic Motion in Physics in secondary schools in Ogun State among male participants in the control group than their female counterparts.

The overall comparison shows that female participants in Virtual Laboratory group had the higher mean score (28.476), followed by male participants in treatment group with a mean score of 27.576, while the female participants in control group had the least mean score (8.601). It implies the interaction of Virtual Laboratory and gender had a better effect on students' achievement in Simple Harmonic Motion in

Physics in secondary schools in Ogun State among female participants who were exposed to Virtual Laboratory strategy than their male counterparts; and other participants in the control group respectively.

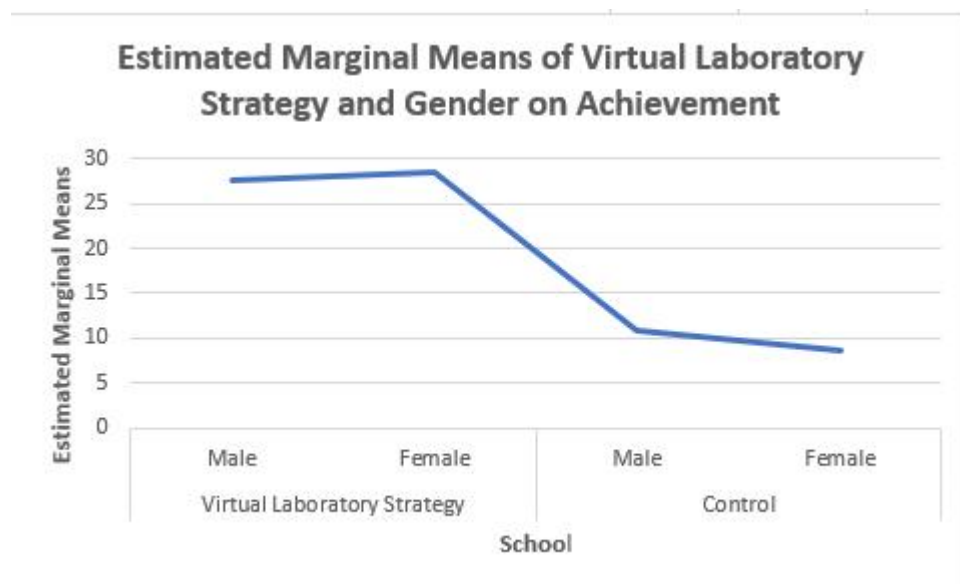


Figure 4.6: Graphical illustration of the 2-way interaction effect of Virtual Laboratory and Gender on Achievement

**H<sub>07a</sub>:** There will be no significant interaction effect of Predict-Observe-Explain, Virtual Laboratory strategies and gender on students' attitude towards Simple Harmonic Motion in Physics in secondary schools in Ogun State.

**Table 4.16.1: Analysis of Covariance of Interaction Effect of Predict-Observe-Explain (POES), Virtual Laboratory Strategies (VLS) and Gender on Students' Attitude towards Physics**

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	472.681	6	78.780	2.239	0.042	0.078
Intercept	6456.083	1	6456.083	183.490	0.000	0.536
Pretest	6.317	1	6.317	0.180	0.172	0.001
Treatments	323.877	2	161.938	4.602	0.011	0.055
Gender	14.435	1	14.435	0.410	0.403	0.003
POES*VLS* Gender	45.649	2	22.825	0.649	0.524*	0.008
Error	5594.403	159	35.185			
Total	542896.000	166				
Corrected Total	6067.084	165				

Source: Field Survey, 2024

\* denotes significance at  $p \leq 0.05$

Table 4.16.1 shows that there was no significant interaction effect of Predict-Observe-Explain, Virtual Laboratory strategies (treatment) and gender on students' attitude towards Physics in secondary schools in Ogun State ( $F_{(2,159)}=0.649, p>0.05, \text{partial } \eta^2=0.008$ ). The null hypothesis was therefore not rejected. This implies that Predict-Observe-Explain, Virtual Laboratory strategies and gender did not have significant interaction effect on the students' attitude towards Physics in secondary schools in Ogun State. The partial eta square value of 0.008 shows the contributing effect size of 0.8%.

**Table 4.16.2: Estimated Marginal Means of Predict-Observe-Explain, Virtual Laboratory Strategies and Gender on Students' Attitude towards Physics**

Treatment Groups	Sex	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Predict-Observe-Explain Strategy (Exp Group 1)	Male	59.077	1.877	55.370	62.783
	Female	58.453	1.084	56.312	60.594
Virtual Laboratory Strategy (Exp Group 2)	Male	57.933	1.336	55.296	60.571
	Female	58.537	1.600	55.377	61.697
Control	Male	54.416	0.962	52.516	56.317
	Female	56.515	0.831	54.874	58.155

**Source:** Field Survey, 2024

Table 4.16.2 shows that male participants in the treatment group 1 had a higher mean score (59.077) than their female (58.453) counterparts. This implied that the interaction of treatment and gender had a better effect on students' attitude towards Physics in secondary schools in Ogun State among male participants who were exposed to Predict-Observe-Explain strategy than their female counterparts. Table 4.17.2 further reveals that female participants in the treatment group 2 had a higher mean score (58.537) than their male (57.933) counterparts. This implied that the interaction of treatment and gender had a better effect on students' attitude towards Physics in secondary schools in Ogun State among female participants who were exposed to Virtual Laboratory strategy than their male counterparts.

In the control group, the female participants had a higher mean score (56.515) than their male (54.416) counterparts. This implied that the interaction of treatment and gender had a better effect on students' attitude towards Physics in secondary schools in Ogun State among female participants who are

in the control group. The overall comparison shows that male participants in the treatment group 1 had a higher mean score (59.077), followed by female participants in treatment group 2 with a mean score of 58.537, while the male participants in control group had the least mean score (54.416). It implies that the interaction of treatment and gender had a better effect on students' attitude towards Physics in secondary schools in Ogun State among male participants who were exposed to Predict-Observe-Explain Strategy than their female counterparts in the same group and other participants in treatment group 2 and control group, respectively.

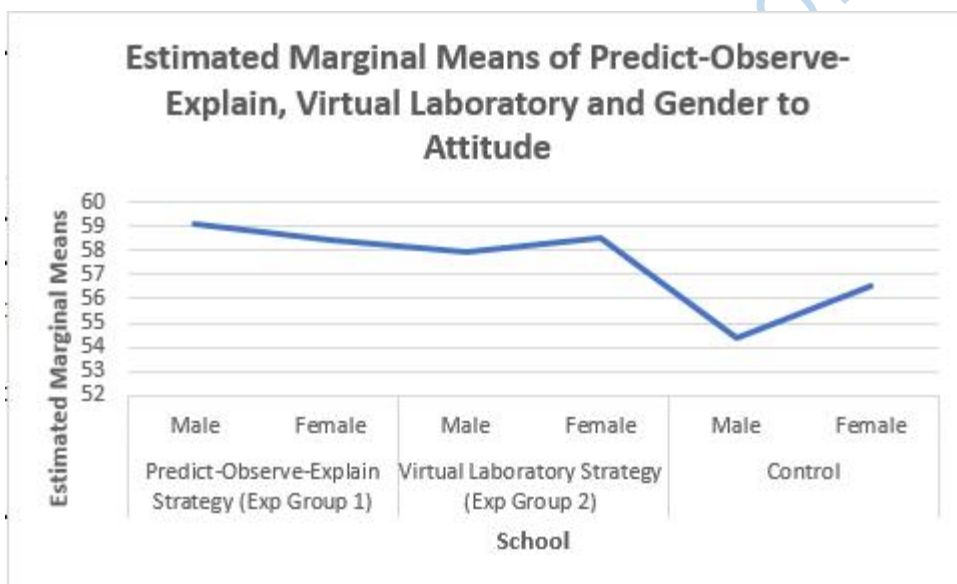


Figure 4.7: Graphical illustration of the 3-way interaction effect of Predict-Observe-Explain, Virtual Laboratory and Gender to Attitude

**H<sub>07b</sub>:** There will be no significant interaction effect of Predict-Observe-Explain, Virtual Laboratory strategies and gender on students' achievement in Simple Harmonic Motion in Physics in secondary schools in Ogun State.

**Table 4.17.1: Analysis of Covariance of Interaction Effect of Predict-Observe-Explain (POES), Virtual Laboratory Strategies (VLS) and Gender on Students' Achievement in Simple Harmonic Motion in Physics**

Source	Type III Sum of Squares	df	Mean Square	F	Sig.	Partial Eta Squared
Corrected Model	13428.135	6	2238.023	212.290	0.000	0.889
Intercept	9765.691	1	9765.691	926.334	0.000	0.854
Pretest	4.881	1	4.881	0.463	0.497	0.003
Treatments	11818.557	2	5909.279	560.530	0.000	0.876
Gender	10.505	1	10.505	0.996	0.320	0.006
POES*VLS* Gender	72.019	2	36.010	3.416	0.035*	0.041
Error	1676.226	159	10.542			
Total	67458.000	166				
Corrected Total	15104.361	165				

Source: Field Survey, 2024

\* denotes significance at  $p \leq 0.05$

Table 4.17.1 shows that there was a significant interaction effect of Predict-Observe-Explain, Virtual Laboratory strategies (treatment) and gender on students' achievement in Simple Harmonic Motion in Physics in secondary schools in Ogun State ( $F_{(2,159)}=3.416, p<0.05, \text{partial } \eta^2=0.041$ ). The null hypothesis was therefore rejected. This implies that Predict-Observe-Explain, Virtual Laboratory strategies and gender had significant interaction effect on the students' achievement in Simple Harmonic Motion in Physics in secondary schools in Ogun State. The partial eta square value of 0.041 shows the contributing effect size of 4.1%.

**Table 4.17.2: Estimated Marginal Means of Predict-Observe-Explain, Virtual Laboratory Strategies and Gender on Students' Achievement in Simple Harmonic Motion in Physics**

Treatment Groups	Gender	Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Predict-Observe-Explain Strategy (Exp Group 1)	Male	27.580	1.033	25.539	29.621
	Female	27.272	0.593	26.101	28.443
Virtual Laboratory Strategy (Exp Group 2)	Male	27.597	0.729	26.157	29.038

Control	Female	28.480	0.839	26.824	30.136
	Male	10.926	0.515	9.910	11.942
	Female	8.585	0.456	7.685	9.486

**Source:** Field Survey, 2024

Table 4.17.2 shows that male participants in the treatment group 1 had a higher mean score (27.580) than their female (27.272) counterparts. This implied that the interaction of treatment and gender had a better effect on students' achievement in Simple Harmonic Motion in Physics in secondary schools in Ogun State among male participants who were exposed to Predict-Observe-Explain strategy than their female counterparts. Table 4.18.2 further reveals that female participants in the treatment group 2 had a higher mean score (28.480) than their male (27.597) counterparts. This implied that the interaction of treatment and gender had a better effect on students' achievement in Simple Harmonic Motion in Physics in secondary schools in Ogun State among female participants who were exposed to Virtual Laboratory strategy than their male counterparts.

In the control group, the male participants had a higher mean score (10.926) than their female (8.585) counterparts. This implied that the interaction of treatment and gender had a better effect on students' achievement in Simple Harmonic Motion in Physics in secondary schools in Ogun State among male participants who are in the control group. The overall comparison shows that female participants in the treatment group 2 had a higher mean score (28.480), followed by male participants in the same group with a mean score of 27.597, while the female participants in control group had the least mean score (8.585). It implies that the interaction of treatment and gender had a better effect on students' achievement in Simple Harmonic Motion in Physics in secondary schools in Ogun State among female participants who were exposed to Virtual Laboratory strategy than their male counterparts in the same group and other participants in treatment group 1 and control group, respectively.

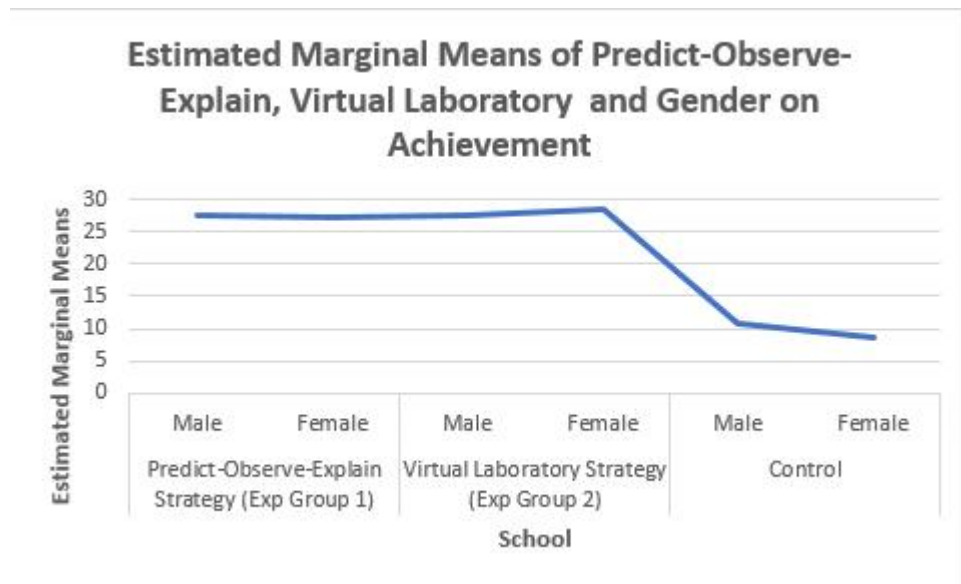


Figure 4.8: Graphical illustration of the 3-way interaction effect of Predict-Observe-Explain, Virtual Laboratory and Gender on Achievement

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### **4.3 Discussion of Findings**

#### **Effect of Predict-Observe-Explain Strategy on Students' Attitude in Physics**

The finding showed significant main effect of Predict-Observe-Explain strategy on students' attitude towards Physics. This finding is not surprising, given the fact that POE strategy is a learner-centered instructional strategy and the students were involved in active learning. Students learn best when they are interested in whatever they are doing. The use of Predict-Observe-Explain strategy falls within the domain of active learning of constructivists where learners are actively involved in the process of teaching and learning. Interactive experiences increase attitude and attitude increase performance<sup>1</sup>.

Attitude as an individual attribute can be developed, influence and changed over time. The finding is in consonance with a study which investigated the effects of activities, based on POE, about growth and development in plant on pre-service science teachers' attitudes toward science teaching and the effect of Predict-Observe-Explain (POE) Strategy on students' achievement and attitude towards Physics<sup>2, 3</sup>. The finding however negates earlier finding of the study which investigated the effects of predict-observe-explain strategy on students' academic achievement, scientific process skills and attitude towards science where no difference was observed in their attitude towards science<sup>4</sup>.

#### **Effect of Predict-Observe-Explain Strategy on Students' Achievement in Physics**

The finding showed significant effect of Predict-Observe-Explain strategy on students' achievement in Physics. The learners in the Predict-Observe-Explain group performed simple and specific tasks to clarify their conceptions and make some intellectual guesses about the lesson topic,

therefore, the Predict-Observe-Explain instructional strategy proved better than the conventional teaching strategy. These tasks and guesses include: predicting the outcome of an event, justifying your predictions, observing a real-life event, and explaining their observations. Specifically, learners were required to perform the activities, identify their preconceptions, take responsibility for, and identify any misconceptions and correct them. As a result of these intellectual guesses, learners were able to be more involved and responsible learners in the classroom by contributing to what the teacher taught instead of being passive listeners. Therefore, the process of teaching-learning was centered on learners.

As a result of the roles learners played, their self-confidence developed, which removed barriers of inferiority complexes among them, especially when handling apparatus and equipment. They were also empowered to take responsibility for their own learning. Learning resulted in overall improvements in learners' abilities to perform better in the practical activities they participated in during the lesson as a result of their roles in Predict-Observe-Explain Instructional strategy.

Additionally, learners' better performance was due to the fact that Predict-Observe-Explain Instructional strategy uses a deductive method of reasoning drawn from prediction, otherwise known as generalizations to observations. The reason for this is that learners' prior knowledge was revealed through their predictions, and they were accountable for those predictions based on the explanations provided. The accuracy of the predictions was confirmed by putting them to the test through hands-on activities, including conducting laboratory experiments according to instructions. It is entirely the learners' obligation to decide for themselves whether or not to accept their initial predictions. This strategy allowed them to take complete ownership of recognizing any pre-conceived notions or misunderstandings they held, leading to the correction of said misunderstandings. In essence, their learning was improved and made permanent, and their potential was realized.

The finding corroborated earlier findings of the effect of POE strategy on the Chemistry achievement of secondary school students<sup>5</sup>. The finding also agrees with the finding of the effects of

Predict-Observe-Explain instructional strategy on students' practical skills in Physics which reported that POE was more effective than conventional method of teaching for high school students in Physics<sup>6</sup>.

The participants were involved in the process of learning, they felt, touched, arranged and perform experiments during the treatment period. A plausible reason for this outcome might be due to the fact that students exposed to Predict-Observe-Explain strategy participated actively in the learning process than the conventional group. Active engagement helps the students to construct knowledge and organize information into meaningful schema<sup>7</sup>. Thus, when learners are actively involved in the process of learning, they construct new information from their existing mental framework for meaningful learning to occur either through the process of accommodation or assimilation<sup>8</sup>. This is in line with one of the principles of learning that says students learn well when they are actively involved in the learning process<sup>9</sup>

### **Effect of Virtual Laboratory Strategy on Students' Attitude in Physics**

The students' behavior, preparedness for the subject, and participation during practical classes are influenced by their attitude. The students taught Physics practical with Virtual Laboratory strategy developed positive attitudes towards Physics than those taught with conventional method.

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<sup>10</sup>. 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<sup>11</sup>.

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<sup>11</sup>. The finding of this study is also in line with a study which found out that learning using computer simulations was able to change the attitudes of

students to be more motivated towards Chemistry subject<sup>12</sup>. 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<sup>13</sup>.

### **Effect of Virtual Laboratory Strategy on Students' Achievement in Physics**

The finding of this study agrees with a study involving university students who investigated simulated electric circuits showing moving electrons acquired more conceptual knowledge than those using physical materials<sup>14</sup>. Similarly, the finding supported the study where students using virtual optics materials displaying light rays outperformed those using physical materials<sup>15</sup>. The idea that virtual experiments support the acquisition of conceptual knowledge because they produce clean data is a possible explanation for the significant difference in the students' achievement scores of the two groups (treatment and control).

Furthermore, the finding of this study is in line with a study where first-year secondary students conducting virtual Physics experiments outperformed those using a physical laboratory on conceptual understanding, which was partly explained by the data produced by the physical laboratory<sup>16</sup>. The study was also supported by research which was conducted to investigate how multimedia and computer animations affect students' knowledge level and achievement in science<sup>17</sup>. Students who were taught using computer simulations performed better than those who were taught conventionally. The result is also in conformity with a study on students' academic success in Chemistry through the use of the Chemistry Virtual Laboratory<sup>18</sup>.

However, finding of this study contradicts an investigation carried out to compare the achievement among students instructed using hands-on Chemistry laboratory versus those instructed using virtual Chemistry laboratory<sup>19</sup>. It was discovered that there was no significant difference in achievement gain scores for the traditional versus the virtual laboratory students. The findings obtained from the study demonstrated that students who completed the traditional hands-on experiment performed as well as students who completed the virtual experiments.

Similarly, the finding of virtual and physical equipment for measuring heat exchange, mass transfer, and humidification were compared and found no significant difference in the performance of chemical engineering students on a test measuring underlying principles which negates the finding of the present study<sup>20</sup>. There is no significant difference between virtual and physical experiments on tests of conceptual understanding as reported for students designing a car or for undergraduates learning about heat and temperature for measures of inquiry skills<sup>21</sup>. Studies carried out found no significant difference in virtual and physical experiments for students investigating the behavior of springs<sup>22</sup>. These studies illustrate that, for acquiring conceptual knowledge, virtual laboratories may replace physical ones

### **Effect of Gender on Students' Attitude to Physics**

Studies of science in general, rather than specific disciplines, suggest that boys have more positive attitudes towards science<sup>23</sup>. The difference in students' attitude in terms of gender will result in difference in achievement and readiness to achieve learning target<sup>24</sup>. This finding is in support of earlier research of science attitudes and achievement of secondary school students from various types of schools in Chennai, India<sup>25</sup>. In all school categories, it was discovered that girls had a more positive attitude toward learning science than boys did.

Similarly, the finding of this study conforms to a study which was carried out on, the effects of gender on students' attitude in Physics in senior secondary schools in Oyo State, Nigeria<sup>26</sup>. It was found that there was a slight difference in attitude among the students in favour of females in Physics. Additionally, the finding of this study is similar to those of high school students who were examined for Biology laboratory experiences and found that gender had a small, negative correlation with attitude toward Biology laboratory experiences, suggesting that girls have a more positive attitude than boys<sup>27</sup>. Furthermore, the finding also supported a similar study, Kuwaiti middle school students' attitudes toward science laboratory work, it was found that attitudes of girls toward science laboratory work are more positive than those of boys<sup>28</sup>.

However, the finding of this study contradicts with the findings of the study on cooperative learning's effects on students' attitudes toward laboratory work which was explored and found that both cooperative and non-cooperative groups showed significant gender differences, with boys having more positive attitudes than girls<sup>29</sup>. Similarly, it did not support the finding of a study on students' attitudes toward introductory Physics course<sup>30</sup>. It was found that there was a significance difference between male and female students' attitude toward Physics. Male students have more positive attitude toward Physics than female students.

Also, this study's finding is also at variance with that of a multidimensional study that examined approximately 4,000 students in grades 6 through 10 and found that boys had significantly higher positive attitudes towards science than girls<sup>31</sup>. Furthermore, the finding of this study did not support the finding of the study that found a correlation between students' attitudes towards Physics and their academic achievement in Physics<sup>32</sup>. The results indicated that there is a correlation between attitude and achievement for girls but not for boys and also showed that there is no difference in attitude between boys and girls towards Physics. Similarly, this finding is contrary to a study which showed that male and female students who have achieved high grades in Mathematics do not differ from one another when it comes to their attitudes towards Mathematics<sup>33</sup>. Also, the finding of this study did not support the findings in the study of gender and achievement in Mathematics by indigenous African students majoring in Mathematics which showed that African students do not differ in their attitudes and gender<sup>34</sup>.

### **Effect of Gender on Students' Achievement in Physics**

The effect of gender on students' achievement in Physics shows no significant main effect of gender on the students' achievements scores in Physics. This may be due to the fact that the strategies appealed to both male and female students. The common notion that male students are better academically or perform better than their female counterparts in some fields such as Physics had been challenged by the findings in this study.

It is therefore assumed that gender stereotyping could not have significantly affected the experimental processes involved in this study thus resulting in no significant main effect of gender on the students' achievement scores in Physics. The results of this study supported the finding of the influence of gender on secondary school students' academic achievement in Basic science using the cooperative learning strategy when examining the effect of gender on students' achievement in Physics<sup>35</sup>. The findings of the study showed that there was no significant difference between male and female students in terms of their academic performance at pretest, posttest or delayed test level.

The finding also agrees with the finding of 10<sup>th</sup> grade Biology students who were exposed to simulated experiment and found no gender difference in achievement<sup>36</sup>. The results of this study also corroborate those of a study that examined the biology achievement of students in private secondary schools in Oyo Town and Ibadan City, Nigeria, where the curriculum was taught using CAI without regard to gender<sup>37</sup>. The finding of this study is in the same direction with the finding of secondary school students who used online CAI as an additional scientific learning technique<sup>37</sup>. It was reported that there is no significant gender difference in achievement.

Additionally, the finding corroborates those of eighth-grade pupils in Ahwaz City, Iran's higher primary school, who were instructed in science using the CAI software programme<sup>38</sup>. There is no gender difference in achievement. The mean performance of male and female junior secondary three (JSIII) pupils exposed to computer assisted instruction (CAI) in Basic science and Technology did not differ significantly from one another<sup>39</sup>. Similarly, this study's finding corroborates those of another study that looked into how students' achievement in basic science was affected by computer-assisted instruction (CAI) and problem-solving instructional techniques<sup>40</sup>. The achievement was found not to have been significantly different. However, the present study's finding is at variance with that of a previous investigation into gender disparities in senior secondary school students' computational difficulties in Chemistry<sup>41</sup>. Analysis of the results showed that male students did not achieve significantly higher scores in Mathematical Chemistry than their female counterparts.

Similarly, the findings of a study on the impact of Constructivist teaching strategies in senior high school students' achievement and self-efficacy in Physics were not supported by the finding of this study<sup>42</sup>. Gender had a notable impact on students' Physics academic performance. Also, the finding of this study negates the study which examined the impact of gender and school location on science and Mathematics students' achievement in western senatorial District of Nassarawa State, Nigeria<sup>43</sup>.

The study revealed substantial disparities in Science and Mathematics grades between male and female students. The study of gender disparities in ICT usage among undergraduates contradicts the finding of this study<sup>44</sup>. The results indicated a disparity between male and female students' ICT use for academic purposes, with males utilizing it more frequently than their female peers.

Also, the results of this study were not supported by the results of the previous study, which showed that students who were taught science by gender sensitive teachers were more successful than students who were taught by non-gender sensitive teachers<sup>45</sup>. In India's class VII high school, girls outperformed males in the knowledge-based scientific subjects when the activity-based approach was used to teach them<sup>46</sup>. Additionally, the study's findings did not agree with the outcome of a t-test comparison of the academic performance of 300 male and 300 female students from various socioeconomic backgrounds in Pakistan's metropolitan city who took the ninth-grade annual examination administered by the Board of Intermediate and Secondary Education, Lahore<sup>47</sup>. In English and Mathematics, as well as in overall performance, it was found that girls performed significantly better than boys.

### **Interaction Effect of Predict-Observe-Explain and Virtual Laboratory Strategies on Students' Attitude towards Physics**

The result of the 2-way interaction effect of Predict-Observe-Explain and Virtual Laboratory strategies on students' attitude towards Physics shows that there was a significant main effect of treatments (Effect of Predict-Observe-Explain and Virtual Laboratory Strategies) on students' attitude

towards Physics. This implies that the combined treatment of (Effect of Predict-Observe-Explain and Virtual Laboratory Strategies) was effective on students' attitude towards Physics. The finding of this study showed no statistically significant difference between students' attitudes towards Physics in both experimental and control groups during the pretest period. This implies that the pretest attitude means scores of the students in the experimental groups (Predict-Observe-Explain Instructional strategy and Virtual Laboratory instructional strategy) and control group (conventional strategy) did not differ significantly. The three study groups were homogeneous prior to the experiment. To put it another way, the attitudes of the groups involved in the study were the same.

The finding of this study also showed a statistically significant difference in the attitude mean scores of the groups after the treatment. The experimental groups have higher mean attitude than their counterparts in the control group. This shows that after controlling for the effect of treatment on students' attitude towards Physics, the participants exposed to Predict-Observe-Explain strategy had the highest mean score followed by those exposed to Virtual Laboratory strategy, while the control group had the least. This implies that Predict-Observe-Explain strategy was more potent in relation to students' attitude towards Physics in secondary schools in Ogun State. This is in agreement with a study carried out which suggests that the Predict-Observe-Explain strategy has a positive impact on students' academic performance and attitudes towards Physics<sup>48</sup>.

### **Interaction Effect of Predict-Observe-Explain and Virtual Laboratory Strategies on Students' Achievement in Physics**

The result of the 2-way interaction effect of Predict-Observe-Explain and Virtual Laboratory strategies on students' attitude towards Physics shows that there was a significant main effect of treatments (Effect of Predict-Observe-Explain and Virtual Laboratory Strategies) on students' achievement in Physics. This implies that the combined treatment of (Effect of Predict-Observe-Explain and Virtual Laboratory strategies) was effective on students' achievement in Simple Harmonic Motion in Physics in secondary school in Ogun State. The finding of this study showed

that there was no statistically significant difference between students' performance in Physics practical tests at both experimental and control groups during the pretest. This implies that the pretest performance mean scores of the students in the experimental groups (Predict-Observe-Explain Instructional Strategy and Virtual Laboratory Instructional strategy) and control group (conventional laboratory strategy) did not differ significantly. The three study groups were homogeneous prior to the experiment. To put it in another way, the knowledge baseline of the groups involved in the study were the same.

The finding of this study also showed a statistically significant difference in the performance mean scores of the groups after the treatment. In comparison to the control group, the experimental groups performed better. This shows that after controlling for the effect of treatment on students' achievement in Simple Harmonic Motion in Physics, the participants exposed to Virtual Laboratory strategy had the highest mean score, followed by those exposed to Predict-Observe-Explain strategy, while the control group had the least. This implies that Virtual Laboratory strategy was more potent in relation to students' achievement in Simple Harmonic Motion in Physics. This corroborated research conducted in the virtual laboratory, which demonstrated its effects on students' performance and attitudes towards Chemistry<sup>49</sup>. In comparison to traditional teaching methods, the results of the study showed that virtual laboratory applications had a positive impact on students' learning outcomes.

### **Interaction Effect of Predict-Observe-Explain Strategy and Gender on Students' Attitude towards Physics**

The result of the 2-way interaction effect of Predict-Observe-Explain and gender on students' attitude towards Physics shows that that there was no significant interaction effect of Predict-Observe-Explain (treatment) and gender on students' attitude toward Physics. This implies that treatment and gender had no significant interaction effect on the students' attitude towards Physics. This shows that male participants in the treatment group had a higher mean score than their female

counterparts. This implies that the interaction of treatment and gender had a better effect on students' attitude towards Simple Harmonic Motion in Physics in secondary schools in Ogun State among male participants who were exposed to Predict-Observe-Explain strategy than their female counterparts. In the control group, the female participants had a higher mean score than their male counterparts. This implies that the interaction of treatment and gender had a better effect on students' attitude towards Physics in secondary schools in Ogun State among female participants in the control group than their male counterparts. This finding is in support of earlier research of attitude towards learning Science and Science achievement among secondary school students from different types of schools in the city of Chennai, India<sup>25</sup>. In all school categories, it was discovered that girls had a more positive attitude toward learning science than boys did.

Similarly, the finding of this study conforms to a study which was carried out on, the effects of gender on students' attitude in Physics in senior secondary schools in Oyo State, Nigeria<sup>26</sup>. It was found that there was a slight difference in attitude among the students in favour of females in Physics. The overall comparison shows that male participants in experimental 1 group had the highest mean score, followed by female participants in experimental group 2, while the male participants in control group had the least. It implies the interaction of treatment and gender had a better effect on students' attitude towards Physics in secondary schools in Ogun State among male participants who were exposed to Predict-Observe-Explain strategy than their female counterparts; and other participants in the control group respectively.

The finding of this study supports the finding of a study on students' attitudes toward introductory Physics course<sup>29</sup>. It was found that there was a significance difference between male and female students' attitude toward Physics. Male students had positive attitude toward Physics than female students. Also, the finding is in conformity with the finding of a multidimensional study among approximately 4,000 students in Grades 6 through 10, where it was found that boys exhibited significantly more positive attitudes towards science than girls<sup>30</sup>.

## **Interaction Effect of Predict-Observe-Explain Strategy and Gender on Students' Achievement in Physics**

The result of the 2-way interaction effect of Predict-Observe-Explain and gender on students' achievement in Physics shows that there was no significant interaction effect of Predict-Observe-Explain (treatment) and gender on students' achievement in Physics. This implies that treatment and gender had no significant interaction effect on the students' achievement in Physics. This shows that male participants in the treatment group had a higher mean score than their female counterparts. This implies that the interaction of treatment and gender had a better effect on students' achievement in Simple Harmonic Motion in Physics in secondary schools in Ogun State among male participants who were exposed to Predict-Observe-Explain strategy than their female counterparts. In the control group, the male participants had a higher mean score than their female counterparts. This implies that the interaction of treatment and gender had a better effect on students' achievement in Simple Harmonic Motion in Physics in secondary schools in Ogun State among male participants in the control group than their female counterparts.

The finding agrees with the study of gender differences in the utilization of information and communication technology (ICT) among undergraduate students<sup>43</sup>. Result showed that there is a significant difference between the mean scores of male and female students in ICT utilization for academic activities which indicate that male students use ICT more than their female counterparts. The overall comparison shows that male participants in experimental 1 group had the highest mean score, followed by male participants in experimental group 2, while the female participants in control group had the least. It implies the interaction of treatment and gender had a better effect on students' achievement in Simple Harmonic Motion in Physics in secondary schools in Ogun State among male participants who were exposed to Predict-Observe-Explain strategy than their female counterparts; and other participants in the control group, respectively.

The finding of this study did not conform to the result of a t-test comparison of the academic performance of 300 males and 300 females in the ninth-grade annual examination (conducted by the Board of Intermediate and Secondary Education, Lahore) of secondary school students from different socio-economic backgrounds in the metropolitan city of Pakistan undertook<sup>46</sup>. It was observed that girls performed significantly better than boys in English Language and Mathematics as well as in the overall achievement scores.

### **Interaction Effect of Virtual Laboratory Strategy and Gender on Students' Attitude towards Physics**

The result of the 2-way interaction effect of Virtual Laboratory Strategy and Gender on Students' Attitude towards Physics shows that there was no significant interaction effect of Virtual Laboratory strategy (treatment) and gender on students' attitude towards Physics. This implies that treatment and gender had no significant interaction effect on the students' attitude towards Physics.

This shows that female participants in the treatment group had a higher mean score than their male counterparts. This implies that the interaction of treatment and gender had a better effect on students' attitude towards Physics in secondary schools in Ogun State among female participants who were exposed to Virtual Laboratory strategy than their male counterparts. In the control group, the female participants had a higher mean score than their male counterparts. This implies that the interaction of treatment and gender had a better effect on students' attitude towards Physics in secondary schools in Ogun State among female participants in the control group than their male counterparts. The overall comparison shows that female participants in experimental group 1 had the highest mean score,

followed by male participants in experimental group 2, while the male participants in control group had the least. It implies the interaction of treatment and gender had a better effect on students' attitude towards Physics in secondary schools in Ogun State among female participants who were exposed to Predict-Observe-Explain strategy than their male counterparts; and other participants in the control group respectively.

This study corroborates previous studies on secondary school students' attitudes about learning science and their achievement in the subject from various school types in Chennai, India<sup>25</sup>. In all school categories, it was discovered that girls had a more positive attitude toward learning science than boys did. Similarly, the finding of this study conforms to a study which was carried out on the effects of gender on students' attitude in Physics in senior secondary schools in Oyo State, Nigeria<sup>26</sup>. It was found that there was a slight difference in attitude among the students in favour of females in Physics.

### **Interaction Effect of Virtual Laboratory Strategy and Gender on Students' Achievement in Physics**

The result of the 2-way interaction effect of virtual laboratory strategy and gender on Students' achievement in Physics shows that there was a significant interaction effect of Virtual Laboratory strategy (treatment) and gender on students' achievement in Physics. This implies that treatment and gender had a significant interaction effect on the students' achievement in Physics in secondary schools. This shows that female participants in the treatment group had a higher mean score than their male counterparts. This implies that the interaction of treatment and gender had a better effect on students' achievement in Simple Harmonic Motion in Physics in secondary schools in Ogun State among female participants who were exposed to Virtual Laboratory strategy than their male counterparts. In the control group, the male participants had a higher mean score than their female counterparts. This implies that the interaction of treatment and gender had a better effect on students' achievement in Simple Harmonic Motion in Physics in secondary schools in Ogun State among male

participants in the control group than their female counterparts. The overall comparison shows that female participants in experimental group 1 had the highest mean score, followed by male participants in experimental group 2, while the female participants in control group had the least. It implies the interaction of treatment and gender had a better effect on students' achievement in Simple Harmonic Motion in Physics in secondary schools in Ogun State among female participants who were exposed to Virtual Laboratory strategy than their male counterparts; and other participants in the control group, respectively.

The finding of this study did support the finding of the previous study in which students who were taught science by gender sensitive teachers performed significantly better than those who were taught by non-gender sensitive teachers<sup>45</sup>. Indian high school class VII girls performed significantly better than boys on knowledge-based science items taught through activity-based strategies<sup>46</sup>. Furthermore, the findings of this study are in accordance with the results of the t-test that compared the performance of 300 males and 300 females in the ninth-grade annual examinations (conducted by the Board of Intermediate and Secondary Education, Lahore). In the metropolitan city of Pakistan, secondary school students of different socioeconomic backgrounds took part in the examination<sup>47</sup>. Girls performed significantly better in English Language and Mathematics as well as overall achievement than boys.

However, the finding of this study did not support the finding that gender influences Junior secondary students' academic achievement in Basic Science using co-operative learning methods<sup>35</sup>. The findings of the study showed that there was no significant difference between male and female students in terms of their academic performance at pretest, posttest or delayed test level. Furthermore, the finding is in agreement with that of a study in which 10th grade Biology students were exposed to simulated experiments and found no gender difference in achievement<sup>36</sup>.

**Interaction Effect of Predict-Observe-Explain (POES), Virtual Laboratory Strategies (VLS) and Gender on Students' Attitude towards Physics**

The result of the 3-way interaction effect of Predict-Observe-Explain (POES), Virtual Laboratory Strategies (VLS) and Gender on Students' Attitude towards Physics shows that there was no significant interaction effect of Predict-Observe-Explain, Virtual Laboratory strategies (treatment) and gender on students' attitude towards Physics. This implies that Predict-Observe-Explain, Virtual Laboratory strategies and gender did not have significant interaction effect on the students' attitude towards Physics. This shows that male participants in the experimental group 1 had a higher mean score than their female counterparts. This implies that the interaction of treatment and gender had a better effect on students' attitude towards Physics in secondary schools in Ogun State among male participants who were exposed to Predict-Observe-Explain strategy than their female counterparts.

This further reveal that female participants in the experimental group 2 had a higher mean score than their male counterparts. This implies that the interaction of treatments and gender had a better effect on students' attitude towards Physics in secondary schools in Ogun State among female participants who were exposed to Virtual Laboratory strategy than their male counterparts. In the control group, the female participants had a higher mean score than their male counterparts. This implies that the interaction of treatments and gender had a better effect on students' attitude towards Physics in secondary schools in Ogun State among female participants who are in the control group. The overall comparison shows that male participants in the experimental group 1 had a higher mean score, followed by female participants in experimental group 2, while the male participants in control group had the least. It implies that the interaction of treatment and gender had a better effect on students' attitude towards Physics in secondary schools in Ogun State among male participants who were exposed to Predict-Observe-Explain strategy than their female counterparts in the same group and other participants in experimental group 2 and control group, respectively.

The finding is in consonance with a study which examined the effects of activities based on POE, about growth and development in plants on pre-service science teachers' attitudes toward science teaching and the impact of Predict-Observe-Explain (POE) Strategy on students' achievement

and attitude toward Physics<sup>2, 3</sup>. The finding, however negates earlier finding of the study which investigated the effects of predict-observe-explain strategy on students' academic achievement, scientific process skills and attitude towards science where no difference was observed in their attitude towards science<sup>4</sup>

### **Interaction Effect of Predict-Observe-Explain (POES), Virtual Laboratory Strategies (VLS) and Gender on Students' Achievement in Physics**

The result of the 3-way interaction effect of Predict-Observe-Explain (POES), Virtual Laboratory Strategies (VLS) and gender on students' achievement in Physics shows that there was a significant interaction effect of Predict-Observe-Explain, Virtual Laboratory strategies (treatment) and gender on students' achievement in Simple Harmonic Motion in Physics. This implies that Predict-Observe-Explain, Virtual Laboratory strategies and gender had significant interaction effect on the students' achievement in Simple Harmonic Motion in Physics in secondary schools in Ogun State.

This shows that male participants in the experimental group 1 had a higher mean score than their female counterparts. This implies that the interaction of treatment and gender had a better effect on students' achievement in Simple Harmonic Motion in Physics in secondary schools in Ogun State among male participants who were exposed to Predict-Observe-Explain strategy than their female counterparts.

This further reveal that female participants in the experimental group 2 had a higher mean score than their male counterparts. This implies that the interaction of treatments and gender had a better effect on students' achievement in Simple Harmonic Motion in Physics in secondary schools in Ogun State among female participants who were exposed to Virtual Laboratory strategy than their male counterparts. In the control group, the male participants had a higher mean score than their female counterparts. This implies that the interaction of treatments and gender had a better effect on students' achievement in Simple Harmonic Motion in Physics in secondary schools in Ogun State

among male participants who are in the control group. The overall comparison shows that female participants in the experimental group 2 had a higher mean score, followed by male participants in the same group, while the female participants in control group had the least. It implies that the interaction of treatment and gender had a better effect on students' achievement in Simple Harmonic Motion in Physics in secondary schools in Ogun State among female participants who were exposed to Virtual Laboratory strategy than their male counterparts in the same group and other participants in experimental group 1 and control group, respectively.

The finding of this study agrees with those of a previous investigation into gender disparities in senior secondary school students' Mathematical Chemistry <sup>41</sup>. Analysis of the results showed that male students did not achieve significantly higher scores in Mathematical Chemistry than their female counterparts. Similarly, the findings of a study on the impact of Constructivist teaching strategies in senior high school students' achievement and self-efficacy in Physics were supported by the findings of this study<sup>42</sup>, where Gender had impacted students' academic performance in Physics

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## Chapter Five

### Conclusion

This chapter deals with information on the summary and conclusion of the study. The study goes further by making recommendations according to its findings for effective policy implication and to raise areas that would be requiring attention as suggestion for further studies

### 5.1 Summary of Findings

(70) (42.5%) of the participants were males, while (96) (57.8%) were females. (166) (100.0%) participants were involved in the study. (59) (35.5%) of the participants were in the age range of 12-14 years, (94) (56.6%) were between 15-16 years, while (13) (7.8%) were 17 years and above. (40) (24.0%) of the participants were exposed to Predict-Observe-Explain, (35) (21.0%) were exposed to Virtual Laboratory while (91) (55.0%) participants were in control group. This study reveals the following major findings concerning the main and interaction effects:

There was a significant main effect of Predict-Observe-Explain strategy on students' attitude towards Physics ( $F_{(1,128)}=6.349$ ,  $p<0.05$ , partial  $\eta^2=0.047$ ). There was a significant main effect of Predict-Observe-Explain strategy on students' achievement in Simple Harmonic Motion in Physics ( $F_{(1,128)}=682.814$ ,  $p<0.05$ , partial  $\eta^2=0.842$ ). There was a significant main effect of Virtual Laboratory strategy on students' attitude towards Physics ( $F_{(1,123)}=5.318$ ,  $p<0.05$ , partial  $\eta^2=0.041$ ). There was a significant main effect of Virtual Laboratory strategy on students' achievement in Physics ( $F_{(1,123)}=625.120$ ,  $p<0.05$ , partial  $\eta^2=0.836$ ). There was no significant main effect of gender on students' attitude towards Physics ( $F_{(1,163)}=1.747$ ,  $p>0.05$ , partial  $\eta^2=0.011$ ). There was no significant main effect of gender on students' achievement in Physics ( $F_{(1,163)}=0.067$ ,  $p>0.05$ , partial  $\eta^2=0.000$ ). There was a significant interaction effects of Predict-Observe-Explain and Virtual Laboratory Strategies on students' attitude towards Physics ( $F_{(2,162)}=4.322$ ,  $p<0.05$ , partial  $\eta^2=0.047$ ). There was a significant interaction effects of Predict-Observe-Explain and Virtual Laboratory Strategies on students' achievement in Simple Harmonic Motion ( $F_{(2,162)}=586.719$ ,  $p<0.05$ , partial  $\eta^2=0.047$ ). There was no significant interaction effects of Predict-Observe-Explain and gender on students' attitude towards Physics ( $F_{(1,126)}=1.073$ ,  $p>0.05$ , partial  $\eta^2=0.008$ ).

There was no significant interaction effects of Predict-Observe-Explain and gender on students' achievement in Physics ( $F_{(1,126)}=2.009$ ,  $p>0.05$ , partial  $\eta^2=0.016$ ). There was no significant interaction effects of Virtual Laboratory strategy and gender on students' attitude towards Physics ( $F_{(1,121)}=0.356$ ,  $p>0.05$ , partial  $\eta^2=0.003$ ). There was a significant interaction effects of Virtual Laboratory strategy

and gender on students' achievement in Simple Harmonic Motion ( $F_{(1,121)}=5.219$ ,  $p<0.05$ , partial  $\eta^2=0.041$ ). There was no significant interaction effects of Predict-Observe-Explain, Virtual Laboratory strategies and gender on students' attitude towards Physics ( $F_{(2,159)}=0.649$ ,  $p>0.05$ , partial  $\eta^2=0.008$ ). There was a significant interaction effect of Predict-Observe-Explain, Virtual Laboratory strategies and gender on students' achievement in Simple Harmonic Motion ( $F_{(2,159)}=3.416$ ,  $p<0.05$ , partial  $\eta^2=0.041$ ).

## 5.2 Conclusion

This study investigated the effects of Predict-Observe-Explain and Virtual Laboratory strategies on secondary school Physics students' attitude to and achievement in Simple Harmonic Motion in Ogun State. The instructional strategies that were employed in this study emphasized the participation and active intellectual involvement of students. These learners centered activity-based strategies (Predict-Observe-Explain and Virtual Laboratory) proved better than the conventional method. This study concluded that Predict-Observe-Explain and Virtual Laboratory instructional strategies enhanced students' performance in Physics. Virtual laboratory instruction proved to be the better of the two strategies (Predict-Observe-Explain and Virtual Laboratory)

## 5.3 Recommendations

These findings led to the following recommendations:

1. It is important to train secondary school Physics teachers on how to use the Predict-Observe-Explain and Virtual Laboratory strategies to improve the teaching of Physics.

2. The utilization of Virtual Laboratory instructional strategy by Physics teachers in secondary schools should be encouraged.
3. Predict-Observe -Explain or Virtual Laboratory strategy should be adopted by Physics teachers so as to correct the pre-conceived notion of students about the concept (Simple Harmonic Motion).
4. Students of Physics irrespective of gender should be given equal opportunities in the learning process using Predict – Observe- Explain or Virtual Laboratory instructional strategy as the two strategies have been shown to be efficacious in addressing issues of differences in gender especially in science education.
5. Physics topics especially, abstract concepts should be taught by associating them with the daily life of the students using simple demonstrations, class activities, team work, and home-work among others.
6. Physics teachers should be encouraged to be computer literate. This will enable them to appreciate and use virtual laboratory instruction to promote effective teaching and learning
7. Federal, State and Local Government should upgrade the infrastructures and equip laboratories in order for the students to be actively involved in their learning.
8. Teacher education programme in Nigerian tertiary institutions should be improved upon to prepare teachers who can apply innovative approached (Predict-Observe-Explain and Virtual Laboratory instructional package) which will promote effective teaching and learning.
9. The instructional designers, computer programmers, instructional developers should develop relevant Virtual laboratory packages for use within the Nigerian school systems.
10. Teachers should expose Physics students to virtual laboratory package so as to promote active learning, discovery learning, motivation, learning by doing and learning by experience among

#### **5.4 Contribution to Knowledge**

This study has contributed to knowledge by proving the efficacy of Predict-Observe-Explain and Virtual Laboratory instructional strategies, thereby providing teachers with effective methods of

teaching Simple Harmonic Motion (SHM) as students' attitude towards and achievement, in Simple Harmonic Motion were found to be greatly enhanced by the use of Predict-Observe-Explain and Virtual Laboratory instructional strategies. This study has also contributed to knowledge by establishing that the use of Predict-Explain-Observe and Virtual Laboratory instructional strategies does not engender gender disparity in students' attitude and achievement towards and in Simple Harmonic Motion (SHM). This indicates that the issue of gender disparity could be minimized in science education if the strategies are embraced by teachers and students. It has also contributed by adding to the existing pool of empirical studies in the study area

### 5.5 Suggested Areas for Further Research

1. There is need to replicate the study using other states in Nigeria to support the validity of this study.
2. These strategies can be replicated at the primary and tertiary levels to determine its effectiveness in improving learning outcomes.
3. It is recommended that a replicated study of this work using other secondary school subjects apart from Physics would be a worthwhile venture as this will increase the scope to which the strategies could be used.
4. Apart from the moderating variable in this study, efforts could be made to investigate the effects of other variables like numerical ability and cognitive style on students learning outcomes in Physics

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## Appendix A

### Physics Achievement Test (Pre-Test)

Name of School.....

Class.....

Gender.....

**Instruction: Answer all the Questions. Each Question Carries Equal Mark**      **Time: 1  $\frac{1}{2}$  hrs**

1. What is the period of a simple pendulum which makes 60 oscillations in one minute?  
A.) 1.0s      B) 10.0s      C) 60.0s      D) 7.75s
2. The period of a 10 kHz radio wave traveling at  $1088 \text{ ms}^{-1}$  is  
A.)  $3.0 \times 10^{-5} \text{ s}$     B)  $1.0 \times 10^{-4} \text{ s}$     C)  $1.0 \times 1044 \text{ s}$     D)  $3.0 \times 1044 \text{ s}$
3. A spring of force constant  $500 \text{ Nm}^{-1}$  is acted upon by a constant force of 50N. Calculate the potential energy stored in the spring

A) 2.5 J B) 1.25J C) 7.50J D) 15.0J

4. A vertical string, suspended from a fixed point and having a small mass attached to the free end is set into oscillations. Which of the following statements about the system are correct?

i. The potential energy of the mass is a minimum at the middle of the swing  
ii. Its kinetic energy is a maximum at the middle of the swing  
iii. The sum of the potential and kinetic energies is constant throughout the swing

A) i, ii and iii B) i and ii only C) ii and iii only D) i and iii only

5. Two simple pendulum A and B of equal lengths and of masses 5g and 20g respectively are located in the same environment. The periods  $T_A$  and  $T_B$  of their respective oscillations are related by the equations

A)  $T_A = 4T_B$  B)  $T_A = 14T_B$  C)  $T_A = T_B$  D)  $T_A = 5T_B$

6. A simple pendulum makes 50 oscillations in one minute. Determine its period of oscillation

A) 0.02 Hz B) 0.83 Hz C) 1.20 Hz D) 50.00 Hz

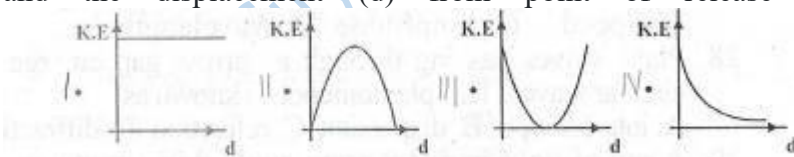
7. The maximum displacement on either side of the equilibrium position of an object in simple harmonic motion represents

A) Period B) amplitude C) wavelength D) frequency

8. The period of a simple pendulum X is 5s. What is the period of a simple pendulum Y which makes 50 vibrations in the same time it takes X to make 20 vibrations?

A) 12.5s B) 2.5s C) 2.0s D) 1.2s

9. Which of the following graphs correctly represents the relationship between the kinetic energy (K.E) and the displacement (d) from point of release of a swinging pendulum bob?



A) I B) II C) III D) IV

10. The energy stored in a spring of stiffness constant  $k = 2000Nm^{-1}$  when extended 4cm is

A) 0.16J B) 1.60J C) 16.00J D) 160.00J

11. The bob of a simple pendulum takes 8.0s to complete 10 oscillations. Determine the frequency of oscillation of the bob.

A) 0.125Hz B) 1.25Hz C) 7.50Hz D) 8.00Hz

12. Frequency is measured in  
A) Meter per second B) Seconds C) Hertz D) Farad
13. Which of the following will reduce the frequency of oscillation of a simple pendulum?  
A). Increasing the length of a string B). Increasing the mass of the bob C). Increasing the amplitude of oscillation D). Decreasing the mass of the bob E.) Decreasing the length of the string
14. Which of the following types of motion will be produced when a pair of equal and opposite non-collinear parallel forces acts on a body?  
A) Vibrational motion B) Random motion C) Translational motion D) Rotational motion
15. The period of a simple pendulum of length 80.0cm was found to have doubled when the length of the pendulum was increased by X. Calculate X.  
A). 26.7cm B). 40.0cm C). 160.0cm D). 240.0cm
16. A body executing simple harmonic motion has an angular speed of  $2\pi$  radians. Its period of oscillation is  
A). 0.05s B). 1.00s C). 2.00s D). 3.14s E.) 6.28s
17. The length of a simple pendulum is increased by a factor of four. By what factor is its period increased?  
A). 0.25 B). 0.5 C). 1.66 D). 2 E.) 4
18. The time  $t_1$ ,  $t_2$  and  $t_3$  for 20 complete oscillations of a simple pendulum experiment are 32.0s, 34.6s and 35.5s respectively. Calculate the mean period of the pendulum.  
A). 1.60s B.) 1.70s C). 1.73s D). 1.78s E). 5.11s
19. The frequency of a body executing simple harmonic motion when left undisturbed is known as \_\_\_\_\_ frequency.  
A). damped B) forced C) free D) natural E) sinusoidal
20. The motion of the prongs of a sounding tuning fork is  
A.) circular B) oscillatory C) random D) rotational E.) translational
21. Which of the following motions will be produced by a pair of equal, opposite and non-collinear parallel forces acting on a body?  
A) Oscillatory B) Random C) Rotational D) Translational E) Vibratory

22. A body executing a simple harmonic motion has an angular velocity of 22 radians per second. If it has a maximum displacement of 10cm, what is its linear velocity?
- A)  $1100\text{ms}^{-1}$  B)  $440\text{ms}^{-1}$  C)  $220\text{ms}^{-1}$  D)  $22\text{ms}^{-1}$  E)  $2.2\text{ms}^{-1}$
23. In a simple pendulum experiment, a boy observed that the times for 30 oscillations are 70.0s, 72.0s and 67.0s respectively. Calculate the mean period of oscillation of the pendulum.
- A) 0.14s B) 0.43s C) 2.32s D) 2.40s E) 6.97s
24. A swinging pendulum between the rest position and its maximum displacement possesses
- A) kinetic energy only B) potential energy only C) gravitational energy only D) both kinetic and potential energy
25. A block of mass 4.0kg causes a spiral spring to extend by 0.16m from its un-stretched position. The block is removed and another body of mass 0.50kg is hung from the same spiral spring. If the spring is then stretched and released, what is the angular frequency of the subsequent motion? [ $g = 10\text{ms}^{-2}$ ]
- A)  $105\sqrt{5}\text{rads}^{-1}$  B)  $52\sqrt{2}\text{rads}^{-1}$  C)  $5\text{rads}^{-1}$  D)  $5\sqrt{5}\text{rads}^{-1}$
26. An object is said to undergo oscillatory motion when it moves
- A) in an erratic manner B) to and fro about a fixed-point C) in a circular path D) along a continuous path from the starting point
27. Which of the following statements about simple harmonic motion is correct? The
- A) Total mechanical energy is always conserved B) linear acceleration is directed to any variable point C) Linear acceleration varies inversely with displacement D) period of oscillation varies linearly as acceleration due to gravity
28. The frequency of a swinging pendulum is the
- A) number of complete revolutions per unit of time B) number of amplitudes the bob makes in a second C) angle the bob swings through in a second D) distance the bob covers in a second
29. Which of the following about an object performing simple harmonic motion is correct? Its acceleration
- A) is maximum at the extreme ends B) is constant and directed towards a fixed point
- C) is zero when it is displaced from the equilibrium position D) varies linearly with the displacement from a fixed point and is directed towards the fixed point
30. Two simple pendula x and y make 400 and 500 oscillations respectively in equal time. If the period of oscillation of x is 1.5 seconds, what is the period of oscillation of y?

A) 0.53s B) 0.83s C) 1.20s D) 1.50s E) 1.88s

## Appendix B

### Marking Guide for Physics Achievement Test (Pre-Test)

1. A	11. B	21. C
2. B	12. C	22. E
3. A	13. E	23. C
4. C	14. D	24. D
5. C	15. D	25. A
6. B	16. D	26. B
7. B	17. D	27. A
8. C	18. B	28. A
9. B	19. D	29. D
10. B	20. B	30. C

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**Appendix C**

**Physics Achievement Test (Post-Test)**

**Name of School.....**

**Class.....**

**Gender.....**

**Instruction: Answer all the Questions. Each Question Carries Equal Mark      Time: 2hrs**

1. Two simple pendula x and y make 400 and 500 oscillations respectively in equal time. If the period of oscillation of x is 1.5 seconds, what is the period of oscillation of y?

A.) 0.53s B) 0.83s C) 1.20s D) 1.50s E) 1.88s

2. Which of the following about an object performing simple harmonic motion is correct? Its acceleration
- A) is maximum at the extreme ends B) is constant and directed towards a fixed-point C) is zero when it is displaced from the equilibrium position D) varies linearly with the displacement from a fixed point and is directed towards the fixed point
3. The frequency of a swinging pendulum is the
- A) number of complete revolutions per unit of time B) number of amplitudes the bob makes in a second C) angle the bob swings through in a second D) distance the bob covers in a second
4. Which of the following statements about simple harmonic motion is correct? The
- A) total mechanical energy is always conserved B) linear acceleration is directed to any variable point C) linear acceleration varies inversely with displacement D) period of oscillation varies linearly as acceleration due to gravity
5. An object is said to undergo oscillatory motion when it moves
- A) in an erratic manner B) to and fro about a fixed-point C) in a circular path D) along a continuous path from the starting point
6. A block of mass 4.0kg causes a spiral spring to extend by 0.16m from its un-stretched position. The block is removed and another body of mass 0.50kg is hung from the same spiral spring. If the spring is then stretched and released, what is the angular frequency of the subsequent motion? [ $g = 10 \text{ ms}^{-2}$ ]
- A)  $105\sqrt{5} \text{ rads}^{-1}$  B)  $52\sqrt{2} \text{ rads}^{-1}$  C)  $5 \text{ rads}^{-1}$  D)  $5\sqrt{5} \text{ rads}^{-1}$
7. A swinging pendulum between the rest position and its maximum displacement possesses
- A) Kinetic energy only B) potential energy only C) gravitational energy only D) both kinetic and potential energy
8. In a simple pendulum experiment, a boy observed that the times for 30 oscillations are 70.0s, 72.0s and 67.0s respectively. Calculate the mean period of oscillation of the pendulum.
- A) 0.14s B) 0.43s C) 2.32s D) 2.40s E) 6.97s
9. A body executing a simple harmonic motion has an angular velocity of 22 radians per second. If it has a maximum displacement of 10cm, what is its linear velocity?
- A)  $1100\text{ms}^{-1}$  B)  $440 \text{ ms}^{-1}$  C)  $220 \text{ ms}^{-1}$  D)  $22 \text{ ms}^{-1}$  E)  $2.2\text{ms}^{-1}$
10. Which of the following motions will be produced by a pair of equal, opposite and non-collinear parallel forces acting on a body?

A) Oscillatory B) Random C) Rotational D) Translational E) Vibratory

11. The motion of the prongs of a sounding tuning fork is

A) Circular B) oscillatory C) random D) rotational E) translational

12. The frequency of a body executing simple harmonic motion when left undisturbed is known as \_\_\_\_\_ frequency.

A) Damped B) forced C) free D) natural E) sinusoidal

13. The time  $t_1$ ,  $t_2$  and  $t_3$  for 20 complete oscillations of a simple pendulum experiment are 32.0s, 34.6s and 35.5s respectively. Calculate the mean period of the pendulum.

A) 1.60s B) 1.70s C) 1.73s D) 1.78s E) 5.11s

14. The length of a simple pendulum is increased by a factor of four. By what factor is its period increased?

A) 0.25 B) 0.5 C) 1.66 D) 2 E) 4

15. A body executing simple harmonic motion has an angular speed of  $2\pi$  radians. Its period of oscillation is

A) 0.05s B) 1.00s C) 2.00s D) 3.14s E) 6.28s

16. The period of a simple pendulum of length 80.0cm was found to have doubled when the length of the pendulum was increased by X. Calculate X.

A) 26.7cm B) 40.0cm C) 160.0cm D) 240.0cm

17. Which of the following types of motion will be produced when a pair of equal and opposite non-collinear parallel forces acts on a body?

A) vibrational motion B) random motion C) translational motion D) rotational motion

18. Which of the following will reduce the frequency of oscillation of a simple pendulum?

A) Increasing the length of a string B) Increasing the mass of the bob C) Increasing the amplitude of oscillation D) Decreasing the mass of the bob E) Decreasing the length of the string

19. Frequency is measured in

A) Meter per second B) Seconds C) Hertz D) Farad

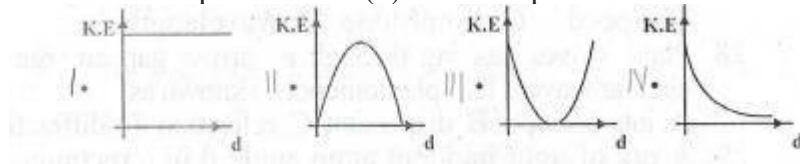
20. The bob of a simple pendulum takes 8.0s to complete 10 oscillations. Determine the frequency of oscillation of the bob.

A) 0.125Hz B) 1.25Hz C) 7.50Hz D) 8.00Hz

21. The energy stored in a spring of stiffness constant  $k = 2000 \text{ Nm}^{-1}$  when extended 4cm is

- A) 0.16J   B) 1.60J   C) 16.00J   D) 160.00J

22. Which of the following graphs correctly represents the relationship between the kinetic energy (K.E) and the displacement (d) from point of release of a swinging pendulum bob?



- A) I   B) II   C) III   D) IV

23. The period of a simple pendulum X is 5s. What is the period of a simple pendulum Y which makes 50 vibrations in the same time it takes X to make 20 vibrations?

- A) 12.5s   B) 2.5s   C) 2.0s   D) 1.2s

24. The maximum displacement on either side of the equilibrium position of an object in simple harmonic motion represents

- A) Period   B) Amplitude   C) Wavelength   D) Frequency

25. A simple pendulum makes 50 oscillations in one minute. Determine its period of oscillation

- A) 0.02 Hz   B) 0.83 Hz   C) 1.20 Hz   D) 50.00 Hz

26. Two simple pendulum A and B of equal lengths and of masses 5g and 20g respectively are located in the same environment. The periods  $T_A$  and  $T_B$  of their respective oscillations are related by the equations

- A)  $T_A = 4T_B$    B)  $T_A = 14T_B$    C)  $T_A = T_B$    D)  $T_A = 5T_B$

27. A vertical string, suspended from a fixed point and having a small mass attached to the free end is set into oscillations. Which of the following statements about the system are correct?

- i. The potential energy of the mass is a minimum at the middle of the swing  
 ii. Its kinetic energy is a maximum at the middle of the swing  
 iii. The sum of the potential and kinetic energies is constant throughout the swing

- A) i, ii and iii   B) i and ii only   C) ii and iii only   D) i and iii only

28. A spring of force constant  $500 \text{ Nm}^{-1}$  is acted upon by a constant force of 50N. Calculate the potential energy stored in the spring

- A) 2.5 J   B) 1.25J   C) 7.50J   D) 15.0J

29. The period of a 10 kHz radio wave traveling at  $1088 \text{ ms}^{-1}$  is

- A)  $3.0 \times 10^{-5} \text{ s}$    B)  $3.0 \times 10^{-5} \text{ s}$    C)  $1.0 \times 10^{-4} \text{ s}$    D)  $1.0 \times 10^{44} \text{ s}$    E)  $3.0 \times 10^{44} \text{ s}$

30. What is the period of a simple pendulum which makes 60 oscillations in one minute?

A) 1.0s B) 10.0s C) 60.0s D) 7.75s

## Appendix D

### Marking Guide for Physics Achievement Test (Post-test)

1. C	11. B	21. B
2. D	12. D	22. B
3. A	13. B	23. C
4. A	14. D	24. B
5. B	15. D	25. B
6. A	16. D	26. C
7. D	17. D	27. C
8. C	18. E	28. A
9. E	19. C	29. B
10. C	20. B	30. A

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**Appendix E**

**Physics Attitude Scale (PAS)**

**Instruction:**

This instrument seeks the students view about each of the statement therein. Kindly respond to the items as correspond to your view. Your responses will be treated confidentially

**Section A**

**NAME OF SCHOOL**.....

**SEX:** ..... **CLASS**.....

**AGE RANGE (YRS):** 12-14 ( ), 15-16 ( ), 17+ ( )

**Section B**

Please tick (✓) as appropriate in the space that corresponds to your feelings or view about each of the Statements that follow

**Key: SA= Strongly Agree, A= Agree, D= Disagree, SD= Strongly Disagree**

	SA	A	D	SD
1. I am sure that I can learn Physics 2. My teachers have been interested in my progress in Physics 3. Knowing Physics will help me earn a living. 4. I don't think I could do a Simple harmonic Motion 5. Physics will not be important to me in my life's work. 6. Males are not naturally better than females in Physics 7. Getting a teacher to take me seriously in Simple Harmonic Motion is a problem 8. Simple Harmonic Motion is hard for me. 9. It's hard to believe a female could be a genius in Physics 10. I'll need Physics for my future work 11. When a woman has to solve a Physics problem, she should ask a man for help 12. I am sure of myself when I do Physics. 13. I don't expect to use much Physics when I get out of school				
14. I would talk to my Physics teachers about a career which uses math 15. Women can do just as well as men in Physics 16. It's hard to get Physics teachers to respect me 17. Physics is a worthwhile, necessary subject. 18. I would have more faith in the answer for a Simple Harmonic Motion problem solved by a man than a woman 19. I'm not the type to do well in Physics 20. My teachers have encouraged me to study more Physics				

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## **Appendix F**

### **Instructional Guide for Experimental Group 1**

#### **Lesson Note I**

<b>School:</b>	As Applicable
<b>Subject:</b>	Physics
<b>Class:</b>	SSII
<b>Topic:</b>	Experiment on verification of Hooke's Law
<b>Number in class:</b>	As applicable

**Average Age:** 16 years  
**Sex:** Mixed  
**Duration:** 80 Minutes  
**Date:** As applicable

**Objectives of the lesson:**

Students should be able to do the following at the end of the lesson:

- investigate Hooke’s Law as well as the parameters within the concept of simple harmonic motion
- graphically and analytically interpret Hooke’s Law
- understand the concept of Simple Harmonic Motion.

**Instructional Materials:** Spring Balance, weights of different masses, retort stand, clamp, metre rule

**Previous knowledge:** They have been taught Elasticity of materials

**Instructional Procedure/Presentation**

Content Development	Time (Mins)	Teacher’s Activities	Students’ Activities
<b>Step 1</b> Introduction	5	Teacher probes into students’ prior knowledge through questions such as: to state Hooke’s law of Elasticity and define Simple Harmonic Motion  Makes known to the students the teaching technique and its demand on them	Students answer the questions asked by the teacher
<b>Step 2</b> Grouping/Elicitation of Students’ ideas	15	Divides students into groups of 4-7; asks them to assume the role of captain, recorder, time-keeper and so on.	Move into different groups and assume different roles as agreed by members
<b>Step 3</b> Setting up the experiment	5	Outlines the experiment's	
<b>Step 4</b> Predict (P)	10	At this step, before doing the experiment. Asks the students to predict the answers to some questions based on the earlier introduced experiment (noting that the answers to the questions can be addressed through the experiment that follows in step 5	Captain directs discussion based on questions and the directives given by the teacher to guide their actions. Students spread out their individually written predictions on a flat surface (desk), where it can easily be read. Have

		<p>Asks students to predict answers to questions or events such as;          Is Hooke's law obey? Give reason          Each member of the group is expected to write out their prediction on pieces of papers supplied them. They are to compare individual answers and collectively brainstorm to come out with group ideas on all questions raised thus far. Predictions are to be written down on the POE worksheet supplied to them by the recorder are those agreed upon by the entire group          Goes round various groups to supervise the activities.</p>	<p>a look at each other's predictions, and make quick comments. Then, the recorder for the group or whoever is assigned, write down their prediction(s) as agreed upon by the group and directed by the group captain on the POE worksheet</p>
<p><b>Step 5</b>          observe (O)</p>	35	<p>Instructs the students to carry out the laboratory activities as follows</p> <ul style="list-style-type: none"> <li>•Suspend the spiral spring vertically on the retort stand firmly</li> <li>•Attach to the lower end the first of the slotted weights</li> <li>•Clamp the metre rule vertically along the side of the spiral spring so that a small pointer (a pin) attached to the bottom of the weights moves along lightly against the metre rule</li> <li>•Record the reading of the pointer as <math>e</math>, and the weight <math>w_1</math> attached to the spiral spring</li> <li>•Increase the force by successive increments of 10 or 20 g and record the pointer reading each time</li> <li>•When you have taken about five of such readings start unloading the weights and again record the pointer readings</li> <li>•Tabulate your readings as in</li> </ul>	<p>Follow the teacher's instructions. The students follow the instructions step by step and record their observation          Spread out their individually written observations on a flat surface (desk), where it can easily be read. Have a look at each other's observations, and make quick comments. Then, the recorder for the group or whoever is assigned, write down their observation(s) as agreed upon by the group and directed by the group captain on the POE worksheet</p>

		the section for observations (Teacher views the observations written down by the respective groups)	
<b>Step 6</b> Explaining the Observations (E)	10	<p>Each member of the group is expected to write out their explanation for their observation on pieces of papers supplied them. They are to compare individual explanations and collectively brainstorm to come out with group explanations to observations. explanations to their observations are to be written down on the POE worksheet supplied to them by the recorder are those agreed upon by the entire group Goes round various groups to supervise the activities. (While students are writing, you might stroll around so as to prepare yourself for the discussion that will follow).</p> <p>Then, asks each group to present their POE worksheet in full-class discussion, by placing the worksheet on a chalkboard. (At this stage, the POE worksheet contains highlights of the predictions-explanations-observations-explanations for each group). After this has been done, teacher might discuss with the class which observation and explanations or reasons they now think are best. At this stage, teacher then engages the students to correlate their prediction with their observation so as to reconstruct their thinking and also reconcile any conflict between their predictions and observations.</p> <p>Ask the students to</p>	<p>Students spread out their individually written explanation to their observations on a flat surface (desk), where it can easily be read. Have a look at each other's explanations, and make quick comments. Then, the recorder for the group write down the explanation for their observation(s) as agreed upon by the group and directed by the group captain on the POE worksheet</p> <p>Students to share their POE worksheet containing their predictions, explanation for their predictions, observations and explanations for their observation in full-class discussion</p> <p>Team leaders or selected group representatives makes their respective presentations in full class discussion</p> <p>At this stage, in order to reconcile any discrepancy between predictions and observations, students are expected to compare their predictions and observations in a brief full class discussion.</p>

		disengage from their groupings	Students move to their respective sits.
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**Teacher's evaluation of the lesson:**

Students are asked the following questions:

- i. How are load and extension related?
- ii. Consider oscillating spring with mass attached, if the mass of the object doubled, what will happen to period of the oscillation

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**Appendix G**

**Instructional Guide for Experimental Group 1**

**Lesson Note II**

**Subject:** Physics

**Topic:** Determination of force constant of a spring

**Duration:** 80 Minutes

**Objectives of the lesson:**

Students should be able to determine the force constant of a spiral spring by the end of the lesson.

**Instructional Materials:** Spring Balance, weights of different masses, retort stand, clamp, metre rule

**Previous knowledge:** They have been taught Elasticity of materials

**Instructional Procedure/Presentation**

Content Development	Time (Mins)	Teacher's Activities	Students' Activities
<b>Step 1</b> Introduction	5	Teacher probes into students' prior knowledge through questions such as: what is force constant? what is the unit of force constant?  Makes known to the students the teaching technique and its demand on them	Students answer the questions asked by the teacher
<b>Step 2</b> Grouping/Elicitation of Students' ideas	15	Divides students into groups of 4-7; asks them to assume the role of captain, recorder, time-keeper and so on.	Move into different groups and assume different roles as agreed by members
<b>Step 3</b> Setting up the experiment	5	Outlines the experiment aim	
<b>Step 4</b> Predict (P)	10	At this step, before doing the experiment. Asks the students to predict the answers to some questions based on the earlier introduced experiment (noting that the answers to the questions can be addressed through the experiment that follows in step 5 Asks students to predict answers to questions or events such as; As the stretching force (i.e. the weight attached to the spring) increases, what happens to the extension, give reason Each member of the group is expected to write out their prediction on pieces of papers supplied them. They are to compare individual answers and collectively brainstorm to come	Captain directs discussion based on questions and the directives given by the teacher to guide their actions. Students spread out their individually written predictions on a flat surface (desk), where it can easily be read. Have a look at each other's predictions, and make quick comments. Then, the recorder for the group or whoever is assigned, write down their prediction(s) as agreed upon by the group and directed by the group captain on the POE worksheet

		<p>out with group ideas on all questions raised thus far. Predictions are to be written down on the POE worksheet supplied to them by the recorder are those agreed upon by the entire group</p> <p>Goes round various groups to supervise the activities.</p>	
<p><b>Step 5</b> Observe (O)</p>		<p>Instructs the students to carry out the laboratory activities as follows</p> <ul style="list-style-type: none"> <li>• Suspend the spiral spring vertically on the retort stand firmly</li> <li>• Attach to the lower end the first of the slotted weights</li> <li>• Clamp the metre rule vertically along the side of the spiral spring so that a small pointer (a pin) attached to the bottom of the weights moves along lightly against the metre rule</li> <li>• Record the reading of the pointer as <math>e</math>, and the weight <math>w_1</math> attached to the spiral spring</li> <li>• Increase the force by successive increments of 10 or 20 g and record the pointer reading each time</li> <li>• When you have taken about five of such readings start unloading the weights and again record the pointer readings</li> <li>• Tabulate your readings as in the section for observations</li> </ul> <p>(Teacher views the observations written down by the respective groups)</p>	<p>Follow the teacher's instructions. The students follow the instructions step by step and record their observation</p> <p>Spread out their individually written observations on a flat surface (desk), where it can easily be read. Have a look at each other's observations, and make quick comments. Then, the recorder for the group or whoever is assigned, write down their observation(s) as agreed upon by the group and directed by the group captain on the POE worksheet</p>
<p><b>Step 6</b> Explaining the Observations (E)</p>	10	<p>Each member of the group is expected to write out their explanation for their observation on pieces of papers supplied them. They are to compare individual explanations and</p>	<p>Students spread out their individually written explanation to their observations on a flat surface (desk), where it can easily be read. Have a</p>

		<p>collectively brainstorm to come out with group explanations to observations. explanations to their observations are to be written down on the POE worksheet supplied to them by the recorder are those agreed upon by the entire group</p> <p>Goes round various groups to supervise the activities. (While students are writing, you might stroll around so as to prepare yourself for the discussion that will follow).</p> <p>Then, asks each group to present their POE worksheet in full-class discussion, by placing the worksheet on a chalkboard. (At this stage, the POE worksheet contains highlights of the predictions-explanations-observations-explanations for each group).</p> <p>After this has been done, teacher might discuss with the class which observation and explanations or reasons they now think are best. At this stage, teacher then engages the students to correlate their prediction with their observation so as to reconstruct their thinking and also reconcile any conflict between their predictions and observations.</p> <p>Ask the students to disengage from their groupings</p>	<p>look at each other's explanations, and make quick comments. Then, the recorder for the group write down the explanation for their observation(s) as agreed upon by the group and directed by the group captain on the POE worksheet</p> <p>Students to share their POE worksheet containing their predictions, explanation for their predictions, observations and explanations for their observation in full-class discussion</p> <p>Team leaders or selected group representatives makes their respective presentations in full class discussion</p> <p>At this stage, in order to reconcile any discrepancy between predictions and observations, students are expected to compare their predictions and observations in a brief full class discussion.</p> <p>Students move to their respective sits.</p>
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**Evaluation:**

Students are asked the following questions:

- i. Plot the graph of weight in Newton on the y-axis against the extension on the x-axis
- ii. Find the slope and interpret the result

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**Appendix H**  
**Instructional Guide for Experimental Group 1**  
**Lesson Note III**

**Subject:** Physics

**Topic:** Determination of effective mass of a spiral spring by oscillation method

**Duration:** 80 Minutes

**Objectives of the lesson:** Students should be able to determine the effective mass of a spiral spring at the end of the lesson

**Instructional Materials:** A spiral spring, a set of slotted weights, a stop watch, Retort stand and clamp, Split cork

**Previous knowledge:** The students have been taught Simple Harmonic Motion

### Instructional Procedure/Presentation

Content Development	Time (Mins)	Teacher's Activities	Students' Activities
<b>Step 1</b> Introduction	5	Teacher probes into students' prior knowledge through questions such as: what is oscillation movement? Give 5 examples of oscillation movement  Makes known to the students the teaching technique and its demand on them	Students answer the questions asked ask by the teacher
<b>Step 2</b> Grouping/Elicitation of Students' ideas	15	Divides students into groups of 4-7; asks them to assume the role of captain, recorder, time-keeper and so on.	Move into different groups and assume different roles as agreed by members
<b>Step 3</b> Setting up the experiment	5	Outlines the experiment's aim	
<b>Step 4</b> Predict (P)	10	At this step, before doing the experiment. Asks the students to predict the answers to some questions based on the earlier introduced experiment (noting that the answers to the questions can be addressed through the experiment that follows in step 5 Asks students to predict	Captain directs discussion based on questions and the directives given by the teacher to guide their actions. Students spread out their individually written predictions on a flat surface (desk), where it can easily be read. Have a look at each other's predictions, and make quick comments. Then,

		<p>answers to questions or events such as;          What is the nature of graph of <math>T^2</math> and <math>M</math>, give reason?</p> <p>Each member of the group is expected to write out their prediction on pieces of papers supplied them. They are to compare individual answers and collectively brainstorm to come out with group ideas on all questions raised thus far. Predictions are to be written down on the POE worksheet supplied to them by the recorder are those agreed upon by the entire group          Goes round various groups to supervise the activities.</p>	<p>the recorder for the group or whoever is assigned, write down their prediction(s) as agreed upon by the group and directed by the group captain on the POE worksheet</p>
<p><b>Step 5</b> Observe</p>	35	<p>Instructs the students to carry out the laboratory activities as follows</p> <ul style="list-style-type: none"> <li>• Set the spiral spring on the retort stand rigidly by using the split cork.</li> <li>• Mark the equilibrium position of the slotted weight and use it as a reference point</li> <li>• Give the hanger and weight a small displacement downwards to set the spiral spring oscillating</li> <li>• Determine the time <math>t</math> for 20 complete oscillations using 10 g mass of the slotted weight</li> <li>• Repeat this timing</li> <li>• Increase the load by another 10 g weight and again take the time for 20 complete</li> </ul>	<p>Follow the teacher's instructions. The students follow the instructions step by step and record their observation          Spread out their individually written observations on a flat surface (desk), where it can easily be read. Have a look at each other's observations, and make quick comments. Then, the recorder for the group or whoever is assigned, write down their observation(s) as agreed upon by the group and directed by the group captain on the POE worksheet</p>

		<p>oscillations twice</p> <ul style="list-style-type: none"> <li>• Continue to increase the load on the hanger for another three sets of weights and then determine the corresponding time for 20 complete oscillations</li> </ul> <p>(Teacher views the observations written down by the respective groups)</p>	
<p><b>Step 6</b> Explaining the Observations (E)</p>	<p>10</p>	<p>Each member of the group is expected to write out their explanation for their observation on pieces of papers supplied them. They are to compare individual explanations and collectively brainstorm to come out with group explanations to observations. explanations to their observations are to be written down on the POE worksheet supplied to them by the recorder are those agreed upon by the entire group</p> <p>Goes round various groups to supervise the activities. (While students are writing, you might stroll around so as to prepare yourself for the discussion that will follow).</p> <p>Then, asks each group to present their POE worksheet in full-class discussion, by placing the worksheet on a chalkboard. (At this stage, the POE worksheet contains highlights of the predictions-explanations-observations-explanations for each group). After this has been done, teacher might discuss with the class which observation and explanations or reasons they now think are best. At this stage, teacher then engages the</p>	<p>Students spread out their individually written explanation to their observations on a flat surface (desk), where it can easily be read. Have a look at each other's explanations, and make quick comments. Then, the recorder for the group write down the explanation for their observation(s) as agreed upon by the group and directed by the group captain on the POE worksheet</p> <p>Students to share their POE worksheet containing their predictions, explanation for their predictions, observations and explanations for their observation in full-class discussion</p> <p>Team leaders or selected group representatives makes their respective presentations in full class discussion</p> <p>At this stage, in order to reconcile any discrepancy between predictions and observations, students are expected to compare their predictions and observations in a brief full class discussion.</p>

	<p>students to correlate their prediction with their observation so as to reconstruct their thinking and also reconcile any conflict between their predictions and observations.</p> <p>Ask the students to disengage from their groupings</p>	<p>Students move to their respective sits.</p>
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**Evaluation:**

Asks the students the following questions:

Plot the graph of T<sup>2</sup> on the y-axis against the corresponding values of M on the x-axis.

Calculate the value of k from slope =  $\frac{4\pi^2}{k}$

Find the intercept of the graph on the x-axis.

What is the effective mass of the spiral spring?

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**Appendix I**  
**Instructional Guide for Experimental Group 1**  
**Lesson Note IV**

**Subject:** Physics

**Topic:** Determination of acceleration due to gravity by means of the Simple Pendulum.

**Duration:** 80 Minutes

**Objectives of the lesson:** Students should be able to determine the value of acceleration due to gravity by using the Simple Pendulum at the end of the lesson

**Instructional Materials:** Small pendulum bob made up of lead or brass, Cotton thread, Split cork, Meter rule, Stop watch, Retort stand and clamp

**Previous knowledge:** The students have been taught Simple Harmonic motion

**Instructional Procedure/Presentation**

Content Development	Time (Mins)	Teacher's Activities	Students' Activities
<b>Step 1</b> Introduction	5	Teacher probes into students' prior knowledge through questions such as: what is acceleration? explain what is meant by acceleration due to gravity  Makes known to the students the teaching technique and its demand on them	Students answer the questions asked by the teacher
<b>Step 2</b> Grouping/elicitation of Students' ideas	15	Divides students into groups of 4-7; asks them to assume the role of captain, recorder, time-keeper and so on.	Move into different groups and assume different roles as agreed by members
<b>Step 3</b> Setting up the experiment	5	Outlines the experiment's aim	
<b>Step 4</b> Predict (P)	10	At this step, before doing the experiment. Asks the students to predict the answers to some questions based on the earlier introduced experiment (noting that the answers to the questions can be	Captain directs discussion based on questions and the directives given by the teacher to guide their actions. Students spread out their individually written

		<p>addressed through the experiment that follows in step 5</p> <p>Asks students to predict answers to questions or events such as;</p> <p>What is the nature of graph of <math>T^2</math> against <math>P</math>, what is the value of acceleration due to gravity?</p> <p>Each member of the group is expected to write out their prediction on pieces of papers supplied them. They are to compare individual answers and collectively brainstorm to come out with group ideas on all questions raised thus far. Predictions are to be written down on the POE worksheet supplied to them by the recorder are those agreed upon by the entire group</p> <p>Goes round various groups to supervise the activities.</p>	<p>predictions on a flat surface (desk), where it can easily be read. Have a look at each other's predictions, and make quick comments. Then, the recorder for the group or whoever is assigned, write down their prediction(s) as agreed upon by the group and directed by the group captain on the POE worksheet</p>
<p><b>Step 5</b> Observe</p>	35	<p>Instructs the students to carry out the laboratory activities as follows</p> <ul style="list-style-type: none"> <li>• Set the simple pendulum as shown in the diagram provided</li> <li>• Hang the pendulum bob on one end of the cotton thread and clamp the other end firmly between the two split corks</li> <li>• Allow the pendulum to dangle freely on the working bench</li> <li>• Use the metre rule to measure 95 cm length of the thread</li> <li>• Displace the pendulum through a small displacement, release and allow to swing</li> </ul> <p>Time 20 complete swings (A --&gt; B -&gt; C --&gt; B --&gt; A) is a complete swing or 1 oscillation as <math>t_1</math></p> <ul style="list-style-type: none"> <li>• Repeat for another 20 swings for the same length a time <math>t_2</math></li> </ul>	<p>Follow the teacher's instructions. The students follow the instructions step by step and record their observation</p> <p>Spread out their individually written observations on a flat surface (desk), where it can easily be read. Have a look at each other's observations, and make quick comments. Then, the recorder for the group or whoever is assigned, write down their observation(s) as agreed upon by the group and directed by the group captain on the POE worksheet</p>

		<ul style="list-style-type: none"> <li>• Find the mean time for <math>t_1</math> and <math>t_2</math></li> <li>• Repeat the above procedure of timing for other values of <math>l</math> such that <math>l = 85</math> cm, <math>75</math> cm, <math>65</math> cm, <math>55</math> cm <math>45</math> cm.</li> <li>• Tabulate your observations as shown below and complete the table for the period <math>T</math> and <math>T_2</math>.</li> </ul> <p>(Teacher views the observations written down by the respective groups)</p>	
<p><b>Step 6</b> Explaining the Observations (E)</p>	10	<p>Each member of the group is expected to write out their explanation for their observation on pieces of papers supplied them. They are to compare individual explanations and collectively brainstorm to come out with group explanations to observations. explanations to their observations are to be written down on the POE worksheet supplied to them by the recorder are those agreed upon by the entire group</p> <p>Goes round various groups to supervise the activities. (While students are writing, you might stroll around so as to prepare yourself for the discussion that will follow).</p> <p>Then, asks each group to present their POE worksheet in full-class discussion, by placing the</p>	<p>Students spread out their individually written explanation to their observations on a flat surface (desk), where it can easily be read. Have a look at each other's explanations, and make quick comments. Then, the recorder for the group write down the explanation for their observation(s) as agreed upon by the group and directed by the group captain on the POE worksheet</p> <p>Students to share their POE worksheet containing their predictions, explanation for their predictions, observations and</p>

		<p>worksheet on a chalkboard. (At this stage, the POE worksheet contains highlights of the predictions-explanations-observations-explanations for each group).</p> <p>After this has been done, teacher might discuss with the class which observation and explanations or reasons they now think are best. At this stage, teacher then engages the students to correlate their prediction with their observation so as to reconstruct their thinking and also reconcile any conflict between their predictions and observations.</p> <p>Ask the students to disengage from their groupings</p>	<p>explanations for their observation in full-class discussion</p> <p>Team leaders or selected group representatives makes their respective presentations in full class discussion</p> <p>At this stage, in order to reconcile any discrepancy between predictions and observations, students are expected to compare their predictions and observations in a brief full class discussion.</p> <p>.</p> <p>Students move to their respective sits.</p>
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**Evaluation:**

Plot the graph of T<sup>2</sup> on the y -axis and P on the x- axis.  
Determine the slope m of the graph as

$$m = \frac{\Delta T^2}{\Delta l}$$

**Appendix J**  
**Instructional Guide for Experimental Group 1**  
**Lesson Note V**

**Subject:** Physics

**Topic:** Acceleration due to gravity by means of the simple pendulum from inaccessible height.

**Duration:** 80 Minutes

**Objectives of the lesson:**

Students should be able to determine the value of acceleration due to gravity by means of the simple pendulum from inaccessible height at the end of the lesson

**Instructional Materials:** Small pendulum bob made up of lead or brass, Cotton thread of about 3 m long, a hook on the ceiling of the room or laboratory, Meter rule, Stop watch, A pair of scissors or blade

**Previous knowledge:** The students have been taught Simple Harmonic motion

**Instructional Procedure/Presentation:**

Content Development	Time (mins)	Teacher's Activities	Students' Activities
<b>Step 1</b> Introduction	5	Teacher probes into students' prior knowledge through questions such as: Period of the simple pendulum depends on what physical quantities  Makes known to the students the teaching technique and its demand on them	Students answer the questions asked ask by the teacher
<b>Step 2</b> Grouping/Elicitation of Students' ideas	15	Divides students into groups of 4-7; asks them to assume the role of captain, recorder, time-keeper and so on.	Move into different groups and assume different roles as agreed by members
<b>Step 3</b> Setting up the experiment	5	Outlines the experiment's	

<p><b>Step 4</b> Predict (P)</p>	<p>10</p>	<p>At this step, before doing the experiment. Asks the students to predict the answers to some questions based on the earlier introduced experiment (noting that the answers to the questions can be addressed through the experiment that follows in step 5)</p> <p>Asks students to predict answers to questions or events such as;</p> <p>If you increased the length of the pendulum what will happen to the period</p> <p>Each member of the group is expected to write out their prediction on pieces of papers supplied them. They are to compare individual answers and collectively brainstorm to come out with group ideas on all questions raised thus far. Predictions are to be written down on the POE worksheet supplied to them by the recorder are those agreed upon by the entire group</p> <p>Goes round various groups to supervise the activities.</p>	<p>Captain directs discussion based on questions and the directives given by the teacher to guide their actions. Students spread out their individually written predictions on a flat surface (desk), where it can easily be read. Have a look at each other's predictions, and make quick comments. Then, the recorder for the group or whoever is assigned, write down their prediction(s) as agreed upon by the group and directed by the group captain on the POE worksheet</p>
<p><b>Step 5</b> Observe (O)</p>	<p>35</p>	<p>Instructs the students to carry out the laboratory activities as follows:</p> <ul style="list-style-type: none"> <li>• Hang the simple pendulum from the ceiling using the hook such that the bob is about 30 cm</li> </ul>	<p>Follow the teacher's instructions. The students follow the instructions step by step and record their observation</p> <p>Spread out their individually written</p>

		<p>from the floor.</p> <ul style="list-style-type: none"> <li>•Measure accurately and record the height <math>h</math> from the floor of the room to the pendulum bob</li> <li>•Displace the pendulum bob through a small angle <math>\Theta</math> and allow it to oscillate freely.</li> <li>•Determine the time <math>t</math> for 20 oscillations and record as <math>t_1</math></li> <li>•Repeat steps (2) - (4) to determine time <math>t_2</math> for 20 oscillations for the same height <math>h</math> above the ground</li> <li>•Determine the mean time <math>t</math></li> <li>•Cut off 5 cm of the thread, retie the bob as closely as possible to the end of the thread to obtain a new height <math>h</math> above the ground and obtain the time <math>t_1</math> and <math>t_2</math> for the new height</li> <li>•Determine the new mean time <math>t</math> for the 20 oscillations</li> <li>•Repeat steps (7) and (8) three times to obtain three new heights <math>h</math> and <math>t_1</math>, <math>t_2</math> and <math>t</math></li> <li>•Tabulate your observations</li> </ul> <p>(Teacher views the observations written down by the respective groups)</p>	<p>observations on a flat surface (desk), where it can easily be read. Have a look at each other's observations, and make quick comments. Then, the recorder for the group or whoever is assigned, write down their observation(s) as agreed upon by the group and directed by the group captain on the POE worksheet</p>
<p><b>Step 6</b> Explaining the Observations (E)</p>	<p>10</p>	<p>Each member of the group is expected to write out their explanation for their observation on pieces of</p>	<p>Students spread out their individually written explanation to their</p>

	<p>papers supplied them. They are to compare individual explanations and collectively brainstorm to come out with group explanations to observations. explanations to their observations are to be written down on the POE worksheet supplied to them by the recorder are those agreed upon by the entire group</p> <p>Goes round various groups to supervise the activities. (While students are writing, you might stroll around so as to prepare yourself for the discussion that will follow).</p> <p>Then, asks each group to present their POE worksheet in full-class discussion, by placing the worksheet on a chalkboard. (At this stage, the POE worksheet contains highlights of the predictions-explanations-observations-explanations for each group).</p> <p>After this has been done, teacher might discuss with the class which observation and explanations or reasons they now think are best.</p> <p>At this stage, teacher then engages the students to correlate their prediction with their observation so as to reconstruct their thinking and also reconcile any conflict between their predictions and observations.</p> <p>Ask the students to disengage from their</p>	<p>observations on a flat surface (desk), where it can easily be read. Have a look at each other's explanations, and make quick comments. Then, the recorder for the group write down the explanation for their observation(s) as agreed upon by the group and directed by the group captain on the POE worksheet</p> <p>Students to share their POE worksheet containing their predictions, explanation for their predictions, observations and explanations for their observation in full-class discussion</p> <p>Team leaders or selected group representatives makes their respective presentations in full class discussion</p> <p>At this stage, in order to reconcile any discrepancy between predictions and observations, students are expected to compare their predictions and observations in a brief full class discussion</p> <p>Students move to their respective sits.</p>
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**Evaluation**

- i. Plot the graph of  $T^2$  on the y- axis and h on the x- axis.
- ii. Deduce the slope m of the graph
- iii. Determine the intercept of the graph on the x-axis when  $T^2 = 0$

**Appendix K****Instructional Guide for Experimental Group II****Lesson Note I**

<b>School:</b>	As Applicable
<b>Subject:</b>	Physics
<b>Class:</b>	SSII
<b>Topic:</b>	Experiment on verification of Hooke's Law
<b>Number in class:</b>	As applicable
<b>Average Age:</b>	16 years
<b>Sex:</b>	Mixed
<b>Duration:</b>	80 Minutes
<b>Date:</b>	As applicable

**Objectives of the lesson:**

Students should be able to do the following at the end of the lesson:

- investigate Hooke's Law as well as the parameters within the concept of simple harmonic motion
- graphically and analytically interpret Hooke's Law
- understand the concept of Simple Harmonic Motion.

**Instructional Materials:** Spring Balance, weights of different masses, retort stand, clamp, metre rule

**Previous knowledge:** They have been taught Elasticity of materials

**Instructional Procedure/Presentation**

Content	Teacher's Activities	Students' Activities
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Development		
<b>Step 1</b> Introduction	Teacher probes into students' prior knowledge through questions such as: to state Hooke's law of Elasticity and define Simple Harmonic Motion	Students answer the questions asked by the teacher
<b>Step 2</b> Setting up the experiment	Outlines the experiment's aim	Observe the demonstrational experiment
<b>Step 3</b> Constructing a table of readings.	Selects and demonstrates the simulated laboratory experiment on verification of Hooke's law from the PhET	Follow the teacher's instructions to verify Hooke's Law by performing the experiment
<b>Step 4</b> Plotting a graph of load against the extension	Answers students' questions	Construct table of readings.
	Assigns students to experimental stands in the physical laboratory in groups of five	Record measured values
	instructs students to repeat the procedure for the experiment as demonstrated by the teacher and generate group readings with a more value of $m$ and the corresponding extension	Ask questions when necessary.
	Deals with challenges faced by the group	
	Evaluates students by asking them questions	Answer evaluation questions

### Evaluation:

Students are asked the following questions:

- i. How are load and extension related?
- ii. Consider oscillating spring with mass attached, if the mass of the object doubled, what will happen to period of the oscillation

**Appendix L**  
**Instructional Guide for Experimental Group 1I**  
**Lesson Note II**

**Subject:** Physics

**Topic:** Determination of Elastic constant of a spring

**Duration:** 80 Minutes

**Objectives of the lesson:** Students should be able to determine the force constant of a spiral spring at the end of the lesson

**Instructional Materials:** Spring Balance, weights of different masses, retort stand, clamp, metre rule

**Previous knowledge:** They are familiar with Hooke's law

**Instructional Procedure/Presentation**

<b>Content Development</b>	<b>Teacher's activities</b>	<b>Students' activities</b>
<b>Step 1</b> Introduction	Teacher probes into students' prior knowledge through questions such as: what is force constant? What is the unit of force constant?	Students answer the questions asked by the teacher
<b>Step 2</b> Setting up the experiment	Outlines the experiment's aim	Observe the demonstrational experiment
<b>Step 3</b> Constructing a table of readings	Selects and demonstrates the simulated laboratory experiment on determination of elastic constant of a spring from the PhET.	Follow the procedure as demonstrated by the teacher to perform experiment determination of elastic constant of a spring
<b>Step 4</b> Plotting a graph of load against the	Answers students' questions	Construct table of readings.

extension		
	Assigns students to experimental stands in the physical laboratory in groups of five	Record measured values
	instructs students to repeat the procedure for the experiment as demonstrated by the teacher and generate group readings with a more value of m and the corresponding extension	Ask questions when necessary
	Deals with challenges faced by the group	
	Evaluates students by asking them questions	Answer evaluation questions

**Evaluation:**

Students are asked the following questions:

- i. Plot the graph of weight in Newtons on the y-axis against the extension on the x-axis
- ii. Find the slope and interpret the result

**Appendix M**  
**Instructional Guide for Experimental Group 1I**  
**Lesson Note III**

**Subject:** Physics

**Topic:** Determination of effective mass of a spiral spring by oscillation method

**Duration:** 80 Minutes

**Objectives of the lesson:** Students should be able to determine the effective mass of a spiral spring at the end of the lesson

**Instructional Materials:** A spiral spring, a set of slotted weights, a stop watch, Retort stand and clamp, Split cork

**Previous knowledge:** The students have been taught Simple Harmonic Motion

**Previous knowledge:** The students have been taught Simple Harmonic motion

**Instructional Procedure/Presentation**

Content Development	Teacher's Activities	Students' Activities
<b>Step 1</b> Introduction	Teacher probes into students' prior knowledge through questions such as what is period of an oscillation	Students answer the questions asked by the teacher
<b>Step 2</b> Setting up the experiment	Outlines the experiment's aim	observe the demonstrational experiment
<b>Step 3</b> Constructing a table of readings	Selects and demonstrates the simulated laboratory how to conduct the experiment on	Follow the procedure as demonstrated by the teacher to perform experiment on

	determination of effective mass of a spiral spring by oscillation method from the PhET	determination of effective mass of a spiral spring by oscillation method
<b>Step 4</b> Plotting a graph of Period of Oscillation against Mass	Answers students' questions	Construct table of
	Assigns students to experimental stands in the physical laboratory in groups of five	Record measured values
	Asks students to repeat the procedure for the experiment as demonstrated by the teacher and generate group readings with a more value of T and the corresponding mass	Ask questions when necessary
	Deals with challenges group group	
	Evaluates students by asking them questions	Answer evaluation questions

**Evaluation:**

Students are asked the following questions:

- i. Plot the graph of T against M
- ii. Find the slope of the graph

**Appendix N**  
**Instructional Guide for Experimental Group 1I**  
**Lesson Note IV**

**Subject:** Physics

**Topic:** Determination of acceleration due to gravity by means of the Simple Pendulum.

**Duration:** 80 Minutes

**Objectives of the lesson:** Students should be able to determine the value of acceleration due to gravity by using the simple pendulum at the end of the lesson

**Instructional Materials:** Small pendulum bob made up of lead or brass, Cotton thread, Split cork, Meter rule, Stop watch, Retort stand and clamp

**Previous knowledge:** The students have been taught Simple Harmonic motion

**Instructional Procedure/Presentation**

<b>Content Development</b>	<b>Teacher's Activities</b>	<b>Students' Activities</b>
<b>Step 1</b> Introduction	Teacher probes into students' prior knowledge through questions such as what is period of an oscillation	Students answer the questions asked by the teacher
<b>Step 2</b> Setting up the experiment	Outlines the experiment's aim	observe the demonstrational experiment
<b>Step 3</b> Constructing a table of	Selects and demonstrates the simulated laboratory how to conduct	Follow the procedure as demonstrated by the

readings	the experiment on determination of acceleration due to gravity by means of the Simple Pendulum from the PhET	teacher to perform experiment determination of acceleration due to gravity by means of the Simple Pendulum
<b>Step 4</b> Plotting a graph of $T^2$ against L	Answers students' questions	Construct table of readings
	Assigns students to experimental stands in the physical laboratory in groups of five	Record measured
	Instructs students to repeat the procedure for the experiment as demonstrated by the teacher and generate group readings with a more value of T and the corresponding L	Ask questions when necessary
	Deals with challenges faced by	
	Evaluates students by asking them questions	Answer evaluation

**Evaluation of the lesson by the teacher:**

- i. Plot the graph of  $T^2$  on the y- axis and L on the x- axis.
- ii. Deduce the slope m of the graph

**Appendix O**  
**Instructional Guide for Experimental Group 1I**  
**Lesson Note V**

**Subject:** Physics

**Topic:** Acceleration due to gravity by means of the simple pendulum from Inaccessible height.

**Duration:** 80 Minutes

**Instructional objectives:** By the end of the lesson, the students should be able to determine the value of acceleration due to gravity by using the simple pendulum from inaccessible height

**Instructional Materials:** Small pendulum bob made up of lead or brass, Cotton thread, Split cork, Meter rule, Stop watch, Retort stand and clamp, a pair of scissors or blade

**Previous knowledge:** The students have been taught Simple Harmonic motion

**Instructional Procedure/Presentation**

Content Development	Teacher's Activities	Students' activities
<b>Step 1</b> Introduction	Teacher probes into students' prior knowledge through questions such as what is period of an	Students answer the questions asked by the teacher

	oscillation	
<b>Step 2</b> Setting up the experiment	Outlines the experiment's aim	observe the demonstrational experiment
<b>Step 3</b> Constructing a table of readings	Selects and demonstrates how to conduct the experiment on determination of acceleration due to gravity by means of the simple pendulum from inaccessible height from the PhET	Follow the procedure as demonstrated by the teacher to perform experiment determination of acceleration due to gravity by means of the Simple Pendulum
<b>Step 4</b> Plotting a graph of $T^2$ against h	Answers students' questions	Construct table of readings
	Assigns students to experimental stands in the physical laboratory in groups of five	Record measured values
	Asks students to repeat the procedure for the experiment as demonstrated by the teacher and generate group readings with a more value of T and the corresponding L	Ask questions when necessary
	Deals with challenges faced by the group	
	Evaluates students by asking them questions	Answer evaluation questions

**Evaluation:**

- i. Plot the graph of  $T^2$  on the y- axis and h on the x- axis.
- ii. Deduce the slope m of the graph
- iii. Determine the intercept of the graph on the x-axis when  $T^2 = 0$

**Appendix P**  
**Instructional Guide for Control Group**  
**Lesson Note I**

**School:** As Applicable  
**Subject:** Physics  
**Class:** SSII  
**Topic:** Experiment on verification of Hooke's Law  
**Number in class:** As applicable  
**Average Age:** 16 years  
**Sex:** Mixed  
**Duration:** 80 Minutes  
**Date:** As applicable  
**Objectives of the lesson:**

Students should be able to do the following at the end of the lesson:

- I. investigate Hooke's Law as well as the parameters within the concept of simple harmonic motion
- II. graphically and analytically interpret Hooke's Law
- III. understand the concept of Simple Harmonic Motion.

**Instructional Materials:** Spring Balance, weights of different masses, retort stand, clamp, metre rule

**Previous knowledge:** They have been taught Elasticity of materials

**Instructional Procedure/Presentation**

Content Development	Teacher's Activities	Students' Activities
<b>Step 1</b> Introduction	Teacher probes into students' prior knowledge through questions such as: to state Hooke's law of Elasticity and define Simple Harmonic Motion	Students answer the questions asked by the teacher
<b>Step 2</b> Setting up the experiment	Outlines the experiment's aim	Observe the demonstrational experiment
<b>Step 3</b> Constructing a table of readings.	Demonstrates how Hooke's law is tested using real apparatus.	Follow the teacher's instructions to verify Hooke's law by performing the experiment
<b>Step 4</b> Plotting a graph of load against the extension	Answers students' questions	Construct table of readings.
	Assigns students to experimental stands in the physical laboratory in groups of five	Record measured values
	instructs students to repeat the procedure for the experiment as demonstrated by the teacher and generate group readings with a more value of $m$ and the corresponding extension	Ask questions when necessary.
	Deals with challenges faced	

	Evaluates students by asking them questions	Answer evaluation
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### Evaluation:

Students are asked the following questions:

- i. How are load and extension related?
- ii. Consider oscillating spring with mass attached, if the mass of the object doubled, what will happen to period of the oscillation

## Appendix Q

### Instructional Guide for Control Group

#### Lesson Note II

**Subject:** Physics

**Topic:** Determination of Elastic constant of a spring

**Duration:** 80 Minutes

**Instructional objectives:** By the end of the lesson, the students should be able to determine the force constant of a spiral spring

**Instructional Materials:** Spring Balance, weights of different masses, retort stand, clamp, metre rule

**Previous knowledge:** They are familiar with Hooke's law

#### Instructional Procedure/Presentation

Content Development	Teacher's Activities	Students' Activities
Step 1	Teacher probes into students' prior	Students answer the questions

Introduction	knowledge through questions such as: what is force constant? What is the unit of force constant?	asked by the teacher
<b>Step 2</b> Setting up the experiment	Outlines the experiment's aim	Observe the demonstrational experiment
<b>Step 3</b> Constructing a table of readings	Demonstrates how the experiment on determination of elastic constant of a spring is conducted using real apparatus	Follow the teacher's instructions to perform experiment on determination of elastic constant of a spring
<b>Step 4</b> Plotting a graph of load against the extension	Answers students' questions	Construct table of readings.
	Assigns students to experimental stands in the physical laboratory in groups of five	Record measured values
	instructs students to repeat the procedure for the experiment as demonstrated by the teacher and generate group readings with a more value of $m$ and the corresponding extension	Ask questions when necessary
	Deals with challenges faced by the	
	Evaluates students by asking them questions	Answer evaluation questions

### Evaluation:

Students are asked the following questions:

- i. Plot the graph of weight in Newton on the y-axis against the extension on the x-axis
- ii. Find the slope and interpret the result

**Appendix R**

**Instructional Guide for Control Group**

**Lesson Note III**

**Subject:** Physics

**Topic:** Determination of effective mass of a spiral spring by oscillation method

**Duration:** 80 Minutes

**Instructional objectives:** By the end of the lesson, the students should be able to determine the effective mass of a spiral spring and the spring constant

**Instructional Materials:** A spiral spring, a set of slotted weights, a stop watch, Retort stand and clamp, Split cork

**Previous knowledge:** The students have been taught Simple Harmonic Motion

**Previous knowledge:** The students have been taught Simple Harmonic motion

## Instructional Procedure/Presentation

Content Development	Teacher's Activities	Students' Activities
<b>Step 1</b> Introduction	Teacher probes into students' prior knowledge through questions such as what is period of an oscillation	Students answer the questions asked by the teacher
<b>Step 2</b> Setting up the	Outlines the experiment's aim	Observe the demonstrational experiment
<b>Step 3</b> Constructing a table of readings	Demonstrates how experiment on determination of effective mass of a spiral spring by oscillation method is conducted using real apparatus	Follow the teacher's instructions to perform experiment on determination of effective mass of a spiral spring by oscillation method
<b>Step 4</b> Plotting a graph of Period of Oscillation against Mass	Answers students' questions	Construct table of readings
	Assigns students to experimental stands in the physical laboratory in groups of five	Record measured values
	instructs students to repeat the procedure for the experiment as demonstrated by the teacher and generate group readings with a more value of T and the corresponding mass	Ask questions when necessary
	Deals with challenges faced by	
	Evaluates students by asking them questions	Answer evaluation questions

### Evaluation:

Students are asked the following questions:

- i. Plot the graph of T against M
- ii. Find the slope of the graph

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## **Appendix S**

### **Instructional Guide for Control Group**

#### **Lesson Note IV**

**Subject:** Physics

**Topic:** Determination of acceleration due to gravity by means of the Simple Pendulum.

**Duration:** 80 Minutes

**Instructional objectives:** By the end of the lesson, the students should be able to determine the value of acceleration due to gravity by using the Simple Pendulum

**Instructional Materials:** Small pendulum bob made up of lead or brass, Cotton thread, Split cork, Meter rule, Stop watch, Retort stand and clamp

**Previous knowledge:** The students have been taught Simple Harmonic motion

**Instructional Procedure/Presentation**

Content Development	Teacher's Activities	Students' Activities
<b>Step 1</b> Introduction	Teacher probes into students' prior knowledge through questions such as what is period of an oscillation	Students answer the questions asked by the teacher
<b>Step 2</b> Setting up the	Outlines the experiment's aim	observe the demonstrational experiment
<b>Step 3</b> Constructing a table of readings	Demonstrates how experiment on determination of acceleration due to gravity by means of the Simple Pendulum is conducted using real apparatus	Follow the teacher's instructions to perform experiment on determination of acceleration due to gravity by means of the Simple Pendulum
<b>Step 4</b> Plotting a graph of $T^2$ against L	Answers students' questions	Construct table of
	Assigns students to experimental stands in the physical laboratory in groups of five	Record measured values
	Instructs students to repeat the procedure for the experiment as demonstrated by the teacher and generate group readings with a more value of T and the corresponding L	Ask questions when necessary
	Deals with challenges faced by the	
	Evaluates students by asking them questions	Answer evaluation

**Evaluation:**

- i. Plot the graph of  $T^2$  on the y- axis and L on the x- axis.
- ii. Deduce the slope m of the graph

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**Appendix T**  
**Instructional Guide for Control Group**  
**Lesson Note V**

**Subject:** Physics

**Topic:** Acceleration due to gravity by means of the simple pendulum from Inaccessible height.

**Duration:** 80 Minutes

**Instructional objectives:** By the end of the lesson, the students should be able to determine the value of acceleration due to gravity by using the simple pendulum from inaccessible height

**Instructional Materials:** Small pendulum bob made up of lead or brass, Cotton thread, Split cork, Meter rule, Stop watch, Retort stand and clamp, a pair of scissors or blade

**Previous knowledge:** The students have been taught Simple Harmonic motion

**Instructional Procedure/Presentation**

Content Development	Teacher's Activities	Students' Activities
<b>Step 1</b> Introduction	Teacher probes into students' prior knowledge through questions such as what is period of an oscillation	Students answer the questions asked by the teacher
<b>Step 2</b> Setting up the experiment	Outlines the experiment's aim	observe the demonstrational experiment
<b>Step 3</b> Constructing a table of readings	Demonstrates how experiment on determination of acceleration due to gravity by means of the simple pendulum from inaccessible height is conducted using real apparatus	Follow the teacher's instructions to perform experiment on determination of acceleration due to gravity by means of the Simple Pendulum
<b>Step 4</b> Plotting a graph of $T^2$ against h	Answers students' questions	Construct table of readings
	Assigns students to experimental stands in the physical laboratory in groups of five	Record measured values
	Instructs students to repeat the procedure for the experiment as demonstrated by the teacher and generate group readings with a more value of T and the corresponding L	Ask questions when necessary
	Deals with challenges faced by the	
	Evaluates students by asking them questions	Answer evaluation questions

**Evaluation of the lesson by the teacher:**

- i. Plot the graph of  $T^2$  on the y- axis and h on the x- axis.
- ii. Deduce the slope m of the graph
- iii. Determine the intercept of the graph on the x-axis when  $T^2 = 0$

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**Appendix U**

**Summary of Item Analysis of Physics Achievement Test (PAT)**

S/N	Level of objective	Ineffective distracter	Lower 27%	Difficult index	Discriminating index	Item after analysis		Decision
1	K		11	8	0.86	0.27		Satisfactory
2	K		9	6	0.68	0.27		“
3	C		10	7	0.77	0.27		“
4	C		11	5	0.73	0.55	1	“
5	K	B	5	8	0.59	- 0.27		Adjustment
6	H		9	4	0.59	0.45	2	Satisfactory
7	H		4	7	0.50	- 0.27		“
8	K		11	5	0.73	0.55	3	“
9	C		11	0	0.82	0.36		“
10	K		7	7	0.32	0.63		“
11	H		11	7	0.82	0.36		“
12	C		6	5	0.50	0.09		“
13	C		11	10	0.95	0.09		“
14	K		8	3	0.05	0.45	4	“
15	C		7	6	0.59	0.09		“
16	H		11	6	0.77	0.45	5	“
17	K		2	5	0.32	- 0.27		“
18	H	A	11	7	0.82	0.36		Adjustment
19	C		8	2	0.45	0.54	6	Satisfactory
20	C	C	3	6	0.36	- 0.27		Adjustment
21	K		8	0	0.36	0.73		Satisfactory
22	C		10	3	0.59	0.73	7	“
23	K		7	2	0.41	0.45	8	“
24	C		9	6	0.68	0.27		“
25	K		6	1	0.32	0.45		“
26	H		9	0	0.41	0.82	9	“
27	K		6	4	0.45	0.18		“
28	K		5	2	0.32	0.27		“
29	C		5	1	0.27	0.36		“
30	C		9	0	0.41	0.82	1 0	“
31	H		10	1	0.50	0.82	1 1	“
32	K		9	2	0.50	0.63	1 2	“

33	H		10	2	0.55	0.73	1 3	“
34	K		9	0	0.41	0.82	1 4	“
35	K		6	2	0.36	0.36		“
36	K		10	2	0.55	0.73	1 5	“
37	K		7	0	0.32	0.64		“
38	H		6	3	0.41	0.27		“
39	C		5	3	0.36	0.12		“
40	C		10	1	0.50	0.82	1 6	“
41	C		9	1	0.45	0.73	1 7	“
42	C		6	3	0.41	0.27		“
43	H	D	2	0	0.09	0.18		Adjustmen t
44	H		11	8	0.86	0.27		Satisfactor y
45	H		10	6	0.73	0.36		“
46	K		8	0	0.36	0.73		“
47	C		11	5	0.73	0.55	1 8	“
48	H		10	1	0.50	0.82	1 9	“
49	K	A	5	2	0.32	0.27		Adjustmen t
50	C		7	4	0.50	0.27		Satisfactor y
51	C		8	2	0.45	0.55	2 0	“
52	C		9	3	0.55	0.55	2 1	“
53	C		5	1	0.27	0.36		“
54	C		6	6	0.55	0		“
55	C		8	1	0.41	0.64	2 2	“
56	C		11	4	0.68	0.64	2 3	“
57	H	B	3	1	0.18	0.18		Adjustmen t
58	K		8	3	0.50	0.45	2 4	Satisfactor y
59	C		6	3	0.41	0.27		“
60	H		9	3	0.55	0.55	2 5	“
61	C		7	2	0.41	0.45	2 6	“

62	K		6	2	0.72	0.36		“
63	H		8	2	0.45	0.55	27	“
64	C		11	2	0.59	0.82	28	“
65	C		5	4	0.41	0.09		“
66	C	C	5	0	0.23	0.45		Adjustment
67	K		11	3	0.64	0.73	29	Satisfactor y
68	K		9	0	0.41	0.73	30	“
69	C		9	4	0.90	0.45		“
70	C		6	4	0.45	0.18		“

**NOTE:** Difficulty index of range between 0.40-0.80 is considered GOOD and Discrimination index of 0.4-1.0 is considered GOOD

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## Bio- data

**Name:** Temitope Matthew ADEPOJU

Flat 2, Redeemer's High School, Redemption Camp Mowe, Ogun State, [tadepoju@ymail.com](mailto:tadepoju@ymail.com),  
08060220204, 08158108333

**Date and Place of Birth:** 9<sup>th</sup> May, 1984

**Nationality:** Nigeria

**Marital Status:** married

**No. of Children & their ages:** Nil

**Name and Address of Spouse:** Adepoju Oluwafunmi Mercy

Flat 2, Redeemer's High School, Redemption Camp Mowe, Ogun State [funmec@yahoo.com](mailto:funmec@yahoo.com) &  
07060220204)

**Name and Address of Next of Kin:** Adepoju Oluwafunmi Mercy, Flat 2, Redeemer's High School,  
Redemption Camp Mowe, Ogun State

### Educational Background

#### Educational Institutions Attended with Dates and Qualification:

##### Primary Education

L.A Primary School 1 Akure, Ondo State 1987-  
1992

##### Secondary Education

Adegbola Memorial Grammar School Akure, Ondo State 1992-  
1998

##### Higher Educational Institutions Attended with Dates & Qualification

Lead City University Ibadan, Oyo-State (LCU) 2021-  
2024

Olabisi Onabanjo University Ago-Iwoye (OOU) 2016-  
2021

National Open University of Nigeria, (NOUN) 2016	2013-
Usman Danfodiyo University Sokoto (UDUS) 2013	2012-
Obafemi Awolowo University, Ile-Ife (OAU) 2011	2010-
National Open University of Nigeria (NOUN) 2022	2019-
The Federal Polytechnic Offa, Kwara State 2006	2005-
The Federal Polytechnic Offa, Kwara State 2003	1999-

**Awards and Fellowships:**

Doctor of Philosophy (PhD) (Physics Education)	2024
Master of Philosophy/ Doctor of Philosophy M. Phil/PhD ( <b>Science Education</b> )	2021
Masters of Science Education M.Sc. (Ed) - <b>(4.26)</b>	2015
Bachelor of Science, B.Sc. (Hons) <b>Physics (Second Class) (3.39)</b>	2022
Post Graduate Diploma (PGDE) ( <b>Education</b> ) ( <b>Upper Credit</b> )	2012
Post Graduate Diploma (PGD) ( <b>Technology Management</b> ) ( <b>Distinction</b> )	2020
Higher National Diploma (HND) (Science Laboratory Technology)- <b>Physics/Electronics</b> ) ( <b>Upper Credit</b> )	2006
National Diploma ( <b>Science Laboratory Technology</b> ) ( <b>Upper Credit</b> )	2003
Senior School Certificate (SSCE)	1998
Primary School Leaving Certificate	1991

**Work Experience:**

• **Akoko-Edo Local Government Council** Igarra, Edo State (NYSC) 2007-2008

**Department:** Works **Post Held:** Electronics Engineer

• **Anglican Science College** Igarra, Edo-State 2007-2008

**Department:** Science **Post Held:** Physics, Mathematics, Electronics Tutor

- **Comprehensive High School Igarra, Edo-State** 2007-2008

**Department:** Science      **Post Held:** Physics, Mathematics, Electronics Tutor

- **Living Spring Comprehensive College** 2008-2012  
Ikotun, Lagos

**Department:** Science      **Post Held:** Physics and Mathematics Tutor

**Membership of Academic Professional Bodies:**

- American Psychological Association (APA) 2024
- Science Teachers Association of Nigeria (STAN) 2024
- Teachers Registration Council of Nigeria (TRCN) 2017
- Nigeria Institute of Science Laboratory Technology (AISLT) 2010
- Association of Behavioural Research Analysts and Psychometricians (AB-ReAP) 2021

**Publications:**

**Thesis/Dissertation/Project**

- **Adepoju, T.M. (2024).** Effect of Predict-Observe-Explain and Virtual Laboratory Strategies on Secondary School Physics Students’ Attitude and Achievement in Simple Harmonic Motion, Ogun State
- **Adepoju, T.M. (2023).** Assessment of Heavy Metals in Agricultural Soil and Vegetable Samples within Ogun State, south-west, Nigeria
- **Adepoju, T.M (2015).**” The Effects of Virtual Laboratory on the Academic Achievement and Attitude of Physics Students in Nigerian Colleges of Education” M. ED Dissertation, National Open University of Nigeria (NOUN)
- **Adepoju, T.M (2012).**”The Level of Improvisation and Organization of Learning Resources for the Teaching of Computer Science in Lagos State Secondary Schools” An unpublished PGDE Dissertation
- **Adepoju T.M (2006).**”Design and Construction of Diodes and Transistor Tester
- **Adepoju T.M (2003).**” Phyto-chemical Analysis of Medicinal Plants such as Pinnatum and Combretum.

**Journal Articles:**

- **Adepoju, T.M & Yara, P. O (2024).** Effect of Predict-Observe-Explain on Secondary School Physics Students’ Attitude in Simple Harmonic Motion in Ogun State, Nigeria
- **Adepoju, T.M & Yara, P.O (2024).** Effect of Virtual Laboratory Strategy on Secondary School Physics Students’ Attitude in Simple Harmonic Motion in Ogun State, Nigeria

- **Adepoju, T.M (2021).** Assessment of the use of Technology in the Classrooms by Secondary School Teachers in Obafemi- Owode Local Government Area, Ogun state, Nigeria. **Journal of Research in Humanities and Social Science, volume 9, issue 5, 41-49 (2321-9467)**
- **Adepoju, T.M (2021).** Adoption of E-learning as a Panacea to the Effects of Covid-19 Pandemic on Teaching and Learning of Science in Nigerian Secondary Schools. **International Journal of Research and Innovation in Social Science (IJRISS), volume v, issue iv, 115-119 (ISSN 2454-6186)**
- **Adepoju, T.M (2020).** Effect of Teachers' Use of Improvised Instructional Materials on Students' Achievement and Interest in Mensuration
- **Adepoju, T.M (2018).** Analysis of Reading Habits of Secondary School Students: Implications for Physics Teaching and Learning in Ogun State. **The International Journal of Humanities & Social Studies, volume 6, ,109-114 (ISSN 2321-9203)**
- **Adepoju, T.M (2018).** The Effects of Virtual Laboratory on the Academic Achievement and Attitude of Physics Students in Nigerian Colleges of Education.

### Technical Reports:

Adepoju T.M (2022). A Technical Report on Student Industrial Work Experience undertaken at Ibadan Electricity Distribution Company (IBEDC), Leme, Abeokuta, Ogun State

### Major Conferences/Workshops Attended

- Diversity & Inclusion: Driving force to innovation for Sustainable Development, Postgraduate College Lead City University, Ibadan, Nigeria, International Council for Education, Research and Training (May 21, 2024)
- Dynamics of a Good Research Problem Statement and Plausible Recommendations for New Knowledge (1<sup>st</sup> Faculty of Education Symposium, Lead City University Ibadan) (13<sup>th</sup> June, 2024)

### Services outside the University (local, State or National or International)

- National Youth Service Corp (NYSC) 2007-2008  
**Status:** Participating Member
- Independent National Electoral Commission (INEC) 2006  
**Status:** Party Agent
- National Population Commission (NPC) 2005  
**Status:** Supervisor/Enumerator
- International Journal of Research and Innovation in Social Science (IJRISS) 2022- till date  
**Status:** A reviewer of Articles (17)

### Extra-Curricular Activities:

Reading, playing table tennis, attending to people /students

### Names and Addresses of Referees

#### Prof. Tunde Yara

Lead City University (LCU), Ibadan, Oyo- State  
**08034715891**

#### Dr Sam-Kayode

Lead City University (LCU), Ibadan, Oyo- State

08165357640

**Adewole Akeem (PhD)**  
Tai Solarin University of Education  
07034271071

16<sup>th</sup>

December,

2024

Signature.....

**The University Compliance Certificate**

This is to certify that this thesis by **Temitope Matthew ADEPOJU** with the Matric number **LCU/PG/002629** in the Department of Science Education, Faculty of Education, Lead City University, Ibadan, Oyo State is in full compliance with the approved University format and style.

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**Signature**

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**Date**

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