EFFECTS OF COMPUTER-SIMULATED INSTRUCTIONAL STRATEGY ON SENIOR SECONDARY SCHOOL STUDENTS' INTEREST AND ACHIEVEMENT IN PRACTICAL PHYSICS IN IMO STATE, NIGERIA

BY

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ABSTRACT

Due to the abstract nature of physics, many secondary school students have low interest and perform poorly in the subject. Literature showed that to stimulate students' interest, better conceptual understanding and achievement, there is the need to introduce computer-simulated experiments in physics practical classes. Previous studies on the use of computer-simulated experiments in physics practical activities have focused more on students in higher institutions than on secondary school students. This study, therefore, investigated the effects of computer-simulated instructional strategy on senior secondary school (SSS) students' interest and achievement in physics practicals in Imo State, Nigeria. It also determined the moderating effect of numerical reasoning ability (NRA) and perceptual reasoning ability (PRA).

This study adopted a pretest-posttest, control group quasi-experimental design. Multistage random sampling was used to select 359 of intact classes of SSS II from six secondary schools from Owerri Educational Zone. Participants were randomly assigned to treatment groups: Computer-Simulated Experiment (CSE), Computer-Simulated and Hands-on Experiment (CSHE) and Conventional Hands-on Experiment (CHE). Treatment lasted eight weeks. Instruments were used: Physics Achievement Test (r =0.84), Students' Interest in Physics Questionnaire (r =0.85), Numerical Ability Test (r= 0.90), Perceptual Ability Test (r = 0.87), Practical Test (r = 0.84) and Software Package. Seven null hypotheses were tested at 0.05 level of significance. Data were analysed using MANCOVA.

Treatment had a significant effect on students' achievement and interest in physics practical, (λ= 0.91, $F_{(4,670)}$ = 8.32, η^2= 0.047). Also, treatment had a significant effect on students' achievement ($F_{(2,336)}$ = 14.76, $p < 0.025$, η^2 = 0.081) but had no significant effect on interest. Students exposed to CSE performed slightly better ($\bar{x}$ = 38.67; SD = 6.86) than those in CSHE ($\bar{x}$ = 38.56, SD = 6.85) and CHE ($\bar{x}$ = 33.37; S.D = 7.51). The NRA had a significant effect on achievement and interest in physics practicals (λ = 0.96, $F_{(4,670)}$ = 3.62, η^2 = 0.021), Also, it had a significant effect on achievement, ($F_{(2, 336)}$ = 420, $p <$ 0.025, η^2 = 0.025) but none on interest. Students with low NRA students performed better than high and moderate ability students. The NRA had no effect on interest. Also, PRA had a significant effect on students' achievement and interest in physics practicals (λ = 0.95, $F_{(4,670)}$ = 4.84; η^2 = 0. 028) as well as a significant effect on students' achievement ($F_{(2,336)}$ = 7.89, $p <$0.025, η^2 = 0.045) but none on interest. Students with high PRA performed better ($\bar{x}$ = 38.19; S.D. = 8.62) than moderate ($\bar{x}$ = 37.56; S.D. = 6.91) and low ($\bar{x}$ = 24.49; S.D. = 6.35) abilities. There was a significant interaction effect of treatment and PRA on students' achievement and interest (λ = 0.95; $F_{(8,670)}$ = 2.21; η^2 = 0.026).

Computer-stimulated experiments enhanced students' conceptual understanding and achievement in physics; however, when combined with hands-on experiment, it became less effective. Therefore, curriculum planners and teachers should use the instructional strategy particularly for moderate perceptual ability and low numerical ability students.

Key words: Computer-simulated instructional strategy, Hands-on laboratory experiment, Imo State Secondary school students, Students' interest and achievement in physics practical,

Word count: 500

CERTIFICATION

I certify that this research work was carried out under my supervision by Joy Nkiruka CHUKWUNENYE of Science Education Unit in the Department of Teacher Education, University of Ibadan.

…………………………….. **Date: ……………………**

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DEDICATION

This works is dedicated to the Almighty God, the lifter of my head, the I am that I am' to my husband and friend, the Rt Revd Geoffrey Nwokediroha Chukwunenye; and to my children: Chibuzor, Tochukwu and Ozioma.

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Joy Nkiruka Chukwunenye

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INTRODUCTION

1.1 Background to the study

Physics is the study of matter and energy and their interaction. It is the bedrock of advancement in science and technology (Nelkon and Parker, 2001). It is a branch of science concerned with nature, properties of matter and energy or the study of the material world and phenomena. It generates exciting intellectual advantages in a technological society. There is a link between Physics and technology as well as economic/industrial development (Kuti, 2006; Adegoke, 2011). This is because, without Physics, there will be no modern devices and hence no technology. Therefore, the importance of Physics to society today is evident in man's reliance on technology. In other words, the indices of development of any country around the globe centre on Physics-based technology. Cell phones, the Internet, motorized equipment and computers are only a few examples of Physics-based technological development that have revolutionized the world today.

More importantly, other disciplines, including chemistry, geography, oceanography seismology and astronomy, depend on knowledge of physics. Physics broadens our understanding of other disciplines, such as geography, earth, agriculture, chemical, biological and environmental sciences, medicine, astrophysics, cosmology and engineering. In the opinion of American Physics Society (APS, 2000), Physics is crucial to our understanding of the world around us, the world inside us and the world beyond us. Furthermore, Physics is described as the most basic and fundamental science which challenges our imaginations and reasoning ability. Physics makes the learner to think fast and this may result in discovery.

To recognize Physics as a foundation of not only sciences but also society, 2005 was designated the world year of Physics, which coincided with the 100th year of Albert Eistein's "Miraculous year" of 1905, during which he published papers on the theory of relativity, quantum theory and the theory of Brownian motion. Albert Eistein's ideas have impact on modern Physics and the whole world. Physicists endeavour to understand the underlying laws and principles governing our universe. By understanding these laws, we can better harness and interact with the environment.

To gain perspectives into how much Physics has contributed to our livelihood, Pravica (2005) refers to the following as "miracles from physicists" alternating current, hydroelectric power, electric motors, radio, microwave ovens, satellites, radar, modern rocketry the solution of the DNA structure, nuclear energy magnetic resonance imaging, x-rays, lasers, World Wide Web and many other discoveries.

Physics is an exciting intellectual adventure; it inspires young people and expands the frontiers of our knowledge about nature. It generates fundamental knowledge needed for the future technological advancement that will continue to drive the economic engines of the world.

As fascinating and useful as Physics is, statistics of enrolment and performance in the external examinations being conducted by the West African Examinations Council (WAEC) show that the level of achievement and enrolment is not very encouraging (Adegoke, 2010; Kuti, 2006). This is revealed by the statistics of Senior Secondary School Certificate Examinations results from 2005-2013, displayed in Tables 1.1 and 1.2.

Table 1.1: Statistics of Enrolment in SSCE May/June 2007-2013

YEAR	Total no. of Students that registered for SSCE	Total no. of Students that registered for Physics Examination
2007	1,267,764	429588 (33.89)
2008	1,354,478	464199 (34.27)
2009	1,357,532	475000 (34.99)
2010	1,315,607	475414 (36.14)
2011	1,524,891	573043 (37.58)
2012	1,688087	638,613 (37.83)
2013	1,695301	647,358 (38.19)
Total	10,203,660	3,703,215 (36.29)

Key: Figures in brackets represent percentage

Source: WAEC, Yaba, Lagos, 2011, 2013.

The statistics of enrolment, in Table 1.1, showed that the total number of students that registered for SSCE for the seven years under consideration (2007-2013) was 10,203,660, while the total number of students that registered for Physics examination was 3,703215. An average of 36.29% of the total number of candidates registered for Physics, which is a poor level of enrolment. Even in 2013 which recorded the highest number of registered candidates, the level of enrolment was not up to 40%.

Table 1.2: Students Performance in SSCE May/June 2005-2013 in Physics

Year	Total Entry For Exams	Total No Of Candidate That Sat For Exams	Number and percentage of candidates that sat and obtained the given Grade A1 to F9			Total Number of candidates absent as % of Entry
			Total Credit A1-C6	D7- D8	F9	
2005	351778	34411 (97.90)	142,943 (41.50)	102,036 (29.62)	89150 (25.88)	7,367 (2.09)
2006	384477	375824 (97.4)	21899 (58.05)	87025 (23.15)	62119 (16.52)	8,653 (2.23)
2007	429588	420622 (97.91)	181753 (43.21)	141050 (33.53)	89155 (21.19)	8,966 (2.08)
2008	464199	453081 (97.60)	218548 (48.23)	98605 (21.76)	125593 (27.71)	11,118 (2.39)
2009	475000	464997 (97.89)	219687 (47.24)	142578 (30.66)	81969 (17.62)	10,003 (2.10)
2010	475414	463137 (97.41)	239974 (51.81)	123886 (26.74)	86215 (18.61)	12,277 (2.58)
2011	573043	563240 (98.28)	359884 (63.89)	1.14970 (20.41)	66157 (11.74)	9,803 (1.71)
2012	638613	624437 (97.78)	429364 (68.76)	120373 (19.27)	57446 (9.19)	14176 (2.21)
2013	647358	637037 (98.40)	297189 (46.65)	175987 (27.62)	146014 (22.92)	10321 (1.59)

Key: Figures in brackets represent percentage

Source: WAEC, Yaba, Lagos, 2011, 2013

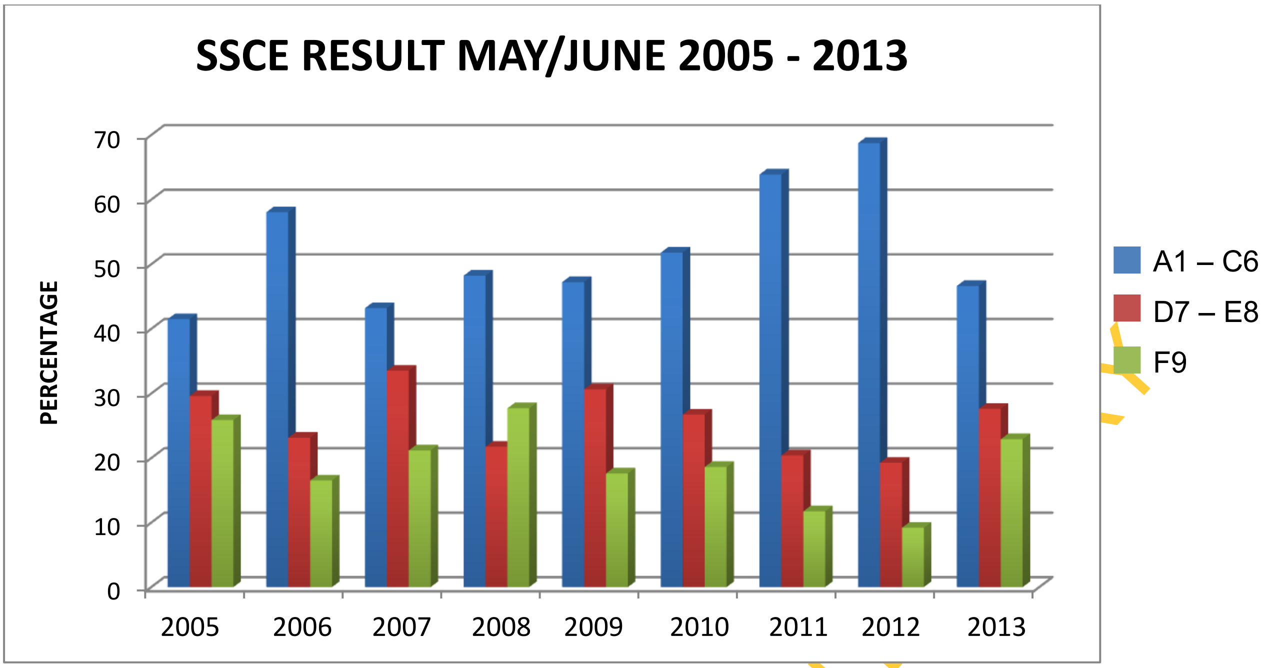

Fig 1: Multiple Bar Chart Representation of Performance of Candidates in SSCE Examination from 2005 – 2013.

On achievement, Table 1.2 and Fig.1 show the level of achievement in Physics between 2005 and 2013. As shown in the table, the overall percentage of candidates who made credit and above was not good enough even in the best year of performance, which was in 2013, when about 69% made credit and above, 31% of the students did not make the acceptable grade that can qualify them to enter higher institutions of learning to pursue courses that are Physics related also only about 37.7% of the entire students that registered for WAEC registered for Physics. A pertinent question that arises is; what went wrong?

The Chief Examiners' Report in Physics (WAEC, 2005-2013), draws attention to the fact that students are not doing well in Physics practical; Optics (use of protractors, parallax error, sighting of images, reading of values and measurement of angles) and simple harmonic motion (measurement of time, taking of period of oscillation and extension of spiral spring, determination of acceleration due to gravity). Other related problems also identified are; Inability of the students to finish their work at the stipulated time, wrong response to questions bordering on the theory of the experiment, inability to plot graphs involving small value and make deductions from the graphs, drawing of large right angled triangle and line of best fit and Setting up experiment and collection of data.

The Chief Examiners' Report recommended hands-on experiment more frequently. Research findings have shown that hands-on experiments are very rare in Nigerian secondary schools. This was attributed to lack of funds and equipment (Boyo, 2011; Nwachukwu, 2012).

Laboratory activities are an integral part of Physics, the aims of which include illustrating, supplementing and driving home points from classroom teaching and learning environment. In other words, it also plays a reinforcement role in learning sciences (Adeyemi, 2008; Omosewo, 2010). Laboratory work is an opportunity for the learner to learn firsthand. "the process of science". Although the role of laboratory course is clearly spelt out, it still receives negative comments from various quarters. The trends began in 1958 through 1983 and 2004. Nedesky (1958); Toothacker (1983) for example had called for the abolition of laboratories from introductory Physics level or curricula because they do not fulfill three objectives, which are (i) reinforcement of lecture materials, (ii) development of attitudes concerning experimentation, and (iii) development of useful laboratory skills. This could be attributed to the fact that laboratory activities which ought to follow at the end of every module at senior secondary school level are not carried out Weiman, Losbein and Perkins, 2010; Zacharia and Anderson, 2010); Boyo, 2011.

However, there are many who still have faith in the role of the laboratories and are of the opinion that hand–on- laboratory provides experience in determining physical quantities, error analysis and on hand-on-experience.(Khoon and Othman 2004). They argue that, although it's true that objectives may not be completely fulfilled, there is no justification for its total abandonment. Potter and Burns (1984), Khoon and Othman (2004) advocates that an introductory Physics course should include both theory and experiment, which complement each other. In essence, an introductory Physics should convey the message that physics is not merely a body of isolated and unrelated facts but a highly unified and consistent picture of the world.

Scientific experiment is a deliberately arranged series of events intended to reveal, as clearly as possible, some regularity in the behaviour of objects (Braddick, 1954). In principle, every event in a well-arranged experimental set-up is closely related with event in the outside world. The experimental system also has some unpredictable variations as a result of this relationship. It is, however, characteristics of Physics more than any other sciences to be able to deal with a relatively simple system, which enables it to secure a high degree of isolation from the outside world. This is made possible by the unique experimental technique which is beyond what is usually employed in any other sciences. A very good example is the use of advanced techniques to simplify the situation, which occurs in the frequent use of high vacuum in experimental work with molecular and atomic particles. By evacuating the air, a free path of several centimetres or metres could be secured for molecule in which it is practically free of any type of interaction with its neighbour. This kind of system could be used to effectively study magnetic field, electric field as well as behaviour of gases, collision, and pressure (Coleman, 1997).

In some sciences, other than Physics, this drastic simplification is not a practical method of investigation. Examples include the biological sciences, in which many systems studied are complicated and only small changes are made in the condition. Coleman (1997) and Adeyemi (2008) state that laboratory activities conducted for students consume time and finance. Students with varying degrees of mechanical aptitude must contend with a variety of instruments and also negotiate the sharing of time units with classmates in order to run their test. In Omosewo (2010) opinion, the time and cost required by students to examine more than just a few factors in an ideal school situation are often prohibitive. In his words, "it is difficult to justify the expense of exploring new ideas and 'hunches' even though that is where the real breakthrough in learning takes place."

Nigeria Educational Research and Development Council (NERDC) in a document released in 2005, at the end of a workshop on difficult concepts of Physics, declared Physics as one of the most difficult subjects in the school curriculum (NERDC, 2005). A statement was also issued indicating that science instruction should not take the form of transmitting bits of knowledge that are detached from any scientific, cultural or human context. This is because teaching science, and particularly Physics, is not a set of facts, but a way of giving order, unity, and intelligibility to the facts of nature. Laboratory course in physics has its important roles to play, which include to illustrate, supplement, and drive home points from classroom teaching and learning and at least to let students experience Physics in action.

Experimental work in sciences (Physics, Chemistry, Biology, and Agricultural Science) as stipulated in the National Policy on Education of the Federal Government of Nigeria (FGN, 2004), is an important component of science and this document recommends activity-based learning as the mode of instruction. The objective of the government is to inculcate in the learner the spirit of enquiry and creativity through exploration of nature and environment. It is, however, unfortunate that those laboratory sessions which ideally should follow at the end of every module are hardly organized for secondary school students (Chief Examiner Report, 2007, 2008, 2009, 2010, 2011). This is either due to ill-equipped laboratories in most public schools or lack of interest on the path of the teachers (Boyo, 2011; Nwachukwu, 2012). Moreover, the time apportioned to Physics and other science subjects is not enough to accommodate laboratory sessions (Weiman, Losbein and Perkins 2010;

Zacharia and Anderson, 2003.). Often quite a number of Physics teachers focus attention on completing the scheme of work rather than on the quality of teaching. In this situation, the ample opportunity needed by the students to develop new content, knowledge, pedagogical techniques and approaches to scientific activities and exploration is not made possible (Boyo2011).

These findings are indications that many students do not have the requisite Physics practical skills, which could only be acquired through frequent exposure to practical sessions (Boyo, 2011). Therefore, the subject seems so tough and abstract for the students. This is why some candidates who registered for the examination could not eventually sit for it, and some who sat for the examinations did not perform well. If the result in Physics does not improve, many more students might lose interest in it. Therefore, it is important to know how Physics teaching, learning activities, learning materials and learning environment could be deployed to make Physics more interesting and engage the students more meaningfully.

It is now a widely accepted idea that computer simulations have the potential to bridge the gap between concrete and abstract reasoning in the science classroom. Akpan, 2001; Sierra –Fernandez and Perales-Paracois 2003; Keller, Finkelstein, Perkins, and Pollock 2005). It has also been asserted that computer has the potential to deal with higher learning outcomes in a way not possible in the science classroom (Dumangolu and Stanbulu 2007; Lee, Guo and Ho 2008; Wieman, Adams and Perkins 2008).

Akpan (2001) describes simulation as the process of designing a model of a real system and conducting experiment with this model for the purpose of either understanding the behaviour of the system or evaluating various strategies for the operation of the system. It is a virtual experiment performed in a virtual laboratory. It is usually any computer-based package which may include the following: (i) Random access-which allows the user to choose and display a segment of activity or an individual frame with minimal search time, or as long as the individual wishes,(ii) step frame, which allows the user to display the next or previous frame of activity; (iii) show frame, which allows the user to repeat activities at any speed up to the real time with forward and backward control; (iii) still time, which allows the user to display any segment or individual frame of activities clearly and as long as the user wants to view it. It could also be described as an instructional computer simulation programme that allows the user to interact with a computer representation of either a scientific model of the natural or physical world or a theoretical system (Lee, Guo and Ho 2008 and Akpan 2006).

Olele (2008) notes that the use of computer and the Internet for learning is of primary concern and is lacking in Nigeria secondary schools and that it has advantages over the traditional method.

Computer simulations can be incorporated into normal class setting (Nancheva and Stoyanov 2005).The advantages are:

- It allows access to the experiment when there is shortage of equipment or time.
- It also provides data for students to work on, if it is not possible to perform an experiment, for instance, due to its lengthy nature.
- It allows the performance of experiments that would not otherwise be available because they are too dangerous.
- It allows students to make mistakes without real cost.

For these reasons, computer simulated experiment is useful not only in saving cost but also in time management because it could be carried out in real time, half time, and even lesser fraction of time as considered fit by the user. This way, it makes time available to further probe into other related variables.

Some challenges are associated with computer-simulated experiment. It is possible for students to develop misconceptions when using simulations. This may be an effect of scale (time or size) and students cannot relate what is seen in simulation to reality. Simulations often provide the perfect picture, whilst experimental procedures are usually subject to errors, the evaluation which is usually important in education. Educationists have tried to address these challenges by an attempting to provide a computer-based equivalent of tasks requiring manual dexterity but have concentrated on giving the learner all the experimental choices that would have been possible if the experiment were real, such as what to measure, what they should plot and how it should be plotted. Students can make mistakes, for instance, overheating a solution or a system. It has been ensured that relative time is accurate when an experiment involves measurement of time. If an event happens in ten seconds in real life, it happens in ten seconds in the programme (Dumanoglu and Stanbulu 2007). However, in longer drawn-out experiments, time can be accelerated but the relative differences in time between events are maintained.

Another challenge of computer simulation to other types of modalities is that computer simulations are often used with problem-based learning method. It may simulate the learners to immerse themselves in a problematic situation and experiment with different approaches (Mintz, 1993; Pol and Suhre 2005). The third challenge is that, without coaching, the learner gains little from "discovery learning" and from computer simulations (Mintz 1993; Huffman, Goldberg and Michlin 2008). Also the constructivist argues that computer simulations oversimplify the complexities of real-life situations, giving the learner a false understanding of a real-life problem or system (Goldberg and Bendali 1995; Lepper and Hendelong 2000;Russell, Lucas and McRobbie 2004).

According to Hartel (2000) and Keller, Finkelstein, Perkins and Pollock (2005), the above mentioned challenges could be solved by enabling the assisting personnel to spend more time on guiding the students. The exercises could further be improved as often as students use it. The teachers must also spend a significant amount of time coordinating the use of instruments among students and managing a sizeable inventory of devices. Although there is no replacement for students' hands-on experience as far as instrumentation and physical processes are concerned, we can lend much greater efficiency to experimentation by letting students use software simulation model in the place of much of physical testing (Wieman and Perkins, 2006; Dumanoglu and Stanbulu 2009). A simulation runs in minutes instead of the several days or weeks required by the physical methods. Apart from giving the students greater efficiency, it enables them to investigate many more variables.

Simulations not only provide for time saving, but it is also an important opportunity to make learning experiences come alive for students (Kun-Yang and Jia-Sheng Heh 2007). It enables them to interact with systems under study and receive immediate responses. It also, enables them to explore, come up with "hunches" and test them to make a well-considered conclusion (Yu, Guo and Ho 2008). Students exposed to simulation will get a taste of the same approach used by many engineers and research scientists in the world of product, design and development. These professionals have replaced a significant amount of their physical testing with software simulations (White and Frederiksen 2000; Adams, Keller and Reid 2005).

Choi and Gennaro 2006; Wieman, Perkins, and Adams (2008) assert that computer-supported learning environment draws on proven "experimental learning" techniques to develop the users' higher-order thinking skills. Simulation present learners with problems or a complex task from which there is need to draw conclusion and establish general principles that may explain or predict learning outcome in similar cases. These kinds of cognitive tasks help learners to develop the capacity for analysis, synthesis, evaluation and fundamental building blocks for the creation of new knowledge (Huffman, Goldberg and Michlin 2008; Lee, Guo and Ho2008; Strangmen and Hall 2009). Simulation provides unique delivery strategy in teaching and learning. It provides educators with direct opportunity to include Gagne's nine levels of learning into instruction and further allows the learner to explore a topic with constant feedback, and without public humiliation (Bill 2001 cited in Boyd and Murphy, 2002).It encourages a case-based learning while relating the abstract to the concrete. Simulation is believed to be a positive addition to instructional design (Allessi and Trollip, 2001;Boyd and Murphrey, 2002; Akpan 2006).

With CSE activities, it is easier to determine the period of a pendulum which is the reciprocal of time (in seconds). This is possible because there is a graphical representation alongside the oscillatory motion of the pendulum which, at a glance, describes to the students how to measure a complete cycle of oscillatory movement, which is either crest to crest or trough to trough. The simulation on refractive index measures angles of incidence and refraction, while the experiment on simple harmonic motion determines acceleration due to gravity. These simulations are used to verify Hooke's law. With the graphical representations and drawings, some abstract concepts which are not usually physically observed in laboratory activities are made more concrete, hence presenting the abstract as concrete as possible.

Theoretical Physics in the classroom and as well as practical Physics in the laboratory are made up of topics that involve the use of equations, formulae, measurement, demonstrations, manipulative skills, perceptual ability, abstract reasoning ability and logical mathematical reasoning ability. The need for reasoning ability and demonstration of manipulative skills to be able to cope effectively with the fundamental notions and principles of Physics has led to the labelling of Physics, both from theoretical and practical points of view, as an abstract school subject and one of the most difficult subjects (NERDC, 2005).

CSE, like hands-on experiment, is a representation of the real situation in a confined environment. The basic difference between CSE and hands-on experiment is that one is carried out in the real laboratory, while the other is in the virtual laboratory. Simulation, therefore, is an imitation of the actual activities. One advantage of using computer-simulated experiment is that equipment may not be available because of its cost or complexity. Such phenomena as satellite orbit, x-rays diffraction, and atomic spectroscopy are carried out by simulation and not by traditional laboratory method.

The time needed for data collection is reduced to enable the student to make replication or spend less time on the experiment. A technique may be taught in the laboratory and be laboured endlessly to show the students how it may be used to obtain experimental results directed towards a variety of ends. There are some experiments that involve the same technique, instead of students spending several sessions in the laboratory carrying out essentially the same operation but with slightly different goals each time. CSE can provide the student with practice in manipulating individualized experimental data after the students have been exposed to an experimental technique in the laboratory. It also enables students to conduct experiment beyond laboratory period. Another advantage of CSE over hands-on is that experiment could be conducted in real time, expanded time or compressed time.

Research has shown that interactive computer-based learning has great potentials for improving students' learning outcomes in Physics practical (Akpan 2001; Perkins, Adams, Dubson, Finkelstein, Reid, Wieman; Le Master and Mckagan 2008; Nwachukwu 2012). CSE can be used as supplement or enhancement to laboratory activities. It could also be used as a pre-laboratory assignment, follow-up assignment or extend laboratory experience, by allowing the teachers to use it in various ways: (i) as computer-simulated experiment only (ii) as a follow-up to laboratory activities, (iii) prior to laboratory activities, (iv) as post laboratory activities .Computer-simulated experiment is common in West Europe, Asia and USA.CSE is in use in countries such as Britain, Germany, China and Asia. Recently, a training was organized in Uganda on the use of CSE for teachers, with the Physics education technology (PHET) group from University of Colorado USA as resource persons (Jila, 2008).

Evidence from literature (such as Osborne, Simons and Collins 2003; Lavonen, Meisalo, Byman, Vitto and Juuit 2005; Adegoke, 2010) shows that students will study and learn meaningfully if interest is aroused in the learner. According to Adegoke (2010), to arouse interest has a lot of implications for the teaching and learning of school subjects, especially those that are assumed by the students to be difficult and abstract, like sciences and Physics in particular. He claims that when students have positive interest in a subject, they are motivated and they tend to do well in it. It is in learning actively and sustaining the interest of the learner that computer-simulated experiment comes into play.

According to Krap (2003), in teaching and learning activities in school situation, there are two points of view from which interest have been approached: interest as a characteristics of a person (topic interest or personal interest); and interest as a psychological state aroused by specific characteristics (situational interest) of the learning environment. Unlike personal interest, which is always topic specific and specific to an individual, situational interest is assumed to be spontaneous, fleeting and shared among individuals. As observed by Gregory Flowerday and Lehman (2001) and Hidi and Renninger (2006), personal interest develops slowly and has long-lasting effects on a person's knowledge and values, whereas situational interest is usually evoked by happenings in the immediate environment and may have only a short-term effect on the individuals' knowledge and values.

Gregory, Flowerday and Lehman (2001) and Lavonen et al (2005) stress that situational interest in the learner is aroused as a function of the interestingness of the content and context and more often under the regulation of the teacher. It is also a fact-that interest in a particular subject could be cultivated through different teaching methods, stimulating learning materials and learning environment (Mayer, 2001; Lavonen et al., 2005; Adegoke, 2010).

Hidi and Renninger (2006) and Krap (2004) show that motivation to learn based on interest has positive effects on studying processes, and learning outcome. It is, therefore, useful to explore how Physics could be taught and learning materials designed to make it more interesting to learners.

Intrinsically motivated activities are activities which people do naturally and spontaneously when they follow their inner interest. People will be intrinsically motivated only for activities that hold intrinsic interest for them, activities that have the appeal of novelty, challenge, or aesthetic value. This implies that interest seems to be a central concept when we try to understand the functional relationship between motivation and learning. However, interest differs from other motivational variables in three aspects. First it is content specific, second, it is as a result of an interaction between a person and his environment; and third, it has both cognitive and affective aspect (Hidi and Renninger 2006 and Krap, 2004). In order to motivate the students to learn Physics, it is imperative on the part of the teacher to create a conducive environment in order to motivate the learners and capture their interest. It is only at this point that optimal learning can take place. When the learner become intrinsically interested. And this is successfully sustained for a while, learning is facilitated. This is why computer-simulated experiment is being investigated to see if it could sustain interest as well as facilitate learning.

Leper and Henderlong (2000) state that arousal of interest is not possible if the pupil does not have a minimal level of competence. Competence is acquired through exposure or hands-on experience. At the International Council of Association of Science Education, (ICASE), World Conference 2007, delegates noted loss of interest and the need to stage action to bridge the gap between science, technology and society. This, they noted as the key reason for global decline in the level of interest in science. (FGN, 2008).This explains why studying Physics has been motivating for the gifted pupils who enjoy learning about natural phenomena, solving problems and experimenting, but the greater population of students experience Physics as difficult and easily lose interest. The majority of these students are within the average range of intelligence. It is, therefore, important for the teacher to determine perceptual and numerical reasoning ability of the learner to know if the students' disposition to Physics is as a result of these factors.

Numerical reasoning ability is the ability to reason with numbers and other mathematical concepts. It is the knowledge of the skills required to apply arithmetic operations either singly or in sequence (Adeleke, 2010). The concept of numerical literacy was posited in 1959 by the United Kingdom Committee on Education (UKCE).According to the Department of Education and Skills, numeracy is proficiency ability. Renninger (2000) and Adeleke (2010) state that to score high in numerical reasoning test, there is need to possess or develop skills that will allow one to handle the data of numerical nature swiftly and accurately. According to (Kaufman, Alan, Lichtenberger and Elizabeth (2006) and Adesoji (2008) knowledge of mathematics, which involves familiarity with basic arithmetic operations, such as equivalence between decimals, and fraction, which are embedded in this test and is also required learning Physics meaningfully. Kuti (2006) asserts that the relationship between numerical reasoning ability and Physics achievement tends to be high and positive.

Perceptual reasoning ability is the ability to form mental relations or create mental image of object in focus on the other hand, is a component of IQ index and scale. It is a subset of Wechsler Adult Intelligent scale (WAIS-IV) (Kaufman et al 2006; WAIS 2008). Perceptual reasoning ability measures the learner's ability to form perceptual relations or create a mental picture of the object in focus. An example is the learner ability to locate non- parallax condition and accurate measurement of angles and other readings in an experiment aimed at determination of refractive index of prism. It is also the ability of the learner to find relations between non-verbal stimuli and non-verbal reasoning stimuli, such as drawing conclusions based on a set of activities, like describing similarities and differences between two pictures. No doubt, theoretical Physics in the classroom as well as practical Physics in the laboratory are surrounded by topics that involve the use of equations, formulae, measurements, demonstrations, manipulative skills, perceptual ability, abstract reasoning ability and logical mathematical reasoning ability. Therefore, learning Physics requires perceptual competence on the part of the students.

The third version, referred to as WAIS III, was released in 1981. This version viewed perceptual reasoning ability as part of the performance IQ, with picture completion, block design, matrix reasoning as perceptual index (subset), while WAIS IV viewed it as one of the four indexes representing major components of intelligence, namely: verbal comprehension index, perceptual reasoning index, working memory index, and processing speed index (Kaufman et al 2006). It is also often recommended as part of a more comprehensive psycho-educational assessment programme for learners who are struggling with age-appropriate tasks or who show inconsistencies in their educational task.

There are many instruments used to measure perceptual reasoning ability, but the one most appropriate for this work is Raven's Standard Progressive Matrices (SPM). This is because its use enables one to determine the ability of the students to see the relationship among several figures, and ability to perceive figures and measure the dimensions of figures accurately. These skills and ability are needed in practical Physics. Another reason is that the validity has proved to be very high when compared to other instruments.

Research evidence (Adegoke 2011; Kuti 2011) has shown that there are positive correlation between perceptual, numerical and abstract reasoning ability and students' achievement in Physics. Thus, the second goal of this study was to find out if there are significant differences in learning outcomes among students with different reasoning abilities in computer-based learning.

The researcher examined the extent to which the use of CSE, students' perceptual ability and numerical reasoning ability will assist to develop scientific skills and attitudes, arouse students' interest and consequently affect their achievement in practical Physics.

1.2 Statement of the problem

Consequent on the loss of interest in Physics by secondary school students, which is evident in very low enrolment and performance, it is expedient for classroom teaching to be enriched with pedagogical skills in order to reinforce learning. There is need to engage the learner in activities that will encourage the acquisition of scientific attitudes and skills which are not being achieved as a result of poor laboratory facilities and activities in secondary schools. This implies that hands-on experiment has failed to complement or enhance classroom teaching neither is it able to capture the learners' interest, since practical classes are viewed as a tedious task, which could be frustrating to the students. Simulations has proved to be a valuable medium through which educators can tap the power of computer to help learner develop higher-cognitive processes and problem-solving skills while the learner interest is sustained, because CSE has the ability to translate the abstract nature of real-life experiment to a more concrete and real experience by providing cues and prompts for higher order learning.CSE can improve hands-on laboratory experiment and appears to be more effective for conceptual understanding.

It is against this background that the study investigated the effect of computer simulated-experimental instructional strategy on senior secondary school students' interest and achievement in Physics. Since the learners need a minimal level of competence in numeracy and perceptual skills to cope and learn the fundamental principles in Physics, this study examined the moderating effect of perceptual reasoning ability and numerical reasoning ability on interest and achievement.

1.3 Hypotheses

Based on the stated problem, the following null hypotheses were tested at 0.05 level of significance.

$H0_1$: There is no significant main effect of treatment (CSE, CSE+HOE, and Control) on the combined dependent variable (students' achievement in Physics practical and interest in Physics).

$H0_2$: There is no significant main effect of perceptual ability on the combined dependent variable (students' achievement in Physics practical and interest in Physics).

$H0_3$: There is no significant main effect of numerical ability on the combined dependent variable (students' achievement in Physics practical and interest in Physics).

$H0_4$: There is no interaction effect of treatment (instructional strategy) and perceptual ability on the combined dependent variable (students' achievement in Physics practical and Interest in Physics).

$H0_5$: There is no interaction effect of treatment (instructional strategy) and numerical ability on the combined dependent variable (students' achievement in Physics practical and interest in Physics).

$H0_6$: There is no interaction effect of perceptual ability and numerical ability on the combined dependent variable (students' achievement in Physics practical and Interest in Physics).

$H0_7$: There is no interaction effect of treatment (instructional strategy) perceptual skills and numerical ability on the combined dependent variable (students' achievement in Physics practical and Interest in Physics).

1.4 Significance of the study

The significance of this study is that it provides an enriched, interactive learning environment which captured the interest of the learner and allowed the learner to carry out laboratory kind of activities in a relaxed environment without necessarily being in the laboratory. It also gives relevant information on the joint and independent effects of interactive computer-based simulation and hands-on laboratory experiment on students' learning out comes in Physics. The result of this study showed the extent to which interactive computer-based simulations could be used as effective substitute when the hands-on laboratory work involved is too hazardous to the learner or too expensive for the schools.

The findings established the extent to which computer simulations are beneficial to students in their quest to acquire scientific process skills, problem-solving skills and integrated science process skills, which are necessary for scientific development of the mind. It will also reveal to the teachers the extent to which teaching practical skills could be brought about through CSE. It provides empirical data to convince the ministry of education and schools of the need to be more interested in the use of computer basic learning skills. It will also provide empirical data to convince the ministry of education and schools to be more interested in the use of computer basic learning skills.

1.5 Scope of the study

This study covered senior secondary school two (SSII) Physics students in the selected schools in Owerri zone 1 and Owerri zone 2 educational districts in Imo State. The study focused mainly on determining the effectiveness of computer-simulated experiment on students' achievement in Physics. The moderating effect of students' perceptual reasoning ability and numerical reasoning ability on interest and achievement in Physics practical were also examined.

Hands-on laboratory experiment and computer simulations on three different activities involving acceleration due to gravity, verification of Hooke's law and determination of refractive index of prism were used.

1.6 Operational definition of terms

Achievement Test in Physics Practicals: This is a test that will combine all the characteristics of practical Physics in the theory form as well as all the questions that could emanate from the activities in view.

Computer Simulated Experiment: This is a virtual experiment carried out in a virtual laboratory with the aid of a computer which allows the user to interact with the computer representation and explore the effect of many different parameters.

Computer-Simulated Experiment + Hands-on Experiment: This is when hands-on laboratory activities is used as enhancement to computer simulated experiment.

Hands-on Laboratory experiment: This refers to the conventional laboratory activities in the usual laboratory class.

Interest in Physics: This is the innate tendency developed by the learner over time which determines the students 'attitude and serves as motivation to learning Physics.

Numerical Reasoning Ability: This is the ability to reason with numbers and other mathematical concept as well as the knowledge required to apply arithmetic operations either singly or in sequence. Students' scores in numerical reasoning ability test will provide the index of numerical ability.

Perceptual Reasoning Ability: It is the ability of the students to create a mental image or form mental relations between objects. Students scores in a non-verbal reasoning test referred to as perceptual reasoning ability test which identifies the perceptual relations between non-verbal stimuli will provide the index of perceptual ability.

CHAPTER TWO

REVIEW OF RELEVANT LITERATURE

The relevant literature is

2.1 Theoretical framework

2.1.1 Engagement theory

2.1.2 Constructivism

2.2 Conceptual framework

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2.2.2 Wechsler's Adult Intelligence Scale

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2.3.1 Computer simulated experiment

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2.3.3 Computer simulated experiment and students interest in Physics

2.3.4 Computer simulated and hands-on laboratory experiment and students achievement in Physics

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2.3.6 Perceptual ability and students' interest and achievement in Physics

2.3.7 Numerical ability and students' learning outcomes

2.3.8 Important general design features

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2.3.10 Comparing computer simulations with expository instruction and Autonomous learning.

2.3.11 Different simulation environments and students' different characteristics

2.3.12 Appraisal of literature reviewed

2.1 Theoretical framework

This work is anchored to the following theoretical framework

1) Engagement Theory

2) Constructivism

Conceptual framework

3) Wechsler's Adult's Intelligence Scale

4) Numerical Literacy

2.1.1 Engagement Theory

This theory was first propounded in 1999 by Greg Kearsley and Ben Shneidermann. The theory posits that engagement occurs when students meaningfully undertake tasks related to their interest and competences, participate freely with (equals) associates, immerse themselves deeply and continue the task with persistence and commitment because of the value attributed to the work. The theory is relevant to this study in that computer simulation naturally attracts the interest of the learner and therefore engages them freely even beyond the classroom, especially for those that have access to intent facilities beyond the classroom.

This theory emerged from the experience of teaching in electronic and distance learning environments (Abimbade, 2007). The fundamental idea underlying engagement theory is that students must be meaningfully engaged in learning activities through interaction with other worthwhile tasks. While in principle such engagement could occur without the use of technology, the theorists believe that technology can facilitate engagement in ways which are difficult to achieve otherwise. Therefore, engagement theory is intended to be a model or framework for technology based learning (Kunda, Greggor and Geol 2009). Many elements from past theories of learning were synthesized. The major premise is that students must be engaged in their course work in order for effective learning to take place. The theory posits three primary means to accomplish engagement: (1) an emphasis on collaborative efforts, (2) project-based assignment, and (3) non-academic focus. It is suggested that these three methods result in learning that is creative. It is based on the idea of creating successful collaborative teams that work on ambitious projects that are meaningful to someone outside the classroom. The three component of this learning activity are **(1) relate:** learning through collaboration (2) **create**: learning using a project –based approach and (3) **donate:** learning using an outside (authentic) focus.

This implies that learning activities occurs in a group context (collaborative teams), they are project based and also have an outside (authentic) focus.

The first principle "relate" discusses the importance of collaboration in learning process and adds that educational activities must emphasize team efforts that involve communication, planning, management, and social skills. The modern work place demands proficiency in these skills, yet historically students has been taught to work and learn on their own. Research on collaboration suggests that in the process of collaboration, students are forced to clarify and verbalize their problems, thereby facilitating solutions.

The second principle, the "create" component, explains the essence for project based learning and making learning, a creative and purposeful activity. Students have to define the project (problem domain) and focus their efforts on application of ideas to a specific context. Conducting their own projects is much more interesting to students than answering sterile textbook problems. And because the learner defines the nature of the project (even if they do not choose the topic) they have a sense of control over their learning which is absent in traditional classroom instruction.

The third principle, the "donate" component, describes the need for projects to have a meaningful and realistic focus. It stresses the value of making a useful contribution while learning. Ideally, each project has an "outside consumer" that the project is being conducted for. The customer could be a camp group, community organization school, Church, government agency, local business or needy individual, and so on. In many cases, the project can be work related, that is an activity that fits into a team's occupational or career interests. Through the addition of realistic projects, students can be better prepared when they enter the workforce in a given field. However, the proponents caution instructors to ensure that the projects are appropriate for the students for the time constraints. The authentic learning context of the project increases student motivation and satisfaction. This principle is consistent with the emphasis on school-to-work programmes in many school systems and colleges, as well as the "service" philosophy of contemporary cooperate training efforts (Abimbade 2007).

Since CSE will meaningfully engage the learner, engagement theory is very much relevant to CSE. Particularly, when it is usually teamwork and makes learning creative, the learner will have a sense of control over learning. All these are also features of CSE

2.1.2 Constructivism

Constructivism was programmed by Jean Piaget in the 20thcentury. His central idea is that knowledge proceeds either solely from the experience of objects or from an innate programming performed in the subject but from successive construction. Piaget further claimed that the mechanism of learning is the process of equilibration in which cognitive structure assimilates and accommodates to generate new possibilities when it is disturbed based on human self-organizing tendency. He asserted that to foster conceptual change, students have to be confronted with discrepant events that contradicts the learner's conception which will involve a "disequilibrium" or "cognitive conflict" that positions students for reflections and resolutions. This discrepant event may be a demonstration or a phenomenon which requires students to explain or make a prediction. An exploratory learning environment, such as computer simulation, can also be used to provide such discrepant events. Simulations have the additional advantage that the students is required to inquire into the event presented by altering values of the parameters, to initiate processes. Exploratory learning does not necessarily mean an unguided or unconstrained learning environment but does mean that learners may discover unexpected lessons and reach conclusions following various paths.

Constructivism is a teaching and learning approach in which the learners construct their own understanding of scientific ideas within the framework of the existing knowledge (Kunyan Yang and Jia Sheng Heb, 2007). To accomplish this process, the learner in a worthwhile task that can bring about learning must be motivated to actively engage with the content and must learn from such engagement.

Assessment Performing Unit (APU) (1986) of the United States of America reflected on the practice of science experiment and problem- solving simultaneously as a suitable referent for designing constructivist online science problem- solving model composed of seven stages, which are: identifying problems, transforming problems, planning, doing experiments, recording data, explaining results , and evaluating results.

In these activities, according to APU (1986) and Adeyemo (2003), the students also need basic science processes of observing, inferring, measuring, communicating classifying and predicting as well as the integrated science process of identifying variables designing investigations, analyzing investigations and experimenting. Akinbola and Afolabi 2010; Mckagan, 2010).

The constructivist approach is based on the following principles:

1) Learning is an active process. Learners, based on their own prior knowledge or and experience, extend the system of knowledge through personal work or interaction with other sources in the learning environment. Learners are given more responsibility and ownership for learning to structure knowledge and solve problems actively according to their own interest, needs and learning purpose.
2) Sets learners in a learning community for developing, testing and modifying their ideas and sharing the intelligence of others by means of dialogue, debate, discussions and negotiation.
3) To gain practical knowledge and skills for other situations, learners have to be furnished with tools and resources to solve authentic problems
4) It is also essential to provide learners with learning scaffolding to excite the zone of proximal development.

This is the characteristic of computer stimulated experiment where the learner takes the responsibility to learning.

Many designers of educational technology believed that this is the trend to build computer learning environments based on a constructivists approach (Paulson, 2009; Alhadaq, Malley, Olson, Aishsaya and Abdulkareem, 2009). Some of the constructivist theorists are John Dewey, Jerome Brunner, Jean Piaget, and Lev Vygotsky.

Educators have discovered that the use of heavily guided activities does not elicit deep thinking and learning from students, while other studies have found that, with pure discovery learning, students were not able to "discover" the science themselves, but rather will, in most cases, verify information or standard theories. Computer simulation has taken care of this by providing of exploratory environment to learning. Recent studies have revealed that appropriate scaffolding of the materials is needed to help students build a mental framework about concepts and consequently construct their own understanding this is also embedded in interactive simulation.

Fong, Lee and chee (2010) states that interactive computer user find "exploratory learning" to be an effective and attractive strategy for learning a new system or investigating unknown features of familiar software. In exploratory learning, instead of working through precisely sequenced training materials, the user investigates a system or investigates unknown features of familiar software. In exploratory learning, instead of working through precisely sequenced training materials, the user investigates a system on personal initiative often in pursuit of a real or artificial task. In exploratory learning, the learners are allowed to solve a problem using different strategies. However, only a limited number of these strategies are known in advance and can be introduced by the designer or the teacher. Educational research has shown that there are several environments in which young students learn, but they learn more when they have the possibility of engaging in meaningful activities by actively constructing entities to guide their learning instead of passively accepting information. To assist this kind of active learning, several initiatives have appeared, one of such initiatives is the software tools in which learners are allowed to explore a broad set of possibilities and construct models with them. Exploratory learning environment has more positive impact on user's learning than guided environment when properly arranged (Perkins, Alhadaq, Malley, Olson, Aishaya, Alabdulkareem and Paulson 2010).

The theory is relevant because during the practical class the learner brings the theoretical aspect including classroom demonstration to bear in order to accommodate and generate further knowledge by interacting with the learning environment, which is the computer simulation, and can also extend beyond the classroom environment.

All these features explained are enshrined in CSE. The learner interacts with the learning environment when interacting with the computer. He is also able to construct his own knowledge. One of the conditions for the use of CSE is that the learner must have been exposed to the theoretical knowledge. It is based on that knowledge and the recent activities that new knowledge will be constructed. Therefore, it is in line with Jean Piaget and other constructivist theories which emphasize the importance of previous knowledge in a new learning situation. According to these theorists, it is the discrepancy between the previous knowledge and the recent activities that create "cognitive conflict" which positions the learner for reflection and resolution through interactions with the learning environment. Computer simulated experiment fits well with the principle of constructivism because simulation provides the use of critical and evaluative thinking. Simulation can also be used as a means of engaging the learner in "learning by doing" or experiential model of learning which involves active process of knowledge construction, and conceptual change.

2.2 Conceptual framework

2.2.1 Concept of numerical literacy

The concept of numerical literacy was propounded in 1959 by United Kingdom Committee on Education. According to the department of skills in United Kingdom, numeracy is proficiency developed mainly in Mathematics and other related subjects. It is more than the ability to do basic arithmetic, but involves developing confidence and competence with numbers and measures, such as ways in which data are gathered by counting, measuring, and presenting them in graphs, diagrams, charts, and tables. In other words, it requires understanding of ways through which data are gathered, measured, and presented in graphs, charts, and tables. In other words it requires understanding of number system, a repertoire of Mathematical techniques and ability to solve quantitative or spatial problems in a range of context.

According to researchers, achievement in school Mathematics which is applied to some science subjects is related to "un- learned Mathematical ability"(Iroegbu 1998; Adesoji 2008a; and Apata 2011).The "un- learned Mathematics ability according to them, is as a result of innate numerical ability of the learner since Mathematics is the language of Physics, with particular reference to practical classes in Physics where students are expected to carry out mathematical operations, plot graphs and work with mathematical theories, it is obvious that the numerical ability of the learner determines, to a large extent, the level of achievements even in Physics practical (Kuti ,2006).

2.2.2 Wechsler's Adult Intelligence Scale

This theory on intelligence model was first proposed by Wechsler Bellevue in 1934.It was first published by David Wechsler in 1955 as a revision of Bellevue-Wechsler's intelligence. The current version of the scale, WAIS IV, was released in 2008.This theory proposes that intelligence is made up of specific elements that could be isolated, defined and subsequently measured independently. These individual elements are not entirely independent but are all interrelated (Kaufman, Alan, Lichtenberger, and Elizabeth, 2006) .This is why achievement and interest in Physics or other sciences could not be measured without reference to some components of this scale or index related perception or numeracy.

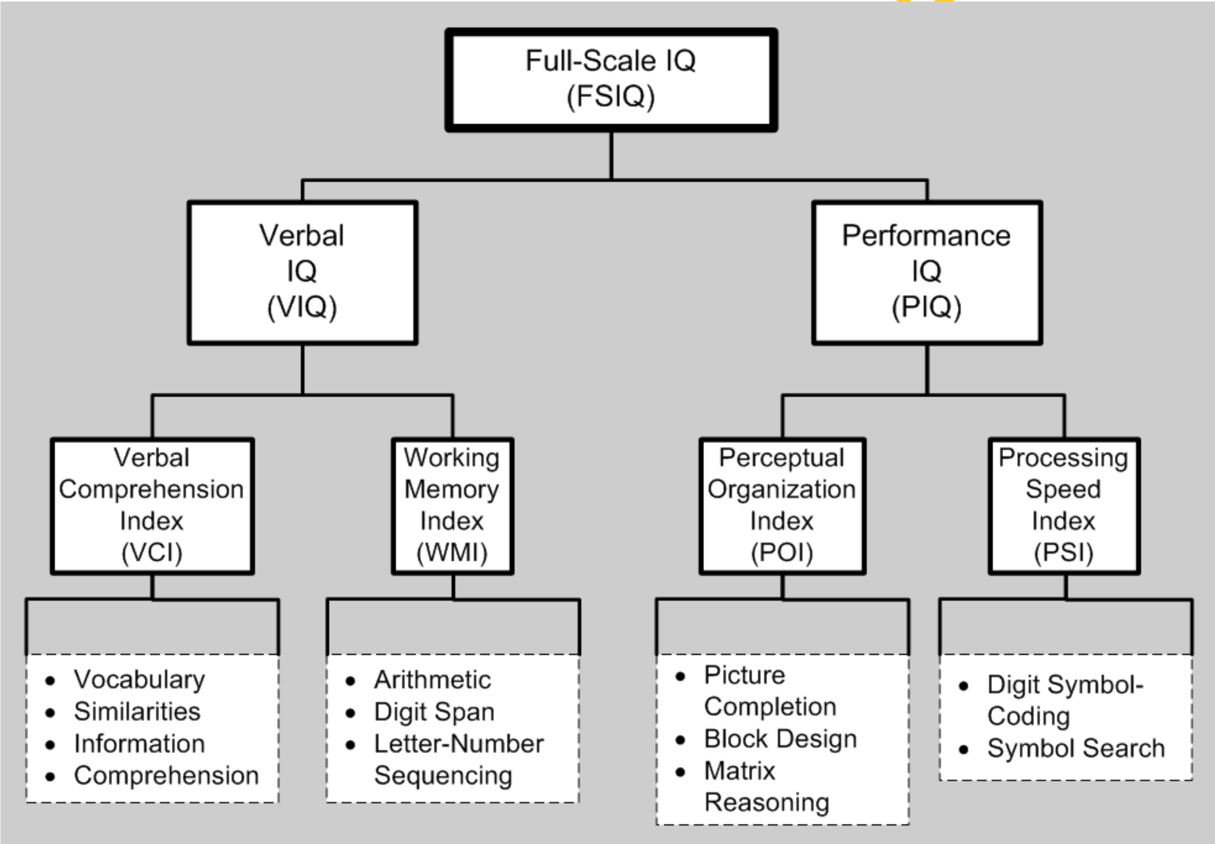
These elements, grouped under four indexes representing major components of intelligence, are:

Verbal Components Index (VCI)
Perceptual Reasoning Index (PRI)
Working Memory Index (WMI)
Processing Speed Index (PSI)

The proponent also regenerated two broad scales which could be used to summarize general intelligent abilities as shown in figure 2.Full Scale IQ(FSIQ) is based on total combined performance of VCI, PRI, WMI, and PSI and general ability index based on the six subsets of VCI and PRI. In other words, general intelligence consists of various specific and interrelated components to which numerical reasoning ability and perceptual reasoning ability belong.

According to Wechsler, the non-verbal performance scale, of which perceptual reasoning is a subset, allows the measurement of non-verbal intelligence which has become known as performance scale (Ryan and Schnakenbergott, 2003). This scale measures the ability of a subject to copy symbols or point out a missing detail rather than just answer questions. This development is very important because it attempts to remove or overcome language bias problem, culture and education.

Figure 2: Wechsler's Adult Intelligent Scale (WAIS – III)



Source: http://www.pearsonassessment .com

The current version of the scale WAIS IV, released in 2008, consists of 10 core subsets and five supplemental subsets with the 10 core subtests comprising full scale IQ with the new WAIS IV. The verbal/performance subscale from the WIAS III was removed and replaced by the index scores. The General Ability Index (GAI) was included. It consists of similarities, vocabulary and information subsets from the verbal comprehension index and block design matrix reasoning and visual puzzles sub-test from the perceptual reasoning index

Figure 3: Wechsler's Adult Intelligent Scale (WAIS – IV)

Verbal Comprehension	**Core**	**Supposed abilities measured**
Similarities	X	Abstract verbal reasoning
Vocabulary	X	The degree to which one has learned, been able to comprehend and verbally express vocabulary
Information	X	Degree of general information acquired from culture
(Comprehension)		Ability to deal with abstract social conventions, rules and expressions
Perceptual Reasoning	**Core**	**Supposed abilities measured**
Block Design	X	Spatial perception, visual abstract processing, and problem solving
Matrix Reasoning	X	Nonverbal abstract problem solving, inductive reasoning, spatial reasoning
Visual Puzzles	X	Spatial reasoning
(Picture Completion)		Ability to quickly perceive visual details
(Figure Weights)		Quantitative and analogical reasoning
Working Memory		**Core Supposed abilities measured**
Digit span	X	Attention, concentration, mental control
Arithmetic	X	Concentration while manipulating mental mathematical problems
(Letter-Number Sequencing)		Attention, concentration, mental control
Processing Speed		**Core Supposed abilities measured**
Symbol Search	X	Visual perception/analysis, scanning speed
Coding	X	Visual-motor coordination, motor and mental speed, visual working memory
(Cancellation)		Visual-perceptual speed

Source: http://www.pearsonassessment .com

From WAIS III and WAIS IV we could see that perceptual reasoning is a scale or index of intelligence, while numerical index are subsets of the working memory index of intelligence also.

The theory is relevant to the study. These two indexes are vital component of performance IQ and a measure of these indexes will result to a measure of performance IQ.

2.2.3 Ravens Progressive Matrix

The Raven's Standard Progressive Matrix (SPM) is standard tests developed by J.C. Ravens in 1934.It consists of 60 items arranged in five sets (A, B, C, D and E) of 12. Each item consists of a figure with missing piece. Below the figure are alternative pieces to complete the figure. One option is usually correct, each set involves a missing principle or theme for obtaining the roughly arranged in increasing order of difficulty. Raw scores could be converted to percentage rank using appropriate norm.

It is a commonly used test that focuses on visual problem solving. (Kunda and Goel, 2008). The design and intelligence laboratory of school of interactive computing in Atlanta has embarked on developing a small set of methods for problem solving in RPM which was propositional, imagistic and multimodal representative to investigate how different representations can contribute to visual problem solving and how the effects of their use might emerge in behaviours. (Kunda, McGregor and Goel, 2009). RPM Raven's Progressive Matrix consists of visually presented geometric –analogy-like problems in which a matrix of geometric figures is presented with one entry missing, and the correct entry must be selected from a set of answer choices.

It is a test that measure educative ability or the ability to extract and understand information from complex situation (Raven, Raven and Court, 1998). The RPM has high level of correlation with other multi- domain intelligence test which has given it a position to centrality in the space of psychometric measures Snow. It is, therefore, often used as a test of general intelligence.

The design and intelligent laboratory of Georgia Institute of Technology in Atlanta in USA stated that, despite the widespread use, neither the computational nor cognitive characteristics of the process of solving the RPM is well understood. Different researchers propose different solution algorithms (Kunda, McGregor and Goel 2009). Some solutions proposed are "gestalt", which uses visual representation and perceptually based operation, and analytic, which uses feature based representation and logical operations. The two approaches could yield identical results on at least portions of the test.

The Raven's family test is used extensively in clinical, educational, vocational and scientific settings as an accurate assessment of intelligence. This forms the basis of its use in this research as an instrument for measurement of perceptual reasoning ability, which is an index of full- scale intelligence.

2.3 Empirical review of related variables

2.3.1 Computer - simulated experiment

Computer-simulated experiment is one of the modes of computer- assisted instruction. Computer- assisted instruction is designed using computer technology and applying it to educational or training process which will assist the students or learners to obtain, review, and apply knowledge through one or a mixture of several modes of computer- assisted instruction, that include tutoring, drilling, games, simulations and tests (Boyd and Murphylet, 2002; Allessi and Trollip ,2001).

Computer simulations have been in use since 1950 (Gramelsberger, 2011). As indicated earlier, simulation is the use of a powerful tool known as the computer to emulate or replicate an object in a real or imagined world Allesi and Trollip (1985; 2001). Simulation as a mode of computer- assisted instruction is a computerized model of a real or imagined system that is designed to teach how a system functions, with the learner choosing choose the tasks to do and the order in which to do them. Allesi and Trollip (2001) identify two types of simulations: (1) those that teach about something and (2) those that teach how to do something. They further divide the "about something" into physical and process (iterative) types and the "how to do something" simulations into procedural and situational types.

(1) **About something simulation**

(i) Physical simulation

(ii) Process (Iterative) simulation

(2) **How to do something simulation**

(i) Procedural simulation

(ii) Situational simulation

1) **Physical simulation,** in this, a physical object, such as a frog, is displayed on the computer screen, giving the student the opportunity to dissect it and learn about it or operate a piece of laboratory apparatus which might be used in an experiment.
2) **Process simulation:** This is different from other simulations, in that the student neither acts as a participant (as in situational simulations) but, instead, selects values of various parameters at the outset and then watches the process occur without intervention.
3) **Procedural simulation:** In this, which a simulated machine operates so that the student learns the skills and actions needed to operate it or when the student follows the procedures to determine a solution as when a student is asked to diagnose a problem and proffer solution.
4) **Situational simulation**: This normally gives the student the opportunity to explore the effect of different methods to a situation or to play different roles in it. Usually, in a situational simulation, the student is always part and parcel of the simulation, taking one of the major assigned roles.

Simulations are generally designed for acquisition of skills, problem-solving or obtaining concept. Computer- simulated experiments could be of any of these four categories depending on the aim and objectives of the lesson, provided they are interactive and results could be recorded.

Green and Gredler (2002), also categorize simulations into two. The first is experiental simulation, which provides students with psychological reality in which students play roles within that reality by executing their responsibilities and carryout complex problem-solving in that domain. Experiential simulation is meant to assist students in situations that are either too expensive or two dangerous to experience in a real world. Four major types of experiential simulation according to Green and Gredler (2002) are data management diagnostics, crisis management and social process simulation. He states that this type of simulation provides opportunities for learners to develop the cognitive strategies and organize and manage their own thinking and learning as required by the exercise. The second type of simulation is symbolic simulation. This is dynamic in nature and represents the behaviour of a system or phenomenon, on a set of interacting processes. The students' role in symbolic simulation is that of principal investigator during which they construct their own learning experiences.

Lee (1999) also categorized simulations into two types; (1) the pure simulation and (2)The hybrid simulation. In this study, categories according to Allessi and Trollip (2001) were adopted.

De Jong (2006); and Strangeman and Hall, (2009)) argue that computer simulations transfers greater learning when compared with other media or traditional methods. Computer simulation affords the learner the unique opportunity of experiencing and exploring a broad range of environment, objects and phenomena within the walls of the classroom. Many people associate computer-based simulation with science fiction, high-tech industries and computer games, but today computer simulation has gained way into tertiary institution as well as secondary school curricula in developed countries and is gradually penetrating the developing Countries. Many science educators and researchers have been disappointed by the fact that numerous students who worked very hard in Physics are still not able to master the subject. However, the introduction of computer technology to learning seems to provide the solution to many obstacles to learning Physics.

Chanlin, (2000) and Peeralas Palacios (2003) observe that the potential of computer simulation in teaching and learning Physics has gained ground through research. Akpan (2001) also states that computer simulation possess the potential of accomplishing higher learning outcomes as well as bridging the gap between concrete and abstract reasoning in a manner that was previously impossible in a traditional science classroom.

Lee, Guo and Ho (2003) define an instructional computer simulation as a programme that allows the user to interact with a computer representation of either (a) a scientific model of the natural or physical world or (b) a theoretical system (Weiler 1996), (as cited by Lee et al ,2008).A good simulation, (i) represents a real situation in which the operations are carried out, (ii) provides the user with certain control over the problem or situation, and (iii) Omits certain distracting variables irrelevant or unimportant for particular instructional goals (Lee,2003).

This was represented by Lee, Guo and Ho (2008) as:

Simulation = Reality – Task irrelevant elements.

In 1961, the popular psychologist Jerome Bruner concluded a conference discussion on innovative teaching materials of the late 1950s by saying:

> ”The intelligent use of (audiovisual) resources will depend upon how well we are able to integrate the technique of the filmmaker or the programme producer with the technique and wisdom of the skillful teacher”

According to Zollman and Escalada (1997), the physical science study committee (PSSC) in USA produced series of films that attempted to harness the current film teaching, through the expertise of film producers and the experience of outstanding Physics teachers although, these films have some shortcoming when applied today, but they did open new areas for Physics teachers and part of this film has survived today as PSSC films or video series Physics cinema classics (2).

The interactive computer- based simulation is an advancement of this technology of interactive video as outlined below:

- Keyboards are similar to the remote control of the video cassette recorder, which allows the user to enter all the functions
- Bar code reader allows the user to control the video disc player by means of information stored in the bar codes.
- Computer control delivers all the commands needed for full interactivity through an RS-232 serial that exists on many videodisc players. According to Wilson and Redish (1993) a “computer controlled video player is a basic elements of a so called hypermedia system for learning Physics” Zollman and Fuller, (1994) note that such as HyperCard on the Apple Macintosh and tool book on MS-Dos machine to control videodisc players.

All these assertions confirmed that the computer - simulated experiment is advancement or interactive video. Iterman (2001) grouped Interactive computer –based simulation into two; small programmes, that are suited to a single problem; and complex programmes, that may be suitable for a broad spectrum of application. The computer simulation experiment belongs to the later.

Steps in designing computer simulated experiment

The steps discussed below are the same steps proposed by Gennaro (1992) for computer- assisted instruction, since computer- simulated experiment is a mode of computer -assisted instruction. Software development for the computer in the classroom is very important. Software, in this regard, refers to the programme which the learner uses to interact with the computer. The designing of educational software is similar to preparing for any classroom instructional activity. According to Gennaro (1992), the designer and the instructor (the teacher) should ensure that the following steps are followed:

1. **Presentation of information or Modelling of Skills:**

   The first element involves introducing the learner to something new in the classroom situation. It involves assisting the groups to learn a certain concept. The instructor models the skills in a way that the student can imitate them. Although the concept can be presented in an abstract form, it is important to demonstrate its practical application to enable the students retain learned information. The instructor's role could be substituted with the educational software.

2. **Guiding the students through the initial step of the information or skills:** This step is more interactive, because, once the presentation has been carried out, the learner will begin to apply the process. At this stage, the role of the instructor is to guide the learner through the concept or the process of being taught and also to correct misinterpretation of information. Guidance should be in the form of feedback.

3. **Practice and gaining of competence:** This is to ensure that the learner carries out the task quickly and efficiently with minimal error. At this stage, only short corrective directions could be provided by the instructor. It is believed that, with repetitive practice ,the learner will eventually perfect the task promptly, with little or no effort.

4. **Assessment of Students learning:** This is usually done by testing either in classroom environment or through the software. It provides the means of assessing the effect of instructional process and providing feedback to the instructor and software designer in order to determine future instructional strategies.

Gennaro (1992) posits that the instructional software is maximized when these four elements are available when presenting a learning experience to the learner. This does not imply that the entire four elements must be present at the same time, especially when the computer is used alongside teachers' instruction; hence, the four elements are shared between the computer and the teacher. However, if in the classroom the computer is responsible for the total instruction, then all the elements should prevail. Allessi and Trollip (2001) classify educational software into five major types: tutoring, drilling, games, simulation and tests. Tutorials are used to address the first two steps of instruction proposed by Gennaro (1992): presenting information, and guiding the student through the materials to be learned. Drilling and games, on the other hand, basically, engage in the third phase where practising is the key element.

Simulations are a little complicated in this definition because they provide any combination of the four elements of the instructional process in the same lesson, which, in recent times involve hyper-media. Simulation is used to initiate a real situation in a controlled environment. Test usually represents the last phase, which is that of assessing learner.

Internet Virtual Physics Laboratory: According to College Board of the United States of America (2008), a virtual laboratory is an interactive experience during which students observe minicomputer-generated objects, data, or phenomena which could be manipulated in order to fulfil the learning objectives of a laboratory experience. They are virtual experiment, performed in a virtual laboratory, using virtual tools, This laboratory was derived from the findings of research concerning Physics alternatives conceptions in mechanics, electricity and optics (Wandersa et al. , 1994, cited in Kun-Yuan and Jia-Shang-Heg, 2007).

Virtual means not physically existing as such but made by software to appear to do so, while to simulate means to imitate or reproduce the appearance, character or condition of an existing system, (National Research Council, 2005).

The above implies that computer simulated experiment exists in the virtual laboratory but not all virtual experiments could be simulated because they can only exist in virtual world. Computer -simulated experiment could be made possible through the Internet Virtual Physics Laboratory (IVPL).

The use of virtual tools: The virtual tools used in this regard depend on the topic and the experiment involved. The students may need to operate the following virtual tools, depending on the tasks to be performed: vertical or horizontal ruler, protractor, scale and many others in order to carry out measurements. A time keeper or calculator may also be provided if necessary by the computer to calculate speed, distance and acceleration more accurately and quickly. All these virtual tools are so simplified that anybody could operate them. The student needs not generate the objects, data or phenomena, as numerous remote experiments done every day by scientist show.

According to National Research Council (2005), the apparent reason for opposition of simulation initially were because early virtual laboratories had a distinctly cartoon-like appearance and feel and scientists can hardly support students' performing investigation with a cartoon as a substitute for a true scientific investigator.. Virtual world is a considerable and emerging education technology tool and questions about learning effectiveness are common and expected (National Research Council, 2005).

Activities with the Internet Virtual Physics Laboratory (IVPL): When a study group or a group of learners are exposed to the essentials of Physics concepts in their respective areas of study, they can be logged into the internet virtual Physics laboratory (IVPL). The IVPL software allows the learner to perform every Physics activities (both in the curriculum and beyond the scheme of work) using various appropriate virtual tools provided by the IVPL to observe the Physics phenomena, as well as measure and reflect on the outcome of the simulated experiment. The IVPL activities were integrated into a sequence of the problem-solving learning activities. This is to allow the learners to work at their own pace when they have access to Micro Computers in the IVPL learning environment.

Creating an Effective Interactive Simulation for Virtual Physics Laboratory: Physics Educational Technology **(**PhET) project as an international or worldwide project is faced with Internationalization and localization for effective online interactive simulations. They defined internationalization as the process of designing software to adapt to various locales without engineering change. Internationalization is often abbreviated as i18n (there are 18 character between I and n). Localization is the process of adapting internationalized software for a specific locale (language and country) .

1. Translation of Sims is created in various languages. Therefore, the most successful method of translating Sims is the contributor model. In this model, the instructor who uses the Sims volunteer their time and expertise to create translated Sims. This contributor model appear to be inexpensive on the surface, but on the contrary, a translator must be a bilingual teacher, who uses the Sim in classroom, usually such person must have the following three characteristics.

- They know the scientific terms and notation in both their language and English

- They will use the Sims in class, and therefore, they know the content and have personal interest in the finished product however, some translators have use other method which had worked.

Some organization that popularized computer- simulated experiment (CSE)

Recently many cooperate bodies and individuals are involved in the internet virtual Physics laboratory some of these bodies are

- Design stimulatory Technology. Group
- Java e- learning. Simulation commonly referred to as Jelsim partnership
- Physics Education Technology simulations library (Ph.ET project)
- Physics web: Interactive Experiment
- Merlot. Webmaster.
- Molecular expression .Optical Microscopy: primer of physics of light and colour.

Physics Education Technology (PhET) Project

Physics Education Technology (PHET) Project is developed and manned by a team of scientists in America based in the University of Colorado USA. This team consists of scientists, software engineers and science educators. They have created over eighty online SIMS as at 2009 for Physics and Chemistry, which have been tested, especially with students in various of environments and found to be very efficient to increase learning and learners' interest. The PhET project is a simulation programme which involves hard work and valuable contributions of a group of internationally acclaimed physicists based in the University of Colorado, especially Kathy Perkins, Wendy Adams and Sam Reid, who have been with the project right from inception.

Interactive simulation is a new way to convey scientific ideas and engage learners in educational activities. The combination of advancement in computer hardware and introduction of software, such as flash and Java as well as the Internet provides tremendous new opportunities. These opportunities include animations, with limited or no interactivity to phylets, which are small Java applets that can be readily adapted by instructors or video games to highly interactive computer- based simulations. PhET has focused on the high end of the complexity scale and has produced highly interactive simulations with sophisticated graphs.

The package has undergone series of tests and validation. One thing that makes the PhET project unique is that it is research- based. They undertake and publish their own research, digest and integrate the results into the design. The group study features effective simulations and how students learn from simulation and their uses in the classrooms.

To start a new simulation, they create a design team with expertise from different areas, such as content specialists, teachers who would use the simulations, design experts, educational researchers and professional software developers. They brainstorm, storyboard, design and develop scenarios of what students will be able to interact with. For every simulation, an interview is conducted for students. During the "think aloud" interview, they are asked to open and play with the simulations and talk about everything they do. This is to ensure that they engage in meaningful learning and to find out what works and what does not work.

If these sims are written in a language of flash or Java, they can run through a standard browser anywhere in the world, which makes them available and free to the user. They can also be integrated into lectures or laboratory activities. They can be used by students for home work, assignments or as informal resources. The software is usually updated or validated. This can only be done based on findings from interviews, user testing and class implementation. From the series of research carried out by the PhET project group and the outcome used to refine and re-evaluate the software, it is clear that knowledge also gained through these evolutions are incorporated into the guideline for general design and informs the development of a new simulations (Adams et al, 2007; 2008).

In 2003, several PhET simulations were incorporated into the curriculum in the United States of America. The immediate objectives of PhET project are

i. To continue to develop new simulations and to refine existing ones
ii. To accompany each simulation with tutorial or series of tutorials that provides activities created to work with simulations.
iii. To provide resources for educators, which include:

- Examples of learning goals that are well- addressed using simulations
- Lecture version of each simulations
- Examples of use as lecturing tools with pure demo and peer instruction activities if need be
- Examples of homework or other

Java Electronic learning simulation (JELSIM)

The Java e-learning simulation is popularly referred to as Jelsim partnership. The group consists of experts with over 35 years of combined experience in computer based e-learning in both educational and academic settings based in Scotland. They are dedicated to improving the quality of online education and training. They provide highly interactive materials which could be made on request and tailored to the need of the clients. Their simulation could usually be downloaded from the Internet. Their content can easily be adapted and they can also develop customized content. This project grew out of their belief in the benefits of simulations and the realization that there is still some way to go if they are to achieve their full potential in online learning (JELSIM 2001).

They also viewed their work as an opportunity to take a fresh look at the concern raised in education literature about the use of computers in simulating practical experiments and as an opportunity to address the problems. They see the JELSIM projects as the first step towards addressing the issue of authentic assessment and possibility of assessing students in the environment in which they learn. The objectives of this project, according to them, were to demonstrate the potential of simulations by showing how many simulations could be used to build up skills in practical activities and experimentation.

2.3.2 Computer simulated experiment and students' achievement in Physics

The Nigerian educational system has been challenged with the advocacy of education for all citizens. To live up to this expectation will require more innovations, especially in the use of computer-based technology, as a result the population that is involved.

Although computer technology in the secondary school system has not been popularized even with the inclusion of computer education in the school curriculum, educators have discovered that computer can be very useful in laboratory science instruction (Olele, 2008; Feurtak, Dunlap, Ruskeu, Tucker and Ivatt, 2010).

Nwachukwu (2012) states that the availability of computer technologies in school has made it possible for more thorough investigations of their influence on students' learning, achievement and Green and Gredler (2002), attitudinal change. In sciences, experiment at times, can be very expensive, too difficult or too dangerous for the students to conduct (Olele, 2008). Through computer simulations, such experiment could be conducted and the intended results actually observed. Through simulated experiment, flight could be made through space with man visiting the moon and hence accomplishing complex and impossible task (Sahin, 2006). In the nearest future, creativity and designed simulation could make impossible task, such as human travelling almost at the same speed with light possible (Akpan, 2001). Computer simulated experiment is gradually gaining prominence as instructional medium and strategy.

In science education classroom, simulations provide an opportunity to apply the scientific method to the solutions of problems by providing learners with rich and variable learning environments in which they can master skills and content as well as understand concepts; inquire, explore cause and effect relationship; develop strategic thinking and quickly test multiple hypotheses well . (Xiufeng, 2006; Yuying and Hsiang-Ju, 2008; Fong-Lee, Wrong and chee, 2009).

Olele, (2008) and Fong, Lee and Chee, (2010) claim that CSE provides a realistic cause and effect environment in which students can quickly, safely and efficiently investigate to learn. Simulations can contribute to conceptual change and provide open ended experience (Anders, Shavelson, Richard, Ruiz-Primo and Araceli, 2000; Stieff and Witensky, 2003). It can provide tools for scientific inquiry (Windschitl 2000; Dwyer and Lopez, 2001; Isanbulu and Dumanoglu, 2007). It also has potential for distance education (Lara and Seca, 2000; Aikhalifah, 2005).

Research has indicated that the use of computer simulations of dissection, compared to the traditional hands-on method of dissection, results in improving students' attitude and achievement, and also saves time. (Kella and Reids, 2005; Stanbulu, Dumanogh, 2007; Mckagan, 2008).

One unique and powerful aspect of CSE is interactivity. The key here is that students must be doing something. Educational research has revealed that learning involving "doing" is retained longer than learning via listening, reading or seeing. CSE provides education which is non-linear and is not teacher directed. This type of learning offers an inquiry approach in science education (Akinbobola and Afolabi, 2010). Educationists have discovered through PhET project and other researches that the use of heavily guided activities does not elicit deep thinking and learning from students. Other studies have found that, with pure discovery, students are not able to "discover" the science themselves. Engaged exploration, which simulation stands for, is advocated. This involves the process of students actively interacting with educational materials and the sense-making process of exploration, which is primarily through the students' ongoing questions. It is a widely accepted fact that learning is based on learner's activity. According to the Institute for Science Education Germany, knowledge cannot be implemented or transferred; it has to be reconstructed to have a long- lasting effect. Therefore, interactivity and immediate feedback is inherent feature offered by simulations to practices such activities.

It is an established fact that learning through interaction with a human teacher is a valuable part of education. However, individual learning and training sessions are also needed to compensate for different learning styles, learning speed and students' interest. Simulation, which is always available more than the teacher and also adaptable to particular needs, presents the opportunity for individualized phases into normal classroom activities. This implies that in science education, CSE can turn over a great deal of power from the teacher to the learner. Instead of directly leading students' through specific content, the teacher provides an environment in which students can discover and explore. One useful strategy in science education is getting students involved in the best way to motivate them to learn and simulation seems to hold a natural attraction to the students to learn science.

Dynamic feedback is another rationale behind computer- simulated experiment. This is because it provides a temporal and visual link between related concepts. This approach, when focused appropriately, facilitates students' understanding of the concept and relationship among them (Clark and Mayer 2003).For example, in a virtual laboratory, when a learner moves electron up and down the antenna, there is an oscillating effect which is propagated through the antenna which immediately suggests, amongst other things, electron acceleration and wave generation. This cannot be visible in a traditional laboratory where real wire and antenna are used.

2.3.3 Computer- simulated experiment and students' interest in Physics

Interest is a very important factor in learning. This is because, without interest, there will be no learning. Research findings have shown that computer simulations automatically arrest the interest of the learner and engage the learner meaningfully and consistently to perform a task of interest and also acquire competence (Adegoke and Chukwunenye, 2013).

According to Lavoner et al. (2005), the term "interest" usually refers to preference to engage in some types of activities rather than others. An interest may be regarded as highly specific types of attitude. When we are interested in a particular phenomenon or activity, we are favourably inclined to attend to it and give time to it.

Richardo (2006) asserts that there is increasing reluctance among secondary school students to choose science courses in their final year in secondary education. This, according to him, is because their interest reduces as they attain higher classes. This attitude has important implications for the future of science and technological advancement (Springer, 2006). Based on this fact, one could deduce that developing interest could lead to positive attitude towards science and scientists; and that learning science is increasingly a subject of concern to science educators.

Many science educators attribute great importance to the affective domain (Renninger, 2000; Hidi, 2001). Computer-simulated experiment engages students' interest and allows them to practise laboratory techniques prior to the actual laboratory experience (Nakleh, 2010). It provides the learner with an active role in learning process (Podolefsky, Perkins, and Adams, 2010) CSE helps students observe and understand dynamic processes and enhance decision-making skills (Resequest, Anders, Shavelson, Richard and Aracelli, 2007).

Research has shown that CSE could improve students' impression about the subject The affective outcomes of science instruction are at least as important as their cognitive counterparts. The affective domain is characterized by a variety of constructs, such as attitudes, performances and interest. Many studies have reported that students' original interest towards science subject, especially Physics and Chemistry diminish remarkably as they move to higher classes (Richardo, 2006; Nwachukwu, 2012). At this point, the importance of simulations comes into play to capture the students' diminishing interest.

Hidi, (2000) posits that a learner's interest could be elicited not solely by text features but also by visual stimuli such as a play object and a picture viewing auditory stimulus like hearing a conversation, or a combination of visual and auditory stimuli. Hence, situational interest is adopted to describe all environmentally-triggered interest.

The two categories of interest, which are situational and individual or personal interest interest, has not only reflect how interest had been viewed and study, but also, the two different ways in which the psychological state of interest can occur in people. While individual interest develops slowly, tends to be long lasting and associated with knowledge and value (Renninger, 2000), situational interest is evoked by something in the immediate environment and consequently may or may not have a long–term effect on individuals' knowledge and value (Murphy and Alexander, 2000). Therefore, manipulating the environmental factors through visual, auditory and interactive exercises could generate environmentally-triggered interest. Individual or personal interest and situational interest are not dichotomous but could interact. Situational interest, when properly managed, could translate to individual or personal interest. Hence, it is the ability of the teachers to illicit situational interest through the learning environment that determines the level of learning that occurs. Without interest, there will be no learning. This is because both situational and individual interest affect topic interest. Topic interest influences affective domain and this influence is evident in persistence in a given task which results to learning.

The level of interest of a learner has been proved to be a powerful influence in learning. It has been discovered that it affects, the goals, attention and level of learning (Hidi and Renninger, 2006; Renninger and Krapp 2004). It is, therefore, imperative to address how and why interest can develop and be sustained over a long period of time. Hidi and Renninger (2006) propose a four-phase model of interest. This model is based on the way in which researcher a measured early or late phases in the emergence of interest. The first phase of interest development is a triggered situational interest. If sustained, it evolves into the second phase referred to as maintained situational interest. The third phase is characterized by an emerging (or less developed) individual interest which may develop out of the second phase. The third phase of interest can then lead to the fourth phase which is a well- developed individual interest. Every stage or phase is characterized by a varying amount of affect, knowledge and value. The length and character of a given phase is likely to be influenced by individual experience, temperament and genetic predisposition. The four phases are considered to be sequential and distinct, and represents a form of cumulating.

In the cases were interest is supported and sustained, either through the effort of others or because of challenges or opportunity that a person sees in a task, there is a progressive development. However, without support, any phase of interest development can go dormant and regress to a previous stage (Hidi and Renninger ,2002; Sansone and Smith, 2004). The model provides the following information: (a) describes of how interest can develop and deepen; (b) points to the need for researchers to identify the phase of interest that they are investigating and the impact of their methods on the way in which report findings are interpreted; (c) suggests ways in which educators could support students to develop interest for particular content.

Interest as a motivational variable refers to the psychological state of engagement or the predisposition to rearrange with particular classes of objects, events, or ideas termed content.

Interest could be distinguished from other motivational variables in this way first, interest includes both affective and cognitive component as separate belt interacting systems. (Krapp 2000; 2002). This is distinct from cognitive evaluation approaches to motivation. Typically, the affective component of interest describes positive emotion accompanying engagement, whereas, the cognitive component refers to perceptual and representational activities related to the engagement of the learner. Although interest is a highly emerging positive affective character, it can also be operative in many affective negative situations.

Second, both the affective and cognitive components of interest have biological roots, especially in mammals (Hidi 2003). It is the biological foundation of the psychological state of interest in the sense that the person is engaged physically, cognitively or symbolically.

Third, interest is the outcome of an interaction between a person and a particular content. (Krapp 2000; Hidi 2001). The potential of interest is in the person but the content and the environment define the direction of interest and contribute to its development. This is where computer simulation and software could be used as instructional strategy or learning environment to arrest the interest of the learner. Since it is designed for acquiring skills, problem solving or obtaining concepts, it enables learners to focus their attention on common parts of concepts. (Shaw, Waugh and Okey 1985).

Development and deepening of interest: the four phase model of interest development

Both situational interest and individual interest have been described to consist of two phases. Situational interest involves a phase in which interest is triggered and subsequently another phase in which interest is maintained. In the same vein, the individual interest consists of two phases which include an emerging individual interest and well developed individual interest. The proposed four-phased model integrates this conceptualization.

The four phase model of interest development describes phases of situational and individual interest in terms of both affective and cognitive processes. It also identifies situational interest as providing the basis for an emerging individual interest (Renninger and Hidi,2002). The four-phase model describes early phases of interest development as primarily consisting of attention and positive feelings and so provides a rationale for identifying early phases of interest in terms of affect or liking. The later phase consist of positive feelings as well as both stored value and knowledge. According to Hidi and Renninger 2006, it is suggested that interest at this stage should be assessed by indicators of stored- up knowledge and repeated engagement, in addition to positive feelings.

Phase 1: Triggered Situational Interest

This refers to a psychological state of interest that results from short- term change in affective and cognitive process. This kind of interest could be sparked by environmental or text features, such as incongruous, surprising information: character identification or personal relevance and intensity (Renninger and Hidi, 2002). This kind of interest is typically but not exclusively externally supported (Bloom,1985). Instructional connections or learning environment that include group works, puzzles, computers such as is typical in this study and many others have been found to trigger situational interest. Triggered situational interest may be a precursor to the predisposition to reengage particular content over time as in more developed phases of interest (Renninger and Hidi 2002).

Phase 2: Maintained Situational Interest

This refers to a psychological state of interest that is subsequent to the triggered state. It involves focused attention and persistence over an extended episode in time and reoccurs and persists .Situational interest is held and sustained through meaningfulness of task and personal involvement. It is typically but not exclusively externally supported. Instructional conditions or learning environment provides meaningful and personal, involving activities such as highly interactive computer based learning (computer simulated experiments), project –based learning, cooperative group works and one-on-one tutoring, which can contribute to the maintenance of situational interest (Hoffmann, 2002). A maintained situational interest may or may not be a precursor to the development of a predisposition to re-engage particular content over time as in more developed form of interest.

Phase 3: Engaging Individual Interest

This kind of interest refers to a psychological state of interest as well as to the beginning phases of relatively enduring predisposition to seek repeated re-engagement with particular classes of content over time.

Emerging Individual interest is characterized by positive feelings, stored knowledge and stored value based on previous engagements. The learner values the opportunity to reengage in tasks related to their emerging individual interest and will also opt to do same when given a choice (Renninger and Hidi, 2002). The learner begins to generate his or her own "curiosity" as an outcome of such curiosity questions or self- set challenges; students redefine and exceed task demands in their work with emerging individual interest. The learner is likely to be resourceful. An emerging individual interest is typically not exclusively self-generated.

It requires some external support in the form of models, peers, or experts and this can contribute to increased understanding. Instructional conditions or the learning environment can enable the development of an emerging individual interest. An emerging individual interest may or may not lead to well-developed individual interest (Linstein and Renninger 2006).

Phase 4: Well-Developed Individual Interest

Well-developed individual interest refers to the psychological state of interest as well as to a relatively enduring predisposition to re-engage with particular classes of content over time. It is characterized by positive feelings of more stored knowledge and more stored value for particular content including emerging individual interest based on previous engagement, the learner values the opportunity to reengage task for which there has been well-developed individual interest and will opt to pursue this if given a choice. The learner begins to generate regularly "curiosity" questions.

This kind of learner is likely to be resourceful when conditions do not immediately allow a question concerning a well developed individual interest to be answered (Renninger and Hidi 2002). A well developed individual interest enables someone to anticipate subsequent steps in processing work with content. A well- developed individual interest produces effort that feels effortless (Linstein and Renninger 2006; Renninger and Hidi 2002). It enables the learner to sustain long-term constructive and creative endeavours and generate more types and a deeper level of strategies for work and task. It enables the learner to consider both the content and context of given a task. It equally promotes self-regulation. A well-developed individual interest is typically but not exclusively self-generated. It may also benefit from external support in forms of models, peers and experts which can contribute to increase in understanding. The learner in this psychological state will persevere to work or address a question even in the face of frustration. Instructional conditions or learning environment can facilitate the development and deepening of well-developed individual interest by providing opportunities that includes interaction and challenge that leads to knowledge building.

Israel took part in the second international science study in 1983-1984. In this study, 82% of the 10-year- olds and 66% of the 14-year- olds said that science was interesting. Among the 17-year- old students, who selected to study science for matriculation examination, 72% found the study of Biology interesting, while only 28% found the study of Physics interesting. (Olusola and Rotimi, 2012).

Students cannot record any meaningful achievement in Physics if they have no interest in the subject. This interest, which was originally referred to as situational interest, when aroused, could be sustained until it translates into individual or personal interest that could lead to improvement in student achievement in Physics. It is much easier to capture students' attention by introducing an enriched activity which would also lead to learning. When situational interest is sustained long enough, it will naturally translate to personal interest.

Interest at this point has become the characteristics of a person (Lavonen et al. , 2005). At this point, interest could lead to great achievement in learning because the learner could sustain challenges involved in learning as a result of interest

2.3.4 Computer-simulated and hands-on laboratory experiments and students' achievement in Physics

Laboratory experiments have long played a central role in science education. Through hands-on experiments, students become active learners and acquire scientific skills and knowledge in a meaningful context (Boyo, 2011), while hands-on activities offer concrete experiences and opportunities to confront students' misconceptions, because they are time-consuming. Learning experiences with fixed school schedule without the prospect to explore and discover students tends to repeat ritualistic laboratory procedures to verify the physics concepts. Therefore, it no longer appears to be a wise decision to design curriculum with excessive laboratory experiences (Adams; Keller; and Reid 2005;Linstein and Renninger 2006).

Choi and Gennaro (2006) compared the effectiveness of microcomputer- simulated experiences with that of parallel instruction involving hands-on laboratory experience for teaching the concept of volume displacement to junior high school. It was discovered that computer-simulated experiences were as effective as and less time- consuming as hands-on laboratory experience for teaching the concept of volume displacement to junior high school. It was discovered that computer- simulated experiences were as effective as and less time consuming as hands-on laboratory experiences. Similarly, Pena and Alessi (1999) investigated the effects of three different presentation formats: microcomputer- based laboratory simulation, and computer- based text on students' ability to understand concepts in Newtonian mechanics. They found that both the microcomputer-based laboratory (MBL) and the simulation presentation formats were more effective than computer-based texts and that simulation was equally as effective as the microcomputer- based laboratory (Lunnetta, 2003). Furthermore, they found that simulation preserved all of the advantages of microcomputer-based laboratory and decreased hardware concern. Simulations, by eliminating much of the logical overhead, allow both students and teachers to focus on the phenomena of interest instead of on the equipment.

Finkelstein et al. (2005) present a rather striking study. In a review of the research findings pertaining to the laboratory as a medium of instruction in science, they concluded that one area in which laboratory learning showed advantage over other modes of instruction was in the development of laboratory manipulative skill, Nevertheless Finkelstein et al. (2005) have shown, among other advantages, the superiority of computer simulations to enhance students' manipulative skills in a large introductory Physics course.

In terms of the mastery of Physics concepts and skills with real equipment students who used real equipment were compared with those who used a computer simulation that explicitly modelled electron flow. It was discovered that students who used the simulated equipment outperformed their counterparts both on a conceptual survey and challenging tasks of assembling real circuits and describing how they worked.

The researchers also observed less productive pursuits such as making bracelets out of wires, among students who used real equipment. They concluded that a variety of visual cues in the computer simulations makes visible concepts that are otherwise invisible to students in a laboratory setting.

They also ascribed the success of computer simulations to its capability to scaffold students' understanding by focusing attention on relevant details (Finkelstein et al (2005).

The computer simulates experiment on the screen, an actual events. It incorporates the quick time movies and microscopic pictures to illustrate the functions that are normally hidden from view. The software allows the students to review structures and functions and give a detailed descriptions that explain the physiological functions of the structures and functions and to give detailed descriptions that explain the physiological functions of the structures being simulated.

The constructivist position that students should have access to multiple viewpoints and representations for information is satisfied by well-constructed simulation (Stanbulu, 2007; Wieman, Adams and Perkins 2008).

Alkhalifah, (2005) reported an empirical study on students' learning outcome from activities when using computer-simulated experiments as compared to hands-on laboratory experiment on kinematics. The computer simulated experiment where carried out either in the laboratory or via the web. Analysis of students' scores showed no significant difference amongst the group although there was a significant improvement in students' understanding of kinematics. Many positive aspects on the use of simulated experiments were reported. This included that simulations helped the learner visualize the relationships between the graphs and the corresponding motions. Another feature that impressed the students was their ability to control the simulations and repeat the experiments. They also reported that the interactivity of the simulations used in this study enabled students to control events and their graphical representations and see immediate results of any interaction. It was concluded that computer-based experiments that incorporate simulations and animations are not different from laboratory instructional treatment that uses traditional hands-on activities.

Helgeson (1988). Carried out a research on the effectiveness of the microcomputer in the science classroom. Classes were randomly assigned to one of the four treatments: (1) microcomputer simulations (2) laboratory activities (3) a combination of simulations and laboratory activities with simulations presented first; (4) conventional instruction. The topics covered included the process skills of observing, hypothesizing, testing, classifying and recording of data. Results showed that laboratory activities, simulations and a combination of these two strategies yielded higher achievement than did conventional instruction. There were no significant differences in achievement among the non-conventional treatment groups.

2.3.5 Computer Simulated Experiment and Hands-on Laboratory and Students' interest

Computer simulated experiment and hands-on experiment is the use of hands- on experiment to enhance computer simulation, when the apparatus is insufficient, dangerous, expensive and when the experimental objectives could equally be achieved virtually(Keller, Finkelstein, Perkins, and Pollock 2005; Xi Ufeng Liu (2006). It could also be referred to as enhanced computer simulated experiment

Many researchers have studied the effect of enhanced computer simulated experiments in some sciences. Xi-Ufeng Liu (2006) through a research discovered that computer modelling enhanced hand-on Chemistry laboratories were more effective than hands-on laboratories alone in facilitating high school students' understanding of chemistry concepts. Thirty-three high school Chemistry students in United States of America were divided into two groups. Each group completed a particular sequence of computer modeling and hands-on laboratories. This also included a pre-test and post-test of conceptual understanding in gas law. A survey of conceptions of scientific models was also carried out. Results revealed that a combination of computer modelling and hands-on proved more effective than either computer simulations or hands-on-laboratory alone and can improve student's interest in science. Okuno, Abe, Yamazaki, Ooe, Igarashi, Hayashi and Suzaki, (2009), Zacharia (2003) investigated the effect of interactive computer-based simulation which was presented prior to inquiry-based laboratory experiments on student's conceptual understanding of some Physics concepts. The results indicated that the use of simulation improved the students' ability to make acceptable prediction and better explanation of the phenomena.

Enhanced computer simulations from the above reports yielded good result where experiment has failed in Chemistry to enhance conceptual understanding better than enhanced CSE. This result might probably be as a result of the nature of the topic which involved microscopic element. Hence, there is need to ascertain its effect in Physics practical.

Laboratories have been earlier described to be the scientists' workshop where practical activities are conducted to enhance meaningful learning of science concepts and theories (Seweje 2000, Olubor and Uyimadu, 2001). Laboratories have also been discovered as primary vehicles for promoting formal reasoning development of scientific attitude, science process skills, integrated science process skills (Adeyemo 2003) and students' understanding, thereby enhancing desired learning outcome. Ogunleye's (2002) research revealed poor laboratory facilities and activities in Senior Secondary School level (Alabiosu, 2000; Onipede, 2003; Boyo, 2011). The above findings showed that hands-on laboratory activities have failed to serve as an enhancement to learning and acquisition of scientific skills .This could be attributed to the students' performance. There is the need, therefore, to ascertain if the limited exposure given to the students in laboratory activities could be enhanced through computer simulated experiment or through modified computer simulated experiment. From the findings of various researchers, these factors mentioned have incapacitated the effectiveness of hands-on laboratory activities. Another factor that has posed a serious challenge to achievement and interest through hands-on laboratory activities is the fact that students see laboratory activities as too tedious and exposing them to hazard. Hence interest has been sacrificed on the altar of caution. This is a serious error for any meaningful achievement. There is need to understand how interest could be developed and deepened in order to enhance the learners' achievement in the classroom. Although interest have been recognize as an important condition for learning, educators had continued to struggle with difficulties of working with academically unmotivated students (Hidi and Harackiewiez 2000). Many teachers do not have a clear understanding of their potential role in helping students to develop interest. In fact, teachers often think that students automatically would either have or do not have interest. Therefore may not realize that they have important roles to play to help students develop interest (Linstein and Renninger, 2006). There is need to also state that some activities are impractical, expensive for schools and, therefore, could not be carried out in the laboratory (Frederiken, 2000; Dwyer and Loopez, 2001; Stieff and Witensky, 2003).

2.3.6 Perceptual ability and students' learning outcomes

Perception is the process of attaining awareness or understanding of the learning environment by organizing and interpreting sensory information (Pomerantz, 2003). Perception involves signals in the nervous system which, in turn, results from physical stimulation of the sense organ (Goldstein, 2009). For example vision involves light striking the retinas of the eyes. Smell is mediated by odour molecules, and hearing involves pressure waves.

Perception is not these "top-down" effect as well as the "bottom-up" process of processing sensory input. The "bottom-up" processing is basically low level information that is used to build up higher -level information that is shapes for object recognition. The "top-down" processing refers to a person's concept and expectations (knowledge) that influence perception (Bernstein, 2010).Perception depends on complex functions of the nervous system, but subjectively seems mostly effortless because this processing happens outside conscious awareness(Goldstein, 2009).

Since the rise of experimental psychology in the late 19th century, understanding of perception by psychology has progressed by combining a variety of techniques (Zangwin, 1987). Psychophysics measures the effect on perception of varying the physical qualities of the input. Sensory neuroscience studies the brain, mechanisms underlying perception. Perceptual system can also be studied computationally in terms of the information they process. Perceptual issues in philosophy include the extent to which sensory qualities, such as sounds, smells or colours, exist in objective reality rather than the mind of the perceiver (Pomerantz, 2003). Although the senses were viewed as receptors, the study of illusions and ambiguous images has demonstrated that the brain's perceptual systems actively and preconsciously attempt to make sense of their input.

Process and terminology

The process of perception begins with an object in the real world termed the distal stimulus or distal object (Goldstein, 2009). By means of light, sound or another physical process, the object stimulates the body's sensory organs. These sensory organs transform the input energy into neutral activity in a process called transduction (Pomernrantz, 2003; Goldstein 2009). The raw pattern of neural activity is called the proximal stimulus. These neural signals are transmitted to the brain and processed. The resulting mental recreation of the distal stimulus is the percept. Perception is sometimes described as the process of constructing mental representation of distal stimuli using the information available in proximal stimuli. An example would be a person looking at a shoe. The shoe itself is the distal.

Perception: As an aid to learning

Learning begins with attention, which automatically aids perception. Attention is a form of interest. Perception as an ability to create a mental picture or image of a given object or situation is neither automatic or easy. (Allessi and Trollip 2006). This is partly because attention is constantly strained by many other stimuli. There are three principles relevant for perception: These are:

(i) Information: (Visual or aural) which must be easy to receive

(ii) Position (Spatial or temporal)

(iii) Differences and changes that attract and maintain attention.

This is very vital in learning especially in the science class. It is the ability of the learner to perceive a given pieces of information that determines the level of assimilation and learning. When a concept which ordinarily looks abstract is made as concrete as possible by, colour, size, high level of details and cues and choice of mode, perception becomes easy. Another consideration for ease of perception is repeatability. Information are more likely to be retained if the learner can often repeat it. Another factor that affects the ease of perception is pace. When information is presented too quickly or too slowly it would either increase or reduce the rate of perception (Allessi and Trollip 2001;Sahin 2006). For perception to occur there is need to attract, and sustain the attention of the learner throughout a lesson. Hence, interest affects perception and achievement.

There is still active debate about the extent to which perception is an active process of hypothesis testing analogous to science or whether realistic sensory information is rich enough to make this process unnecessary stimulus. When light from this object enters the person's eye and stimulates the retina, that stimulation is the proximal stimulus. Pomerantz (2003).

Hence Alan (2011) identifies three components of perception as:

1. The perceiver: The person who becomes aware about something and comes in to final understanding. The three factors that influence his or her perceptions are experience, motivational state and emotional state. In different motivational and emotional states, the perceiver will react or perceive something in different ways. Also in different motivational or emotional states, the perceiver will react to or perceive something in different ways. Also in different situations, he or she might employ a "perceptual defense, "where they tend to see what they want to see"

2. The Target: This is the person who is being perceived or judged. Ambiguity or lack of information about a target leads to a greater need for interpretation and addition.
3. The situation also greatly influences perceptions because different situations may call for additional information about the target. Stimuli are not necessarily translated into multiple percepts. Experiment is randomly done at a time in what is called “multistable perception”

Bertoline, (1998), Jones et al (2004), Harvey and Gingold (2006), and Minogue et al (2006) investigated the impact of computer simulated haptic force feedback on learning. The human computer interaction (HCI) was display elements, such as windows manipulation, tool bars menus and 3D virtual objects as well as interaction hardware, which were mouse, keyboard, motion capture system, cyber glove, wand, head tracker and natural language and display system. The haptics in HCT were kinesthetic and tactile force feedback and new channel of information. Their findings are stated below

- The fundamental concepts in Physics are so unique that they often require the constructions of active mental models of their physical and mathematical models in the minds of students.
- Human spatial cognition which provides us the ability to think quickly and to recognize complex mental models is an important building block to general cognition of learning Bertoline (1998)
- Multiple brain region involved in spatial task are activated by multisensory inputs suggesting convergence of information from different modalities in human spatial perception.

Perceptual reasoning ability test is designed to test one’s spatial visualization skills, especially one’s ability to interpret two dimensional representations of three dimensional objects. This suggest that inherently dual-modal stimuli, such as various Physics force (spring force, electrostatic force, gravitation and so on.) that require both spatial and haptic cognitions may be better understood when both modalities are involved in learning the semantics of related Physics phenomena.

Sutherland (1965), the father of computer graphics, predicted that mathematical and Physics concepts which never before has any visual and haptic representation can be shown and felt, allowing us to learn them in the same way as we learn our own natural world. This was predicted forty eight years ago. One of the tools used to measure perceptual ability is the Raven’s progressive matrices. These are non-verbal multiple choice test that measure the reasoning components of spearman's "g", which is often referred to as general intelligence. These tests were originally developed by John C. Raven in 1936.

In each of the test item, the subject is asked to identify the missing element that completes a pattern which may be presented as 4X4, 3X3, or 2X2 matrix, giving the test its name.

The underlying factor is to develop simple measures of the two components of spearman's "g", which is often wrongly equated as general intelligence". These two components are (1) the ability to think clearly and make sense of complexity which is known as educative ability and (2) the ability to store and reproduce information, known as reproductive ability. The matrices are available in three different forms for participants of different abilities namely: These forms are:

1) **Coloured progressive matrices (CPM):** This is suitable for children between age 5 and 11years as well as elderly people and individuals of any age that are mentally impaired. It consists of 36 items in 3 sets of 12and administered for 15 to 30 minutes.
2) **Standard progressive matrice (SPM):** This is suitable for children and teenagers of ages 6-16years. It could also be used with older adolescents and adults or those who score near the ceiling of the standard SPM. It consists of 60 items in 5 sets of 12. It is administered for 40 to 45 minutes
3) **Advanced progressive matrices:** This is suitable for those 12 years and above whose intellectual ability is above average. It consists of 12 practice items and 36 test items. It is administered for 40-60minutes. It is also the most difficult of the three versions. When administered under time, it could be used to assess intellectual efficiency, that is the speed and accuracy of high-level cognitive work.

2.3.7 Numerical ability and students' learning outcomes

Numerical reasoning ability has earlier been defined as the ability to reason with numbers and other mathematical concepts. It is the knowledge required to apply arithmetic operations, either singly or in sequence. The first type of numerical ability test covers basic arithmetic such as addition, subtraction, multiplication, division and number sequences, and simple mathematics, such as percentages and powers fractions. This test can be categorized as speed test and is used to determine the basic numeracy without the use of calculator. Numerical reasoning ability is the ability to understand the relationship between sets of numbers. It is a good predictor of academic performance and an indicator of an individuals' ability to solve problems involving numbers (Barrett, 2004).

There is no widely accepted definition of the difference between numerical ability and numerical aptitude as far as psychometric test is concerned. The two terms are interchangeable. However, the same does not apply to the term numerical reasoning psychometric success (2009).

According to Psychometric Success (2009) and Adeleke (2010),there are basically two types of numerical questions that appears in psychometric tests. These are the speed questions and power test. The speed questions are so easy, that with unlimited time, most people to whom the test is administered could answer them all successfully. However, the time allowed to complete the test is so short that even the most able person is not expected to finish. This means that the result depends on the number of correct answers made in the relatively short time allowed. In contrast, a power test contains questions that vary in difficulty and no one is expected to get all of the answers correctly even with unlimited time in practice. A definite but ample time is set for power tests. The numerical ability test used in this research belongs to the speed questions category.

All numerical ability tests, according to Adeleke (2010), can be classified basically into four: numerical computation, numerical estimation, numerical reasoning and data interpretation.

Numerical Speed Test: This test usually consists of computation and estimation, which are forms of speed test. The questions involve basic arithmetic including addition, subtraction, multiplication, division, percentages ratios, fractions and decimals. To score well on these questions one will need to be able to make quick and accurate calculations without using a calculator.The test requires the application of the basic rules of numeracy with problems presented in the accepted mathematical sequence (Barrett, 2004). Experience has shown that people who are numerate perform well in this test even though they may have "forgotten" about mental arithmetic. (Barrett, 2006).

Numerical Power Test: It usually consists of numerical reasoning and data interpretation. A numerical reasoning test is a power test rather than a speed test because the questions require the participant to interpret the information provided and then apply the appropriate logic to answer them. In other words, one needs to work out how to get the answer rather than just doing the necessary calculation (Adeleke, 2010).

Various researchers have reported improper choice of graph scale, inability to distinguish graph axes, poor calculative abilities amongst other factors as reasons for poor performance in practical classes. They consequently linked these to low performance and low development of basic science skills (WAEC Chief Examiners' Report, 2007). This skill described above is basically numerical ability. This implies that for any learner to excel in practical Physics and in Physics, generally, such learner must know the language of Physics which is evident in high numerical ability (Adesoji, 2008).

Computer simulated experiment, hands-on experiment, numerical and perceptual reasoning abilities

A lot of evidence showed a very high positive correlation between Physics and Mathematics (Adesoji 2008).Many expressions used in Physics are mathematical connotations. Most experiments in Physics involve drawing of graphs, use of mathematical symbols and calculations. Any student who intends to be proficient in Physics must possess a strong background in mathematics (Adesoji, 2008).

Royal Grammar School Oxbridge (2011) defines Physics as the principal subject where numerical analysis is applied to practical problems and measurements. This implies that numerical ability is absolutely necessary and important for any student to succeed in Physics. Therefore, any learner that possesses good numerical reasoning ability is at an advantage in learning Physics.

Adesoji (2008) states that students are not the same, especially when it involves the rate at which facts and principles in science are assimilated or when the ability to perform a specific task is in consideration. In other words, students have varying abilities when confronted with one task or the other. Therefore, a learner with an appreciable level of numerical reasoning ability will perform well in Physics generally.

On the other hand, perception is the organization, identification and interpretation of sensory information in order to fabricate a mental representation through the process of transduction. All perceptions result into physical stimulation of the sense organs. Perception is also described as the process of constructing mental representations of stimulus using the available information. This is very important to sciences, technology and Physics practical, in particular. This is because, in practical activities, three dimensional objects are involved and one's perception about the physical and chemical properties of the material during interaction in experimental studies goes a long way to determine the extent of one's success in such activities.

A computer simulation which is also referred to as computational model is one that attempts to simulate an abstract model of a particular system. This aspect of computer modelling has become a useful part of mathematical modelling of many natural systems in Physics, referred to as computational Physics. Astrophysics, Chemistry and Biology.

Therefore there is the need to ascertain if there is any relationship between perceptual reasoning ability and the numerical reasoning ability of the learner; and to verify how the correlation between these construct aid the learners' achievement in the task at hand. Some studies have shown that ability aids learning or performance. Ability tends to be associated with greater academic achievement and ability or performance, when used in conjunction with measures of these constructs, is an excellent predictor of achievement (Adeyemo, 2002)

According to Chukwunenye (2007), low ability students benefit more by learning in small mixed ability groups rather than in large groups, and small groups also facilitate achievement in high ability learners. Ability grouping could enhance students' performance in practical class.

Enhanced computer simulated experiment is an instructional strategy in which hands-on laboratory experiment is used to enhance computer- simulated experiment. Perceptual reasoning ability is also defined as a measure of how quickly a person is able to perceive changing data, remember data for future use and make correct decisions within a very short period of time. This type of test assesses how quickly a person is able to compare letters, numbers, shapes, sequences or other data in a quickly changing environment and use this ability to solve other problems (Adeleke 2010).

Perceptual reasoning ability, according to Wechsler (2008), is a component of intelligence quotient (IQ) scale. That was first released in 1939 by Believue Wechsler. The scale is currently in its fourth revision (WAIS-IV), which was released in 2008.

Wechsler's scale is founded on his definition of intelligence as "the global capacity of a person to act purposefully, to think rationally and to deal effectively with his environment". He believed that intelligence was made up of specific elements that could be isolated, defined, and also measured. He further stated that the individual elements can be independently measured. However, all the elements are interrelated. In other words, general intelligence consists of various specific and interrelated components, with perceptual reasoning as one of such components. Numerical reasoning ability is also a component of intelligence quotient scale (IQ). It is a verbal IQ scale (Wechsler 2008). It is that aspect of intelligence that belongs to the subset of working memory index (WMI), which measures the ability of the learner to work with number, sequence, digit span and perform simple arithmetic.

The perceptual and numerical reasoning abilities will be measured using raven standard progressive matrix and Hawley's numerical reasoning ability tests. This is because these construct are very important for achievement in the computer simulated experiment instructional strategy and in teaching strategies generally.

The traditional approach to the teaching of Physics has continued to suffer from over dependence on quantitative, mathematical methods, which have to be mastered before the subject can be understood. With the computational power and modern graphical characteristics of the computer, this sequence can be reversed with the mathematical methods, placed at the end of the learning cycle and not as a prerequisite for understanding. According to some educationists, the value placed on experiment, either as a demonstration or hands-on experiment, is overestimated. This is because, at the secondary school level, the experiments are geared towards verification of facts. According to Richardo (2006), an experiment should not be a criterion for truth but as a learning tool for the newcomer.

A number of authors have argued that, in science courses, classroom simulations potentially have an important and valid role in creating virtual experiment and problem – based micro-worlds that allow students to use instruments and monitor experiments, test new models and improve their initiative understanding of complex phenomena. They indicated that simulation can help students to identify relationship between components of a system, to learn about the system and to control them.

Through simulations, the learner has the opportunity to practice with variety of situations similar to "real life" problems. It also encourages the skill of synthesis by applying what the students already know to a unique situation, thus strive for a higher level of cognitive functioning by providing the students with a conducive learning environment in which students search for meaning, appreciate uncertainty and acquire responsibility. Computer simulations present students with problems and allow them to utilize the simulation as a powerful tool to carry out investigations and to solve problems. Computer simulations are designed both to teach contact and to enhance higher-order problem-solving skills. It allows learners to explore and manipulate variables and then obtain results and provide feedback to their thinking and learning processes in science. (Akpan 2001; Paulson, Perkins and Adams 2009 ;De Jong 2006a).

Three possible delivery methods for simulation

Adams et al, (2009) reported that the website offer the possible delivery method for simulations: First is , Run the Sims online ,which involves clicking the "run now" button on the website and this requires live Internet connection. Second is, download an individual Sims by clicking "download the PhET offline website; this is an installation program that puts the website and all of its contents (except the teacher contributed activities) onto the user's computer. A user then has access to all the SiMs and supporting materials without the need for an Internet connection. The third method is to get the software installed into the computer. All languages for each Sims are available on the website.

2.3.8 Important general design features

Through extensive students' interview, PhET project team has also learned a number of general design features that are important for ease of use, engagement and learning. These are:

i. Highly interactive animation that provides direct and immediate response to users actions

ii. An appealing environment and reasonably sophisticated graphics that literally invites the student to interact and explore.

iii. Simple and intuitive controls, such as click and drag manipulation, slides, and radio buttons, with minimal reading required.

iv. Connections to real life objects.

To create a good SIM requires both experts' understanding of science and careful testing with students. The creation process also helps experience scientific models. It is worthy to note that an average novice student perceives what goes on in the computer screen differently from experts. It is only through multiple refining test cycles by producers of experts with students and the resulting modifications that it will be possible to know if students have the same interpretations of what is happening in the SIM as the experts.

Extensive studies have also revealed how often classroom demonstration, textbook visuals and even laboratory equipment can be confusing and misleading for novice students because of this gap between expert and novice perception (Wiemann, and Perkins, 2006) studies have also shown that good SIMs can actually be pedagogically more effective than apparently similar classroom demonstrations and laboratory exercise with real experiment (PhET, 2009).

A very good SIM will also enable the student to explore the “what if” experience. Apart from the students usually discovering many control variables readily, they also have the opportunity of discovering what happens under extreme conditions, which is referred to as the “what if experiences”. Take the “circuit construction kit” (CCK) as an example of a simulated experiment where the student is expected to build a d.c. circuit of nearly arbitrary complexity with realistic appearance (or schematic), like light bulbs, resistors, batteries and wires. The highly visible electrons move round the circuit lighting the bulbs, losing energy in accordance with Kirchhoff’s laws.

In the above case, there are both expected and surprising aspects of how students interact with SIM. Among the expected result is that students will explore and usually discover the many controls or variables more readily than their teachers. Students also will consistently explore what happens under extreme cases. PhET and some other SIMs designers have learnt to take advantage of this, by building in little pedagogically effective “surprises”, such as having the CCK battery burst into flame when the current is too large.

Another expected result is that, even with very little careful design all, apart from the simplest SIM, need some questions or activities to guide the students in educationally effective exploration.

Each PhET SIM is created as a standalone learning tool with several layers of complexity. This approach gives teachers the freedom to select and use those that best match their students’ learning goals. Results revealed that we are yet to see any student misled by the wildly unrealistic scales commonly used, such as large blue electrons or light that crawls across the computer screen. As long as these elements are given a slightly cartoonist appearance, they are perceived to be unrealistic but useful representations.

2.3.9 Computer simulated experiment and degree of reality

When presenting objects in a simulation, the degree of realism to be used must be decided. It is always preferable to use an intermediate degree of realism, which also implies an intermediate degree of abstraction. An example is a model of a car. To do this, the model, must not be displayed as a little car but rather as constructed of mass points simulations should not try to mimic nature as closely as possible; it should rather, serve as an intermediate step towards abstraction. It is also possible to use videos combined with animations to bridge the gap between real and simulation worlds. This is necessary because simulations are supposed to bridge the gap between reality and abstraction for effective reconstruction of knowledge.

Still with the car in focus, in the real world, there are no rigid bodies, only elastic ones. While models of the rigid body are elegant mathematically, they are not appropriate for learning. The problem in this case is that the model of a rigid body is close to common sense.

In common sense, the movements of the discrete parts of an extended objects does not need an explanation because, in some instances, the distribution of forces with no delay is assumed. The model of rigid body is based on the same assumption Herman (2000) argues that this type of thinking should be questioned and improved rather than being supported by an early introduction of the rigid body model.

A model to be presented at this point should be a simplification of the elastic body after the principle and complexity of an elastic world has been understood. Therefore, an effective simulation at this point should be able to bridge this gap between concrete (rigidity) and abstract (elasticity) world bodies.

2.3.10 Comparing computer simulations with expository instruction and autonomous learning.

According to Yu-fee et al. (2008), the three major traditional frameworks of Physics learning are:

i. Hands –on Experiment

ii. Expository Learning

iii. Autonomous learning

Yu-fee et al. (2008) carried out research to compare the effectiveness of computer simulation and these three traditional frameworks of Physics learning were reported.

Computer simulations and expository instruction:

Expository instruction involves the traditional framework of Physics learning with the assumption that knowledge is transferable by an authority. Although an insightful explanation by an expert teacher might shed light on sophisticated Physics concepts, a vital element in Physics learning tends to be missing in this framework. According to the constructivist view of learning, learners must actively construct their own knowledge rather than receive performed information transmitted by others (Green and Gredler, 2002).

Without active participation, many students tend to isolate, control and forget the Physics concept received through expository instruction, but one of the goals in education is that students will be able to exhibit evidence of transfer that extends beyond the exact conditions of initial learning (Bransford and Schwarts, 1999).

Huffman and Michin (2008) carried out a study which demonstrated active knowledge construction based on the learning experiences of computer simulations. These researchers developed “the constructing physics understanding project” (CPU). This study compared the computer- based experiences with both expository instruction and hands-on experimentation. The CPU activities were much more than verifying a scientific phenomena but emphasis includes discussing ideas with the teacher and other students, while the traditional comparison classes were on listening to lectures and doing activities to verify concepts. They reported that the CPU was very successful because it involved highly interactive environment. They therefore, advocated the integration of computer simulation into the learning framework of expository instruction.

Eylon, Ronen and Gabriel (1996) explored the potential of a computer program “RAY” to enhance optics learning in secondary schools. They investigated two modes of using “RAY” environment in the first mode. The teacher in the experimental group had a single computer in the classroom and the Ray environment was used by the teacher as a teaching aid, while the second group depended on some special rays which involved other intricacies and possible hazards. They assert that the use of computer simulations made it possible for students to rely less on special rays and on other geometrical shortcuts.

The speed and flexibility of simulations also enable the teacher to spend more time on interpretation of concepts and phenomena. Despite the successful use of computer simulations, some researchers have reported insignificant results when simulation learning experiences were compared with expository Physics learning.

Chanlin (2000) investigated the effect of animation in Physics learning of eighth grade and ninth grade students. After the period of study, it was discovered that there was no significant difference between the students of different treatment groups. She suggests that the limited capacity of working memory in processing animation among lower spatial ability learners might be worth noting. Although her result did not involve computer- simulated environment, Chanlin notes that animation may not be necessary for students when concepts can be presented with sufficient clarity in a graphic form.

Sierra-Fernadez and Perales-Palacois (2003) investigated the effect of instruction with computer simulation to students learning Newtonian mechanics. They did not find any significant differences in the concept and attitude test scores between students who had simulation experiences and those who only used a textbook. Nevertheless, results showed that students with more knowledge of Physics scored higher than those with less knowledge of

Physics and Chemistry in concept test. It was also discovered that lack of systematization in the confirmation of hypotheses sometimes led students to wrong conclusions and some students had difficulties in interpreting the speed-time and velocity-time graphics shown on the screen. Furthermore, while some students recognized their incorrect hypotheses after carrying out the simulation activities, they were unable to explain the unexpected phenomena shown on the computer screen. The message emergent from this conclusion appears to be that additional supports, such as immediate feedbacks or prompts, are needed to help students who might have trouble in the learning process.

Computer simulations and autonomous learning

Autonomous learning, according to Lee, Guo and Ho (2008), is defined as the spontaneous behaviours by students who construct understanding in Physics independent or collaboratively without support from an authority. An example of autonomous learning is the effort put forth by a student to finish homework. It is through this reflective and effortful learning process that a true understanding of Physics is acquired.

Although autonomous learning is in accordance with the constructivist view of learning, this framework of Physics learning probability work best for few brightest and most hardworking students. Researchers observes that some of the students with the highest formal reasoning scores but with poor habits of study appear to acquire a better than average conceptual grasp of the material. There are no short cuts to achieving understanding in Physics. The situation is even more difficult for the majority of Physics students. Studies have shown that many students in the Physics classroom do not appear to be at a formal operational level determined by Piaget’s measures (Cohen, Hillman and Agues 1978, cited in Lee et al, 2008). When students encounter difficulties in the autonomous learning process, they are left alone without appropriate assistance. However, some researchers have suggested that immediate and frequent feedback is a significant factor to enhancing students’ Physics performance.

When computer simulation was used to provide individual guidance, it was found to offer students dues necessary for successful problem- solving both qualitatively and quantitatively. In the autonomous learning framework, the first mode of the study by Eylon et al (1996) investigated the unique contributions of the computerized environment, RAY, to students understanding in geometrical optics. The study indicates that individual use of the RAY environment can help to promote students’ understanding of geometrical optics in some important aspect. They concluded that three aspects of learning process contributed to their study:

(a) RAY allows exploration and provides direct feedback in the process of solving problems.
(b) The task design directly addresses the learning difficulties experienced by students.
(c) It is useful to provide opportunities for reflection on problems, solutions and reformation of knowledge.

Similarly, Steinberg and Oberem (2000) investigated the effect of an interactive computer-based tutorial using photoelectric tutor, on students' understanding of the photon model and the photoelectric experiment. The program photoelectric tutor was assigned as home-work after a lecture on the photoelectric effect and the students were explicitly advised to read the relevant chapters in the textbook before beginning the tutorial. Students were asked to draw a qualitatively correct I-V graph. After a student had drawn an I-V graph, the programme checked whether the critical features of the graph were qualitatively correct. When an error was identified, the computer initiated a dialogue to address the difficulty. This programme asks questions to help the student recognize the error and to guide the students through the reasoning necessary to overcome the underlying difficulty. The dialogue continues until the students' draws a qualitatively correct graph. Analysis of the students' responses on the posttest questions indicated that not only did a greater percentage of students who used the photoelectric tutor answered correctly, but also these students gave much better physical explanations. The effectiveness of the programme was largely due to the emphasis on having students go through the reasoning required for drawing and in interpreting the graphs.

2.3.11 Different simulation environments and students' different characteristics

In the last decade, many researchers have compared the effect of different simulation environments and looked deeper into their effects on students of different characteristics. Analysis of studies from this category often show mixed results of students' performance. Generally, the message from these studies is that the diverse performance of different students should be noted and that redundant simulation activities might not be necessary. It appears that, sometimes, too much support is not helpful but obstructing to students in exploratory activities.

Some researchers investigated the cognitive impact of three different types of simulation (physical, procedural and process) for teaching the concept of energy to fourteen year- old students. It was discovered that simulation can have different genders and prior achievement levels. For the middle achieving students, the facility to repeat the same experiment, many times, seem to have been helpful, perhaps because of the opportunity to build confidence in their understanding. However, field notes on the study recorded certain behaviour with high- achieving male students which were compactable with boredom and loss of concentration. The lack of challenge and variety might have become obstacles for the high-achieving male students to develop understanding and might have been the factors which led to a lower score on the posttest than the pretest. For students with low prior achievement, the lack of clear learning goals and immediate feedback might have prevented learning from occurring. Adams et al. (2009) note that computer simulations need to be more carefully differentiated for students of different characteristics than is commonly the case. In addition, researchers have investigated the effects of computer simulations when combined with different learning supports. De Jong (2006a) explored discovery learning with a computer-simulated environment in collision. They compared students' performance when discovery learning was supported by model progression (computer simulation that was divided into a number of levels) Assignments (small exercises, that help to perform a sensible action and that may point to specific aspects of the simulation model) and pure computer simulation. They found that the gain scores for the intuitive qualitative knowledge test were different between students of different characteristics (computer science students and Biology students). De Jong (2006b) notes that they found clear effects by adding assignment and model progression in two other sides though these effects were not significant in this study. They attributed this to the quality of the assignment given and the unnecessary models at the lower levels.

Also, Lee, Guo and Ho (2008) investigated the effect of a computer learning environment to enhance the understanding of displaced volume. They found that the enhanced animations (additional tools which enable students to personally modify mass, volume and shape) did not enhance performance and even had a negative effect. They claim that this might be because more than 70% of the students were able to distinguish mass and volume initially and the reshaping of objects might have confused some students. Overall, reflective integration (when students compared their prediction and the outcome and indicated whether they were the same, they got feedback on the congruence between prediction and outcome, revised their ideas if necessary, identified patterns from two experiments and created principles by filling in missing words from pre-specified choices) compared to spontaneous integration significantly increased students performance.

They concluded that directing students to make sense of the experiments and to generalize their ideas into principles will lead to knowledge integration and result to a rather enduring understanding. Interestingly, another finding from the study is that students with cohesive beliefs who received reflective integration treatment gained more understanding from immediate posttest to delay posttest whereas the other groups declined. For students who viewed science as a collection of isolated facts and believed that the best way to learn science is by memorization, the advantage of reflective integration instruction was only at the immediate posttest. This result suggested that reflective instruction helps students with dissociated beliefs, but has little long- term impact on their knowledge integration.

2.3.12 Appraisal of the literature reviewed

The literature reviewed has shown that students' interest in Physics diminished as they move from lower class to higher class. Little or no attention is given to practical work at secondary school level, (Zacharia and Anderson, 2010; Boyo 2011;). has revealed that hands-on laboratory practical, which ought to follow at every module at senior secondary school level, is sparingly arranged for the students.

It was also discovered that hands–on laboratory experiment in the occasion when arranged for the students is time- consuming and usually goes beyond school period. It is equally expensive and sometimes very dangerous and, therefore, skipped by the teacher. This automatically results to lack of interest in the task presented and hence record low achievement. Also, practical classes, which need to serve as complements to normal classroom teaching, have failed in their roles (Nedesky, 1958; Toolmacker, 1984). These scholars call for abolition of laboratories in introductory Physics curricula at different intervals, based on this reasons.

Laboratory activity is a conventional way of carrying out practical activities in secondary schools, computer simulations had proved successful in universities and colleges. (De Jong 2006b;Adams et al 2005).

Many groups have embarked on a project to explore the effectiveness of interactive computer- based simulation. Such groups are Physics Education Technology (PhET) project, Java electronics simulation, (Jelsim) project and Merlot group. Most of the studies reviewed indicated that computer- simulated experiment have been successfully used. While other researchers also discovered that the interactive computer- based simulation prior to performing a laboratory - based experiment enhances learning more than using only laboratory activities or hands-on experiment (Lee, Guo and Ho 2008).

Some researchers have proposed that computer- simulated experiment does not only enhance learning of Physics, but can also actually replace real experiment in Physics.(Request, Anders, Shavelson, Richard and Ruiz-Primomana, 2007). This study will help provide useful information on the effectiveness of computer- simulated experiment in Nigerian secondary schools and how the interest of the learner could be captured to learn Physics. It will also show how computer- simulated experiments could be used as effective supplement to learning practical Physics within the available contact period.

CHAPTER THREE

METHODOLOGY

This chapter focuses on research design, sample and sampling procedures, research instruments, reliability and validity of the instruments, procedure for data collection and data analysis.

3.1 Research design:

A 3x3x3 pretest, posttest, control group quasi-experimental design was adopted for this study. The pretest, posttest, control group quasi experimental design.

Where:

Experimental group 1 = Q_1 X_1 Q_2 (E_1)

Experimental group 2 = Q_1 X_2Q_2 (E_2)

Control group 3 = Q_1 X_3 Q_2 (C)

Where X_1 is Computer Simulated Experimental Group

X_2 is combination of computer-simulated experimental group + Hands-on Laboratory experiment

X_3 is hands-on laboratory experimental group

$Q_{1,}$ $Q_1$and $Q_1$are pretest observation given by experimental and control group

Q_2, $Q_{2,}$ O2 are posttest scores given by experimental groups and control groups.

Computer-simulated experiment, (computer simulated experiment + Hands-on experiment) and Conventional laboratory method as control group

$E_{1,}E_1$, C as post-test groups.

3.2 Variables of the study

The variables in this study were: independent variable, moderator variable and dependent variable.

Independent Variable:

This is the instructional strategy engaged in this study in teaching senior secondary school Physics practical. This was manipulated at three levels:

(i) Computer simulated experiment. (CSE)

(ii) Combination of Computer Simulated Experiment and Hands-on experiment.(CSE+HOE)

(iii) Conventional Hands-on Laboratory Experiment. (HOE).

Moderator Variables:

The following moderator variables were examined in this study.

(a) Perceptual reasoning ability at three levels viz: High, medium and low.

(b) Numerical reasoning ability at three levels viz: High, medium and low.

Dependent Variables:

Two specific learning outcomes constituted the dependent variables in the study:

(i) Students' achievement in Physics practical.

(ii) Students' interest in Physics

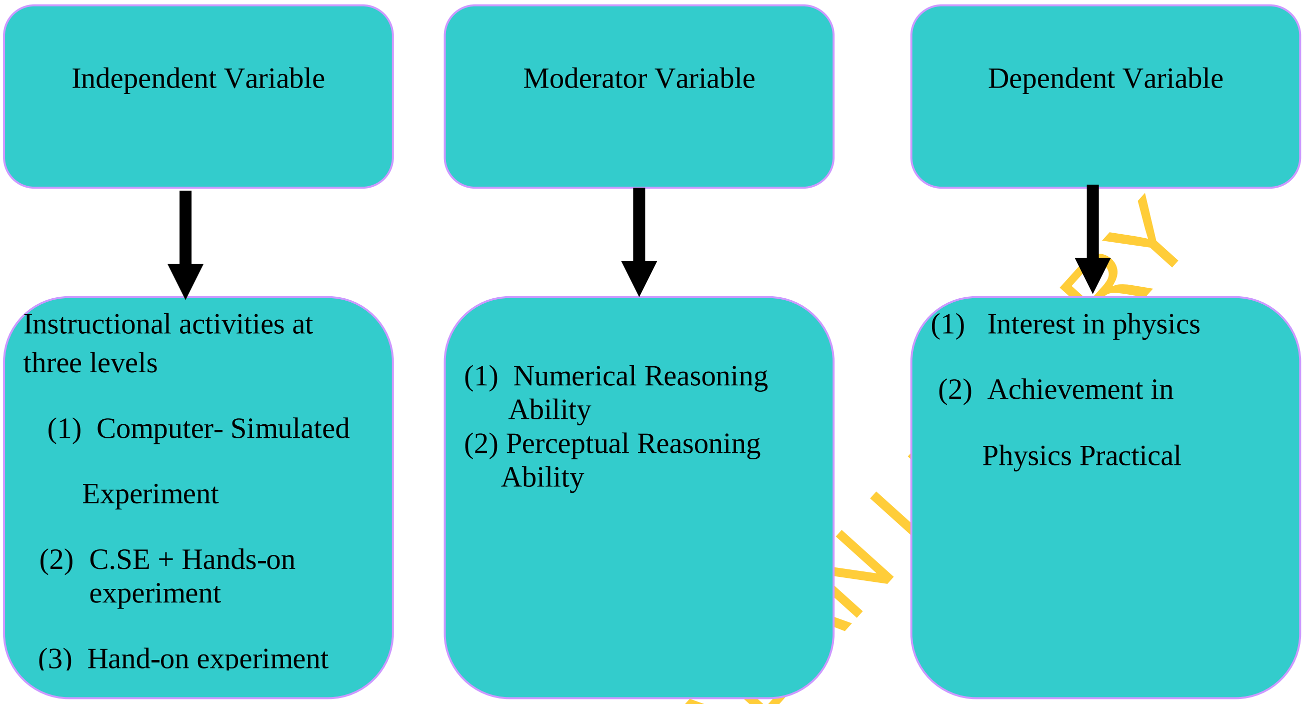
This study adopted 3 x 3 x 3 factorial design, shown in Table 3.1.3

Table 3.1: Factorial Matrix of the Design: 3x3x3 Factorial Matrix of the Design

Treatment	Numerical Reasoning Ability	Perceptual Reasoning Ability		
		Low	Medium	High
Computer- simulated experiment	Low			
	Medium			
	High			
Computer -stimulated experiment plus Hands-on-experiment	Low			
	Medium			
	High			
Conventional laboratory experiment	Low			
	Medium			
	High			

3.2.3 Variables in the Study:

This is represented as follows:



3.3 Sample and sampling technique

Sample: Preliminary investigations showed that there were 270 public senior secondary schools in Imo State under six educational administrative zones, which are Owerri zone 1, Owerri zone 2, Orlu zone 1, Orlu zone 2, Okigwe zone 1, and Okigwe zone 2.

Two educational administrative zones were purposively chosen. All the schools in the chosen administrative zones were subjected to scrutiny based on the following criteria;

1. Availability of adequate, willing and qualified teachers .
2. The students must have covered content area.
3. Acquisition of pre-requisite skills and knowledge on the concept of simple harmonic motion and light.
4. Readiness or willingness of the teachers to be involved.
5. Students must not have been exposed to the chosen practical session .
6. Schools with computers and internet facilities at least for the required group.
7. Schools with good laboratory facilities at least for the required group.
8. A class size of minimum of 35 pupils.

Using stratified sampling, three schools were selected from each administrative zone respectively and were randomly assigned to two experimental and one control groups.

Students' Sample: From each school selected, all the SSS II science students in the classes formed part of the sample.In all, a total of 13 teachers, 359 Physics students (CSE= 128; CSHE =105, Control= 126), made up of male and female participants, were involved in the study.

Table3.2: Sampling Procedure:

S/N	Name of school	Education Administrative Zone	Name of LGA	Experimental group	Minimum No of Students sampled
1	Girls' school 1	Owerri: 1	Owerri Municipal	1	90
2	Boys' School 2	Owerri: 1	Owerri Municipal	2	68
3	Mixed school 3	Owerri 1	Owerri Municipal	3	37
4	Boys' School 4	Owerri 1	Owerri North	1	37
5	Girls' School 5	Owerri 1	Owerri North	2	80
6	Mixed School 6	Owerri 1	Owerri North	3	89
Total	**6**	**2**	**2**	**6**	**359**

3.3.1 Selection of Topics:

Selection of topics was based on WAEC Chief Examiners' Report (2007 to 2011), which showed that the following topics were problematic to students, determination of acceleration due to gravity, verification of Hooke's law, and experiment on Optics. The Physics content area chosen for this study was Mechanics because it defines the main tool in Physics, which also presents the most universal law of nature, Newton's law of gravitation, which is applicable to all masses, (Galili, 1995) . According to Omiwale (2011), it is for the above reason that mechanics usually opens any Physics curriculum.

Selection of topics was also based on topics already covered in the theory section as stated in the scheme of work. This was because prerequisite knowledge on theory usually served as a good background for practical session. Based on these factors, the simple pendulum experiment, verification of Hooke's law and determination of refractive index of prisms were used in this study.

3.4 Research instruments

Six instruments were used to collect data for this study, namely:

1. Theory of Physics Practical Tests (TPPT).
2. Students' Interest in Physics Questionnaire (SIPQ)
3. Numerical Reasoning Ability Test (NRAT)
4. Perceptual Reasoning Ability Test (PRAT)
5. Physics Practical Test (PPT)
6. Software Package of Computer-Simulated Experiment from web site (SCSE)

3.4.1 Theory of Physics Practical Tests (TPPT)

It was an achievement test adapted from WAEC past questions. It was based on theory of practical in chosen topics, which were simple harmonic motion and Optics .It consisted of 50 multiple choice items .Each item had four options(A, B, C, D). It sought information on the level of theoretical knowledge acquired by the students in relation to the concept of the task ahead, which were simple harmonic motion, simple pendulum spring and masses (Hooke's law) as well as determination of refractive index of prisms. The introductory part of this instrument also sought information on name, class, age. It also provided information on duration of the test.

3.4.2 Validation of the tests:

Test items were developed by the researcher based on Bloom's taxonomy of educational objectives, which are six levels, namely: knowledge, comprehension, application, analysis, synthesis and evaluation, to cover the appropriate level of cognition .Three levels of Blooms' taxonomy of learning outcome were reflected; knowledge, comprehension and application ,as well as content areas of the topics. 20 items were drawn from the initial pool of 60 test items. These items were also evaluated by some lecturers from Faculty of Education, University of Ibadan.

For suitability, item difficulty level and discrimination level of the test items were also ascertained after administering to some Secondary School students using the formula Kuder Richardson formula 20 (K20).

The discriminating power was calculated and the items that had the value of 0.4 and below were discarded from the total number of items because they had poor discriminating power . The item difficulty level "p" was also computed .A total of 50 items which possessed between

40 – 69% difficulty index were teased out, While other test items were dropped because they were either too easy with p value of above 70% or too difficult with P value between 0%-30%.

Table 3.3: Table of Specification for TPPT

From the above table, it was clear that the questions were based on main concepts. The questions were also limited to the first three levels because of the chronological age and level

Content Area	Categories of Cognitive Domain			
	Knowledge	Understanding or Comprehension	Application	Total Items Across Concept
Use of Spherical Bob	1	16	30	3
Period	8, 17	2,4, 5, 6, 19	3, 22, 18	10
Simple Harmonic Motion	9, 11, 21	14, 27, 28	15, 27	8
Frequency	10, 26	20		3
Speed and Velocity		23		1
Acceleration		24		1
Weight and Energy		13, 12		2
Refraction	31, 38, 48, 50	32, 33, 34, 44	39, 41, 46	11
Deviation		37		1
Total Internal Reflection	45, 49	43		3
Amplitude	7	25		2
Refractive Index		35, 36, 40, 47	42	5
Total	15	25	10	50

of the students. Comprehension carried more weight because it is comprehension or understanding that leads to application. Also teaching is mainly geared towards understanding of the concept. The questions were also arranged in a way that plausible options (distractions) were challenging enough to distract students that do not understand the concept.

3.4.3 Reliability

The test retest reliability method was used to measure the reliability level of the test. Fifty (50) test items was administered to fifty students in SS II at Ihiala Secondary School, Ihiala, Anambra State.

The reliability of the achievement tests was calculated to be 0.86, 0.91 and 0.88 respectively. The internal consistencies of the tests were also determined using Kuder Richardson 20 formula. The KR 20 reliability Co-efficient was 0.83 respectively which was high enough for usage.

3.4.4 Students' Interest in Physics Questionnaire (SIPQ)

The researcher adapted an international research project known as the Relevance of Science Education (ROSE INT) questionnaire. It is a questionnaire designed to measure interest in science learning. It was originally developed by Schreiner (2004) and was used for an international project known as Relevance of Science Education (ROSE INT). The ROSE INT questionnaire was prepared through international cooperation so that the findings could help teachers and researchers make science more interesting (Schnriener and Sjoberg, 2004). However, in this study, only 30 items out of the 245 items in ROSE INT were adapted to suit the socio-cultural background of the students. The questionnaire consisted of two sections. Section 'A', which sought information on demography, such as age, sex, school and local government area while section 'B' consisted of items which students would be asked to respond to.These 30 items were on four point Likert type of scale of (a) not interested (NI) (b)fairly interested (FI) (c) interested (I) (d) very interested (VI).The responses were scored 1,2,3 and 4 with a total of 120 obtainable marks. It measured mainly students' interest in secondary school Physics.The face and content validity of the instrument was carried out through the advice of experts in Department of Teacher Education University of Ibadan and the researcher's supervisor. The questionnaire was administered to some students who were not part of the study. A reliability of 0.92 was obtained and this was considered high enough for the instrument to be used for the study.

Development of CSE Manual:

The CSE manual was the instructional manual with which the virtual instrument was operated. It was an alternative version of the actual experiment carried out by the students in the conventional laboratory.

3.4.5 Physics Practical Tests (PPT)

This was Physics practical test items on simple pendulum, Hooke's law, and prism adapted from past WAEC questions of years 2003 to 2011.It was used to assess the students' problem-solving skills ,which included manipulative, observation, identification of problems, planning, doing experiment, recording data, explaining results and evaluating results, while determining the acceleration due to gravity using simple pendulum, verification of Hooke's law or determining the refractive index of rectangular prism. In modifying the questions, the researcher reflected questions that specifically dealt with period, time, amplitude, oscillation, motion, force, angles, refractions, reflections, and related equations to suit the cognitive level of students that were sampled in the study. The questions were developed to reflect Bloom's taxonomy of learning outcome: knowledge, comprehension, application, analysis, synthesis and evaluation, in line with the content area.

These items were evaluated by some lecturers from Faculty of Education, University of Ibadan as well as evaluators in the same University and the researcher's supervisors. In order to determine whether the items measured what it purported to measure, their suggestions were also used to produce the final draft so as to obtain the reliability of this instrument. The instrument was administered to fifty students outside the research area. The same instrument was used for the same set of students after two weeks and the reliability co-efficient of 0.84 was obtained using Kuder Richardson (KR20). This level was considered high enough for the instrument to be used for the study.

3.4.6 Laboratory Equipment:

This consisted of physical materials used in laboratory activities, such as clamp and stand, bob, strings, optical pins, stop watch, different masses, prisms, drawing board and papers.

3.4.7 Numerical Reasoning Ability Test (NRAT)

This was an instrument used to determine the students' ability to reason with numbers and other mathematical concepts as well as the knowledge required to apply arithmetic operations either singly or in sequence. It was designed to measure the ability of the students to carry out the four processes that is the recognition of constant, variable classification, ordering and recognition of constant correspondence in dealing with arithmetical numbers. It was an objective test consisting of 15 items with options A, B, C, D. Students' scores in numerical reasoning ability test provided the index of numerical ability in terms of high, medium and low using Percentiles: High= 66.68% - 100%; medium =33.4% to 66.67%; low= 0 to 33.3%.NRAT developed by Hamley (1934), has been used elsewhere (Beret and Williams, 1997; Adegoke 2003). The instrument was administered to a set of students that were not part of the study. The reported reliability of NRAT was between 0.85 and 0.92 using the Kuder Richardson formula (KR 20) (Lee, 1967; Berret and William, 1997; Adegoke 2010).

3.4.8 Validation of NRAT

The researcher revalidated this instrument by administering the modified form of it to fifty senior secondary school Physics (SS II) students from schools that were not part of the study sample. The reliability index of 0.90 was obtained using Kuder Richardson formula 20 (KR 20).The NRAT was scored dichotomously. The discrimination power and the difficulty index of the items were computed. The discriminating power was calculated and it had D value of 0.87.The scores obtained by the students were used to place the students into three groups of high, medium and low ability groups using percentiles :

High	=	The top =66.68% to 100%
Medium	=	The next =33.4% to 66.67%
Low	=	The bottom = 0 to 33.3%

3.4.9 Perceptual Reasoning Ability Test (PRAT)

This was an instrument used to determine students' ability to create a mental picture of objects or figures. It was a test of students' ability to carry out the dynamic process of cognizing correspondence and similarity in sets of spatial visual figures which were assessed by the Raven's progressive matrices. The Raven progressive matrices are non-verbal tests of reasoning ability. They are a measure of two components of Spearman's "g" usually referred to as general Intelligence (Raven, 1936,). In the test, the students were asked to identify the missing element that completes a pattern which was presented as 4x4, 3x3, or 2x2 matrix, thus giving the test its name, (Raven, Court and Raven, 1983).

There are three forms of Raven's progressive matrix:

(i) Coloured progressive matrices(CPM)

(ii) Standard progressive matrices (SPM)

(iii) Advanced progressive matrices (APM)

The one suitable for this study was standard progressive matrices (SPM). The scale consisted of 60 problems divided into five sets of 12 each. Students had to select which of the six or eight pattern pieces fitted best into an overall array of matrix. A students' total score provided an index of his or her intellectual capacity in the area of perceptual relations. The scale had test-retest reliability, ranging from 0.83 to 0.93. The correlation between the scores on the Raven progressive matrices and other intelligence tests range from 0.40 to0.80 (Raven, Court and Raven, 1983) .Since Raven's progressive matrices is non-verbal, it can measure an aspect of the general intellectual ability which is independent of language or formal schooling.

Relatively affected by educational or cultural background, it has been used throughout the world in a variety of settings with a number of international populations (It is also the most commonly and widely used instrument in Nigeria for assessing intellectual ability (Bakare 1979;Adegoke, 2003). The maximum score obtainable from the scale is 60, while the minimum score obtainable is 0. According to United States psychological corporation publication, Spearman considered Raven's standard progressive matrix (SPM) to be the best measure of (g) when evaluated by factor analytic methods which were used to define (g) generally. Concurrent validity coefficient of Raven's progressive matrix proves higher when compared to other instruments, such as Stanford-Binet and Wechsler's scale, which could equally be used to measure perceptual reasoning ability.

3.4.10 Validation of PRAT

The researcher revalidated this instrument by administering PRAT to fifty senior Secondary School (SSII) Students from two schools that did not form part of the main study sample. The same test was repeated for the same set of students after two weeks. The reliability index of 0.91 was obtained using Kuder Richardson formula 20. (KR 20).The PRAT was scored dichotomously. The discrimination power and the difficulty index of the items were computed. The discriminating power was calculated and the value of "D" was 0.87.The scores obtained by the students were used to place the students into three groups of high, medium and low perceptual of ability using percentiles:

High	=	The top =66.68% to 100%
Medium	=	The next =33.4% to 66.67%
Low	=	The bottom = 0 to 33.3%

3.5 Procedures for the study

The researcher, teachers and research assistants collected the required data directly from the selected school. After permission was obtained from the principals, the researcher, teachers and research assistants used all the instruments to collect the required data directly from the selected secondary schools. To ensure unity and clarity in the data collection, the teachers and research assistants were was trained on how to use the instrument, the purpose, principles and procedures governing each group and the use of each treatment. The training involved orientation, discussions and practice. It lasted for two weeks.

At the first contact with the students, they were briefed on the importance of full participation in the programme from the beginning to the end and also reminded that the research had incorporated some topics to be taught in the school. They were enjoined to take it seriously since the teacher's assessment of the topics would contribute to the term's examination. A training session was also organized on the use of computer.

Training of Instructors and research assistants

The first two weeks were used for training of participating teachers and research assistants. This ensured that the teachers acquired competence in their assigned strategies. This training was conducted by the researcher and it took place in phases.

Phase 1: This involved the general set- up of the study and classroom interaction pattern assigned to the respective schools. The duties and advantages of the guides assigned to each teacher was explained to the teachers.

Phase II: The lessons for the eight week were discussed thoroughly with participating teachers with respect to their various groups and questions were entertained.

Phase III: Each teacher within the period of training demonstrated a practical activity according to the experimental group assigned to them. These demonstrations showed weather the teachers mastered the actual features of the experimental pattern involve in their various group.

Phase IV: The teachers were given a copy of each instrument to respond .

Administration of Pre-test:

The teacher gave a brief introduction on the activities about to be embarked upon and the pretest was administered .It included; theory of Physics Practical Tests (TPPT),Students' Interest in Physics Questionnaire (SIPQ), Numerical Reasoning Ability Test (NRAT) and Perceptual Reasoning Ability Test (PRAT). They were compiled into booklet form and the students were asked to attempt them in the given order within the stipulated time. The trained teachers and research assistance have been taught in accordance with the objectives of the treatment.

Treatment:

The students were divided into three groups, namely:

(i) CSE group – Experimental Group I

(ii) Computer Simulated Experimental Group / Hands on-- Experimental Group II

(iii) Hands-On Laboratory Group – Control Group III

3.5.1 Experimental Group I: CSE

STEP I: **Presentation of Concept**

Activity (i) introductory class and demonstration of experiment using real apparatus by the teacher

Activity (ii) Students brainstorming on the problem or task to identify issues involved and students allowed to ask questions.

STEP II: **Performance of tasks by the Teacher**

Activity (i) Logging on to the internet virtual laboratory was presented to the students.

Activity (ii) Students brainstorming on the problem or task to identify issues involved and teacher entertained questions from students.

Activity (iii) Demonstration of concept using simulations and taking readings

STEP III: **Scheduling of duties by Teacher**

Activity (i) Students were grouped in threes to a computer in order to take individual readings.

STEP IV: **Performance of Tasks by Students**

Activity (i) Individual students embarked on a given task in turns and obtained readings from simulations.

STEP V: **Presentation of findings**

Activity (i) Students used data obtained to make table of reading, plotted graph and carried out calculations.

STEP VI: **Submission of papers**

STEP Seven: **General discussion based on the task performed.**

3.5.2 Experimental Group II: CSE + Hands-on Laboratory

STEP I: **Presentation of Concept**

Activity(i) Introductory class and demonstration of experiment using real apparatus by the teacher.

Activity(ii) Students brainstormed on the problem or task to identify issues involved and students allowed to asked questions.

STEP II: **Performance task by the Teacher**

Activity(i) Used real apparatus to take readings

Activity(ii) Students brainstormed on the activity performed by the teacher and teacher entertained questions from the students.

STEP III: **Scheduling of duties by the Teacher**

Activity (i) Students were grouped in threes and encouraged to take individual readings using real apparatus.

STEP IV: **Performance of Task by students**

Activity (i): Individual students embarked on a given task and obtained readings.

Activity (ii): Teacher went round in supervision as the activities went on. Questions were also entertained.

STEP V: **Presentation of Further Problem**

Activity (i) The teacher logged on to the internet and took readings using simulations while entertaining questions from the students.

Activity (ii) Students brainstormed and asked questions

STEP VI: **Performance of tasks by students**

Activity (i) Students repeated performance of the teacher and obtained readings using computer simulations.

STEP VII: **Submission of Paper**

Activity (i) Students used data obtained to make table of readings, plotted graphs and carried out calculations

STEP VIII: **General discussion based on the task performed**

3.5.3 Control Group: Conventional Hands-on Laboratory

STEP I: **Presentation of Concept**

Activity (i) introductory class and demonstration of experiment using real apparatus by the teacher

Activity (ii) Students brainstormed on the problem or tasks to identify issues involved and student allowed to ask questions.

STEP II: **Performance of task by the Teacher**

Activity (i) Readings were obtained by the teacher using real apparatus

Activity (ii) Students were asked questions and they answered.

STEPIII: **Scheduling of duties by Teacher**

Activity (i) Students were grouped into three and took individual readings

STEP IV: **Performance of task by the students**

Activity (i) Individual students embarked on a given task in turn and obtained readings using real apparatus

STEP V: **Presentation of Findings**

Activity (i) Students used data obtained and made table of reading, plotted graphs and carried out other calculations.

STEP VI: **Submission of Papers**

STEP VII: **General discussions based on the task performed**.

Administration of Post-test

At the end of eight weeks of treatment, the posttest was administered by the researcher to three groups, namely: experimental group one (CSE group), experimental group two (CSE +hands -on group) and control group. The instruments administered for the posttest were Theory of Physics Practical Test (TPPT) and interest questionnaire.

The work schedule is summarized below:

Week	**Activities**
Week 1	Researcher visit selected schools
Week2 and 3	Training of instructors and research assistants
Week 4	General teaching on assessing the internet visual laboratory
Week 5	Administration of Pretests
6 – 13 week	Treatment
Week 14	Administration of Post test

3.6 Method of data analysis:

The data were analysed using MANCOVA, through the use of SPSS Version 17, with pre-test scores as covariates. The main effect and interaction effect of the independent and moderating variables on students' interest and achievement in Physics were determined. If the result of the multivariate test was significant (for main effect), the univariate test of individual dependent variables was examined to show which of the independent variables affected the dependent variable. Prior to examining the univariate ANCOVA results, the alpha level was adjusted to 0.025 (Bonferronni type of adjustment).Since two dependent variables were analysed to determine the direction of significance and to estimate the amount of variation as a result of the independent variable. Where significant interaction effects existed, graph was drawn to disentangle the interactions.

CHAPTER FOUR

RESULTS AND DISCUSSIONS OF FINDINGS

This chapter presents the results of data analysis and the discussion of the findings. The data collected were subjected to Multivariate Analysis of Covariance (MANCOVA). In this type of analysis, the two dependent variables (students' achievement in Physics practical and interest in Physics) were combined. Therefore, rather than examining each of the independent variables one after the other as usually done in Analysis of Covariance (ANCOVA), the two dependent variables were combined using the method of cross product (Tabachnich and Fidell, 2001; Adegoke, 2012). The level of significance for the interpretation of the results of the Multivariate Tests was set at $p < 0.05$. For the interpretation of the Univariate Tests, a Bonferronni adjustment criterion of 0.025 was adopted. The results are presented in this chapter in line with the order in which the hypotheses were stated in chapter one.

4.1 Testing the hypotheses

4.1.1 Ho1: There is no significant main effect of treatment on the combined dependent variable (students' achievement in Physics and interest in Physics).

In order to test the significance of the main effect of treatments (CSE, CSE+HOE, and Control) on the combined dependent variable (students' achievement in Physics and interest in Physics) a MANCOVA test was run. Table 4.1 shows the composite table for the multivariate tests

Table 4.1: Multivariate Analysis of Covariance (MANCOVA)

Effect		Value	F	Hypothesis df	Error df	Sig.	Eta Squared
Intercept	Wilks' Lambda	.406	244.961	2.000	335.000	.000	.594
PAP	Wilks' Lambda	.977	3.858	2.000	335.000	.022	.023
PRI	Wilks' Lambda	.918	14.869	2.000	335.000	.000	.082
TRE	Wilks' Lambda	.908	8.319	4.000	670.000	.000	.047
NUA	Wilks' Lambda	.958	3.617	4.000	670.000	.006	.021
PEA	Wilks' Lambda	.945	4.839	4.000	670.000	.001	.028
TRE x NUA	Wilks' Lambda	.975	2.155	4.000	670.000	.073	.013
TRE x PEA	Wilks' Lambda	.949	2.205	8.000	670.000	.025	.026
NUA x PEA	Wilks' Lambda	.965	1.490	8.000	670.000	.157	.017
TRE x NUA x PEA	Wilks' Lambda	.969	1.336	8.000	670.000	.222	.016

Key: PAP = Pre- achievement in Physics Practical, PRI = Pre- interest in Physics, TRE = Treatment, NUA = Numerical Ability, PEA = Perceptual Ability.

As seen in Table 4.1, there was a significant effect of treatment (CSE, $CSE_{+\ HOE}$, and Control) on the combined dependent variable (students' achievement in Physics practical and interest in Physics), Wilks' Lambda = 0.91, F (4, 670) = 8.32, $p < 0.05$, partial $\eta^2 = 0.047$. The effect size (4.7%) of treatment on the combined dependent variable was fair. Having established that treatment had significant effect on the combined dependent variable, there is the need to examine each of them using Bonferronni adjusted alpha level of 0.025. To this we need Univariate ANCOVA Tests of Between-Subjects Effects.

Table 4.2 presents the composite Tests of Between-Subjects Effects for each of the dependent variables. Analysis of each individual dependent variable, using Bonferroni adjusted alpha level of 0.025, showed that there was a significant effect of treatment on achievement in Physics practical, F (2, 336) = 14.76, $p < 0.025$, partial $\eta^2 = 0.081$. The effect size (8.1%) of treatment on the Physics achievement test was moderate. The table shows that there was no significant effect of treatment on students' interest in Physics, F (2, 336) = 0.91, $p > 0.025$, partial $\eta^2 = 0.01$. The effect size (1.0%) of treatment on the students' interest in Physics was low.

Table 4.2: Multivariate Analysis of Covariate (MANCOVA) Tests of Between-Subjects Effects

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.	Eta Squared
Corrected Model	PAP	5427.479	22	246.704	5.623	.000	.269
	PIS	5251.146	22	238.688	3.470	.000	.185
Intercept	PAP	5257.579	1	5257.579	119.839	.000	.263
	PIS	20335.161	1	20335.161	295.631	.000	.468
PRP	PAP	261.592	1	261.592	5.963	.015	.017
	PIS	203.382	1	203.382	2.957	.086	.009
PRI	PAP	1032.298	1	1032.298	23.530	.000	.065
	PIS	191.966	1	191.966	2.791	.096	.008
TRE	PAP	1294.908	2	647.454	14.758	.000	.081
	PIS	124.764	2	62.382	.907	.405	.005
NUA	PAP	368.659	2	184.329	4.202	.016	.024
	PIS	450.816	2	225.408	3.277	.039	.019
PEA	PAP	692.416	2	346.208	7.891	.000	.045
	PIS	158.559	2	79.280	1.153	.317	.007
TRExNUA	PAP	287.821	2	143.910	3.280	.039	.019
	PIS	72.693	2	36.346	.528	.590	.003
TRE x PEA	PAP	237.076	4	59.269	1.351	.251	.016
	PIS	713.788	4	178.447	2.594	.036	.030
NUA x PEA	PAP	132.718	4	33.179	.756	.554	.009
	PIS	657.210	4	164.302	2.389	.051	.028
TRE x NUA x PEA	PAP	368.820	4	92.205	2.102	.080	.024
	PIS	118.706	4	29.676	.431	.786	.005
Error	PAP	14741.005	336	43.872			
	PIS	23111.951	336	68.786			
Total	PAP	505958.000	359				
	PIS	3004519.000	359				

Key: PRP = Pre- achievement in Physics, PRI = Pre -Interest in Physics, TRE = Treatment, NUA = Numerical Ability, PEA = Perceptual Ability, PAP = Post- Achievement in Physics, PIS = Post- Interest Score.

Having established that there was significant effect of treatment on Physics Practical, there was the need to examine which treatment produced the highest mean gain in achievement. Table 4.3 presents the descriptive statistics of each of the treatment groups' scores in Physics practical test items. Figure 4.1 also shows the graphical representation of the treatment groups' mean gain.

Table 4.3: Groups' Mean Score in Achievement Test in Physics

Treatments	Number	Pre Physics Practical Score		Post Physics Practical Score		Mean Gain
		Mean	SD	Mean	SD	
CSE	128	18.78	8.60	38.67	6.86	19.89
CSE+H0E	105	19.79	11.00	38.56	6.85	18.77
Control	126	20.58	11.15	33.37	7.51	12.79

Key: Number in parentheses as represents Standard Deviation

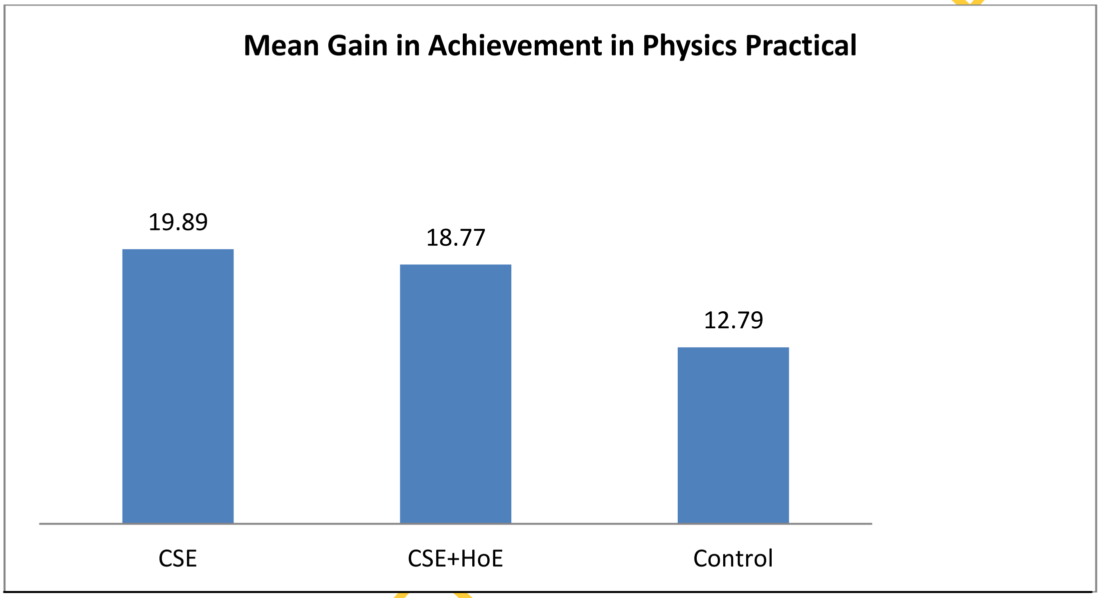


Figure 4.1: Mean Gain Score in Achievement in Physics among the Treatment Groups

Table 4.3 and Figure 4.1 show that the students in the Computer-Simulated Experiment Group had the highest mean gain (19.89)in achievement in Physics, while the students in the control group had the lowest mean score (12.79).

Although the findings of this research have shown that there was no significant main effect of treatment on students' interest in Physics, it is necessary to show the level of students' interest in each of the treatment groups. This is to determine the extent to which treatments impacted on their interest after the experiment. The import of this becomes clearer if we take into consideration the fact that this experiment was unique in that it was not common to use simulated experiments to teach students in most schools in Nigeria. Therefore a look at their pretest and posttest scores in interest in Physics will give an insight into their mean gain in interest.

Table 4.4: Groups' Mean score in Interest in Physics

Treatments	Number	Pre Interest in Physics Score		Post Interest in Physics Score		Mean Gain
		Mean	SD	Mean	SD	
CSE	128	87.11	9.02	91.12	9.46	4.01
CSE+H0E	105	87.27	9.19	92.83	8.31	5.56
Control	126	85.96	7.54	89.50	8.57	3.54

Key: Number in parentheses represents Standard Deviation

Table 4.4 shows that the students in the enhanced Computer Simulated Experiment Group had the highest mean gain (5.56) in interest in Physics, while the students in the control group had the lowest mean score (3.54). However, as discussed in the preceding section, the observed differences in mean gain were not statistically significant. Figure 4.4 shows the graphical representation of the groups' mean gain.

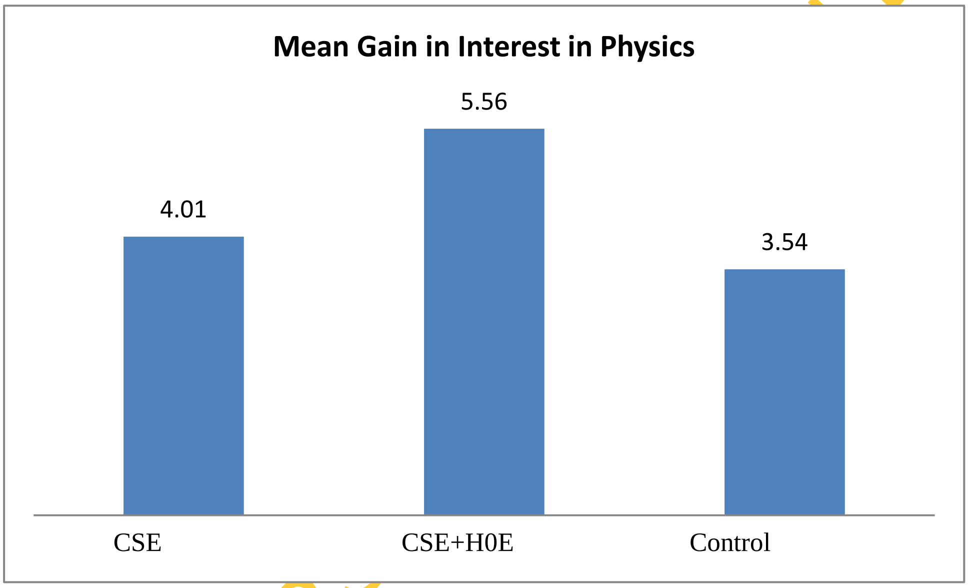


Figure 4.2: Mean Gain in Score in Interest in Physics among the Treatment Groups

4.1.2 Hypothesis two

Ho2: There is no significant main effect of numerical ability on the combined dependent variable (students' achievement in Physics practical and interest in Physics).

In order to test the significance of the main effect of numerical ability on the combined dependent variable (students' achievement in Physics practical and interest in Physics) a MANCOVA test was run. Table 4.1 presents the composite table for the multivariate tests.

Table 4.1 revealed that, there was a significant effect of numerical ability (High, Moderate and Low) on the combined dependent variable (students' achievement in Physics practical and interest in Physics), Wilks' Lambda = 0.96, $F(4, 670) = 3.62$, $p < 0.05$, partial $\eta^2 = 0.021$. The effect size (2.1%) of numerical ability on the combined dependent variable was fair. Having established that Numerical Ability had significant effect on the combined dependent variables, there is the need to examine each of them using Bonferronni adjusted alpha level 0.025.

Table 4.2 presents the Tests of Between-Subjects Effects for each of the dependent variables. Analysis of each individual dependent variable, using Bonferroni adjusted alpha level of 0.025, showed that there was a significant effect of numerical ability on achievement test in Physics Practical, $F (2, 336) = 4.20$, $p < 0.025$, partial $\eta^2 = 0.024$. The effect size (2.4%) of Numerical Ability on the achievement in Physics was fair.

The table shows that there was no significant effect of numerical reasoning ability on students' interest in Physics, $F (2, 336) = 3.28$, $p > 0.025$, partial $\eta^2 = 0.019$. The effect size (1.9%) of Numerical Reasoning Ability on the students' interest in Physics was low.

Having established that there was significant effect of Numerical Reasoning Ability on achievement in Physics practical, it is important to determine which of the three groups had the highest mean gain in achievement. Table 4.5 presents the descriptive statistics of each of the groups' scores in Physics practical test items

Table 4.5: Groups' Mean Score in Physics Practical Test Items

Numerical Ability	Number	Pre Physics Practical Score		Post Physics Practical Score		Mean Gain
		Mean	SD	Mean	SD	
LOW	113	6.18	5.12	37.51	7.36	31.33
MODERATE	13	16.52	3.01	36.00	7.83	19.48
HIGH	223	26.89	3.12	36.50	7.55	9.61

Key: Number in parentheses represents Standard Deviation

Table 4.5 shows that the students who were rated as being low in numerical ability had the highest mean gain (31.32) in Physics practical, while the students who were rated as high had lowest mean score (9.61). Figure 4.3 shows the graphical representation of the groups' mean gain.

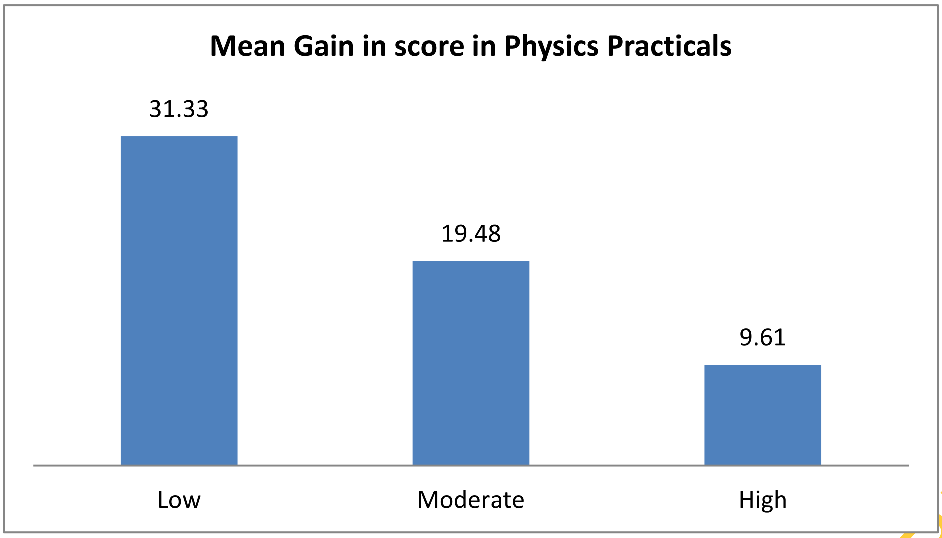


Figure 4.3: Mean Gain in Score in Physics Practical among Numerical reasoning Ability Group.

Although there was no significant effect of numerical reasoning ability on students' interest in Physics, there is the need to show the level of interest in each of the numerical reasoning ability groups. These are shown in Table 4.6

Table 4.6: Groups' Mean score in Interest in Physics

Numerical Ability	Number	Pre Interest in Physics Score		Post Interest in Physics Score		Mean Gain
		Mean	SD	Mean	SD	
LOW	113	85.09	6.98	90.80	8.21	5.71
MODERATE	13	87.70	9.62	86.83	10.38	0.87
HIGH	223	87.60	9.10	91.61	9.61	4.01

Key: Number in parentheses represents Standard Deviation

Table 4.6 shows that the students in the low numerical reasoning ability group had the highest mean gain (5.71) in interest in Physics, while the students in the moderate ability group had the lowest mean score (0.87).Figure 4.4 shows the graphical representation of the groups' mean gain.

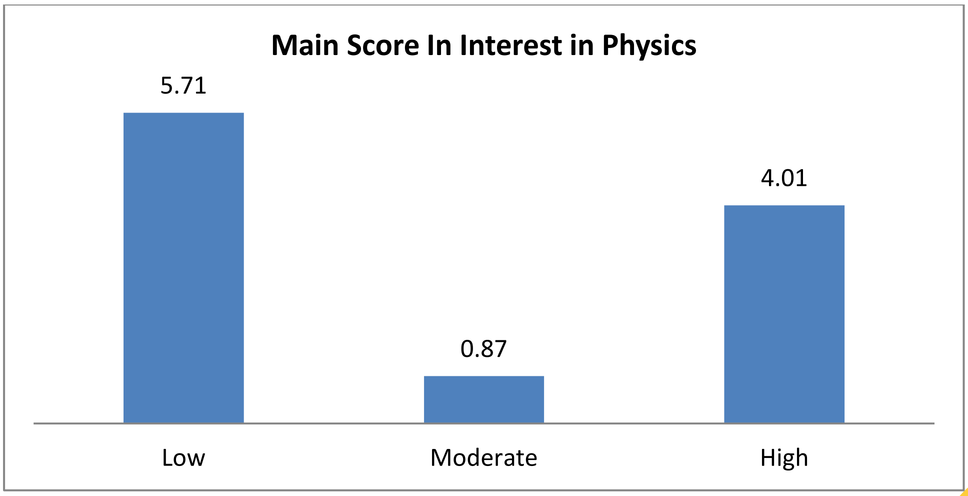


Figure 4.4: Mean Gain in Interest in Physics among the Numerical Reasoning Ability Group.

4.1.3 Hypothesis Three

Ho3: There is no significant main effect of Perceptual Ability on the combined dependent variable (students' achievement in Physics practical and interest in Physics).

In order to test the significance of the main effect of perceptual ability (High, Moderate and Low) on the combined dependent variable (students' achievement in Physics practical and interest in Physics) MANCOVA test was run. Table 4.1 shows the composite table for the Multivariate Tests. Table 4.1 shows that, there was a significant effect of Perceptual Ability (High, Moderate and Low) on the combined dependent variable (students' achievement in Physics practical test items and interest in Physics), Wilks' Lambda = 0.95, $F(4, 670) = 4.84$, $p < 0.05$, partial $\eta^2 = 0.028$. The effect size (2.8%) of perceptual ability on the combined dependent variable was fair. Having established that Perceptual Ability had significant effect on the combined dependent variables, there is the need to examine each of them using Bonferronni adjusted alpha level.

Table 4.2 presents the Tests of Between-Subjects Effects for each of the dependent variables. Analysis of each individual dependent variable, using Bonferroni adjusted alpha level of 0.025, showed that there was a significant effect of perceptual reasoning ability on students' achievement in Physics scores, $F(2, 336) = 7.89$, $p < 0.025$, partial $\eta^2 = 0.045$. The effect size (4.5%) of Perceptual Ability on achievement in Physics was fair. Table 4.2, however, also shows that there was no significant effect of Perceptual Ability on students' interest in Physics, $F(2, 336) = 1.15$, $p > 0.025$, partial $\eta^2 = 0.007$. The effect size (0.7%) of Perceptual Ability on the students' interest in Physics was negligible.

Having established that there was significant effect of Perceptual Ability on Students' achievement, in Physics practical, we need to show which of the three groups had the highest mean gain in achievement. Table 4.7 presents the descriptive statistics of each of the groups' scores in Physics practical test items.

Table 4.7: Groups' Mean Score in Physics Practical

Perceptual Ability	Number	Pre Physics Practical Score		Post Physics Practical Score		Mean Gain
		Mean	SD	Mean	SD	
LOW	106	17.09	10.36	24.49	6.35	7.40
MODERATE	135	20.72	10.24	37.56	6.91	16.84
HIGH	118	20.91	9.86	38.19	8.62	17.28

Key: Number in parentheses represents Standard Deviation

Table 4.7 shows that the students who were rated as being high in perceptual reasoning ability had the highest mean gain in score (17.28) in Physics practical test , whereas the students who were rated as low had the lowest mean score (7.40). Figure 4.5 shows the graphical representation of the groups' mean gain.

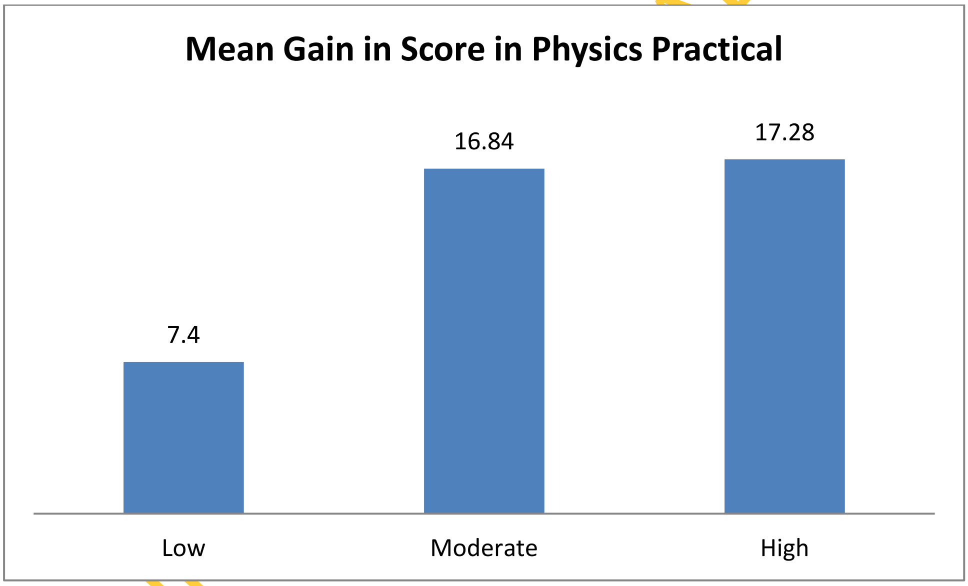


Figure 4.5: Mean Gain in Physics Practical – Perceptual Reasoning Ability Group.

Although there was no significant effect of Perceptual Ability on students' achievement in Physics practical, there is the need to show the level of interest in each of the perceptual reasoning ability groups. The mean scores in interest in Physics are presented in Table 4.8

Table 4.8: Groups' Mean score in Interest in Physics

Perceptual Ability	Number	Pre Interest in Physics Score		Post Interest in Physics Score		Mean Gain
		Mean	SD	Mean	SD	
LOW	106	83.90	5.32	88.57	7.62	4.67
MODERATE	135	88.18	9.16	94.69	7.73	6.51
HIGH	118	87.69	9.64	89.12	9.86	1.43

Key: Number in parentheses represents Standard Deviation

Table 4.8 shows that the students with moderate perceptual reasonig ability group had the highest mean gain (6.51) in interest in Physics, while the students in the high perceptual reasoning ability group had the lowest mean score (1.43). However, as discussed in the preceding section, the observed differences in mean gain were not statistically significant. Figure 4.4 shows the graphical representation of the groups' mean gain.

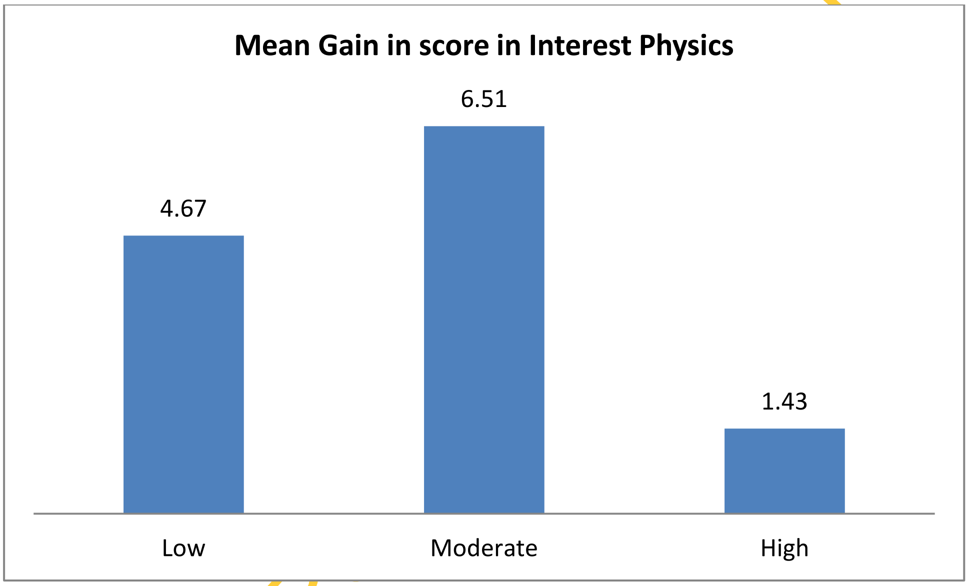


Figure 4.6: Mean Gain in Interest in Physics among Perceptual Ability.

4.1.4 Hypothesis Four

Ho4: There is no significant interaction effect of treatment and numerical ability on the combined dependent variable (students' achievement in Physics practical and interest in Physics).

In order to test the significance of the effect of the interaction of treatment and numerical ability on the combined dependent variable (students' achievement in Physics practical and interest in Physics) a MANCOVA test was run. Table 4.1 shows the composite table for the Multivariate Tests. From Table 4.1, it is evident that there was no significant effect of interaction of treatment and numerical ability on the combined dependent variable (students' achievement in Physics practical test items and interest in Physics), Wilks' Lambda = 0.98, F (4, 670) = 2.16, $p > 0.05$, partial $\eta^2 = 0.013$. The effect size (1.3%) of interaction of treatment and numerical ability was negligible.

The results in Table 4.2, using Bonferroni adjusted alpha level of 0.025,s also showed that there was no significant effect of interaction of treatment and numerical ability on students' achievement in Physics Practical, F (2, 336) = 3.28, $p > 0.025$, partial $\eta^2 = 0.019$. The effect size (1.9%) of interaction of treatment and numerical ability was small. Table 4.2 also shows that there was no significant effect of interaction of treatment and numerical ability on students' interest in Physics, F (2, 336) = 0.53, $p > 0.025$, partial $\eta^2 = 0.003$. The effect size (0.3%) of treatment and numerical ability on the students' interest in Physics was negligible.

Table 4.9 and 4.10 present the adjusted mean scores of the students' scores in Physics practical test and Interest in Physics. The results in Tables 4.9 and 4.10 show clearly that the interaction of treatment and numerical ability did not significantly impact on the adjusted post-achievement scores and Interest in Physics.

Table 4.9: Adjusted Post- achievement test Mean Scores of the Treatment* Numerical Ability

Treatment	Numerical Ability	Number	Mean	Standard Error	95% Confidence Interval	
					Lower Bound	Upper Bound
CSE	Low	46	41.84	1.47	38.96	44.73
	Moderate	23	37.81	2.43	33.03	42.59
	High	59	37.76	1.17	35.47	40.05
CSE + H0E	Low	30	43.69	2.25	39.26	48.12
	Moderate	-	.	.	.	.
	High	75	36.89	1.27	34.40	39.38
Control	Low	37	39.93	2.15	35.71	44.15
	Moderate	-	.	.	.	.
	High	89	30.50	1.11	28.32	32.67

Note: Pre- Physics achievement test score = 19.7103

Table 4.10: Adjusted Post Interest test Mean Scores of the Treatment* Numerical Ability

Treatment	Numerical Ability	Number	Mean	Standard Error	95% Confidence Interval	
					Lower Bound	Upper Bound
CSE	Low	46	88.11	1.84	84.50	91.72
	Moderate	23	84.70	3.04	78.72	90.69
	High	59	94.31	1.46	91.43	97.18
CSE+ H0E	Low	30	87.34	2.82	81.80	92.88
	Moderate	-	.	.	.	.
	High	75	92.86	1.59	89.74	95.98
Control	Low	37	87.70	2.69	82.42	92.99
	Moderate	-	.	.	.	.
	High	89	91.32	1.39	88.59	94.05

Note: Pre- Interest in Physics score = 86.75

4.1.5 Hypothesis Five

Ho5: There is no significant interaction effect of treatment and perceptual ability on the combined dependent variable (students' achievement in Physics practical and interest in Physics).

In order to test the significance of the effect of the interaction of treatment and perceptual ability on the combined dependent variable (students' achievement in Physics practical and interest in Physics) a MANCOVA test was run. Table 4.1 shows the Composite table for the Multivariate Tests. From Table 4.1, there was a significant effect of interaction of treatment and perceptual ability on the combined dependent variable (students' achievement in Physics practical and interest in Physics), Wilks' Lambda = 0.95, F (8, 670) = 2.21, $p < 0.05$, partial $\eta^2 = 0.026$. The effect size (2.6%) of interaction of treatment and perceptual ability was moderate.

However, the results in Table 4.2, using Bonferroni adjusted alpha level of 0.025, showed that there was no significant effect of interaction of treatment and perceptual ability on students' achievement in Physics practical, F (4, 336) = 1.35, $p > 0.025$, partial $\eta^2 = 0.016$. The effect size (1.6%) of interaction of treatment and perceptual ability was small. Table 4.2 also shows that there was no significant effect of interaction of treatment and perceptual ability on students' interest in Physics, F (4, 336) = 2.60, $p > 0.025$, partial $\eta^2 = 0.030$. The effect size (3.0%) of treatment and perceptual ability on the students' interest in Physics was moderate. However, as a result of Bonferronni adjustment of alpha level to 0.05, the effect size is not taken into consideration.

Tables 4.11 and 4.12 present the adjusted mean scores of the students' scores in Physics practical test and Interest in Physics. The results in Table 4.11 and 4.12 indicate that the interaction of treatment and perceptual ability had impact on the adjusted post- achievement scores but had no significant impact on Interest in Physics.

Table 4.11: Adjusted Post-achievement test Mean Scores of the Treatment* Perceptual Ability

Treatment	Perceptual Ability	Number	Mean	Standard Error	95% Confidence Interval	
					Lower Bound	Upper Bound
CSE	Low	44	35.54	1.11	33.37	37.72
	Moderate	38	40.60	2.35	35.98	45.22
	High	46	41.27	1.02	39.27	43.27
CSE+ H0E	Low	14	38.91	1.90	35.18	42.64
	Moderate	67	39.05	1.09	36.90	41.20
	High	24	42.90	1.61	39.74	46.06
Control	Low	48	32.79	1.13	30.57	35.01
	Moderate	30	37.01	1.60	33.86	40.16
	High	48	35.84	1.11	33.65	38.02

Note: Pre-Physics Score = 19.7103

In order to further examine the level of interaction effect of treatment and perceptual ability on the adjusted post achievement test, a graph was plotted. The graph was also used to disentangle the observed interaction. Figure 4.4 presents the graph of the interaction.

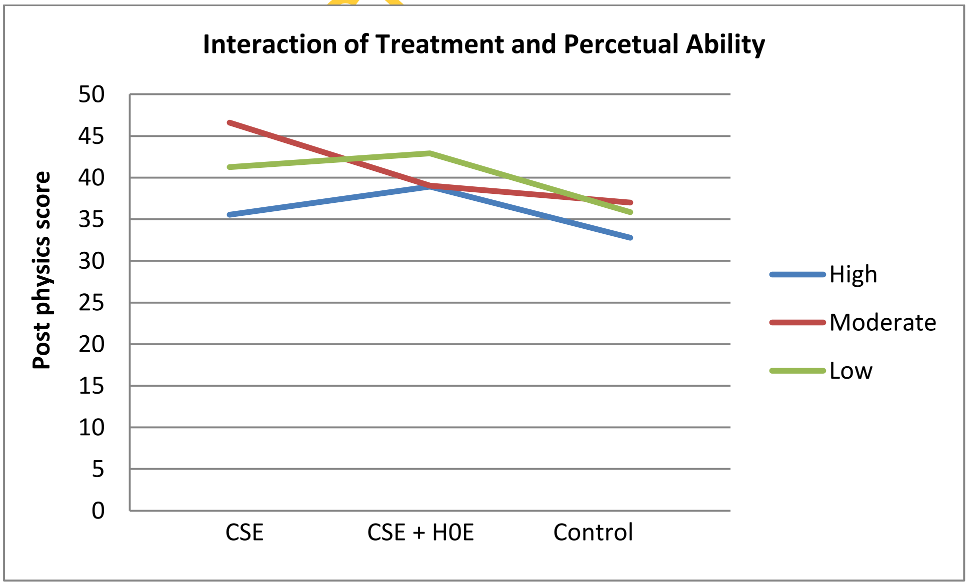


Figure 4.7: Interaction of Treatment and Perceptual Ability

From Figure 4.6, it is obvious that CSE worked best for students who were classified as being moderate in perceptual ability. The graph also indicates that achievement in Physics practical for students can be improved through the use of computer simulated experiments. This tendency cuts across all levels of perceptual ability groups of the students.

Table 4.12: Adjusted Interest in Physics Mean Scores of the Treatment* Perceptual Ability

Treatment	Perceptual Ability	Number	Mean	Standard Error	95% Confidence Interval	
					Lower Bound	Upper Bound
CSE	Low	44	87.71	1.38	84.99	90.43
	Moderate	38	91.01	2.94	85.24	96.80
	High	46	88.39	1.27	85.89	90.89
CSE + H0E	Low	14	85.24	2.37	80.57	89.91
	Moderate	67	92.90	1.37	90.20	95.59
	High	24	92.17	2.01	88.21	96.12
Control	Low	48	88.27	1.41	85.50	91.05
	Moderate	30	93.90	2.00	89.96	97.85
	High	48	86.35	1.39	83.62	89.09

Note: Pre Interest in Physics Score = 86.75

4.1.6 Hypothesis Six

Ho6: There is no significant interaction effect of numerical ability and perceptual ability on the combined dependent variable (students' achievement in Physics practical test items and interest in Physics).

In order to test the significance of the effect of the interaction of numerical ability and perceptual ability on the combined dependent variable (students' achievement in Physics practical test and interest in Physics) a MANCOVA test was run. Table 4.1 shows the Composite table for the Multivariate Tests.

From Table 4.1 it is evident that there was no significant effect of interaction of numerical and perceptual ability on the combined dependent variable (students' achievement in Physics practical test and interest in Physics), Wilks' Lambda = 0.96, F (8, 670) = 1.49, $p > 0.05$, partial $\eta^2 = 0.017$. The effect size (1.7 %) of interaction of numerical ability and perceptual ability was low.

The results in Table 4.2, using Bonferonni adjusted alpha level of 0.025, also showed that there was no significant effect of interaction of numerical and perceptual ability on students' achievement in Physics Practical, F (4, 336) = 0.76, $p > 0.025$, partial $\eta^2 = 0.009$.

The effect size (0.9%) of interaction of numerical ability and perceptual ability was negligible. Table 4.2 also reveal that there was no significant effect of interaction of numerical and perceptual ability on students' interest in Physics, $F(4, 336) = 2.40$, $p > 0.025$, partial $\eta^2 = 0.028$. The effect size (2.8%) of interaction of numerical ability and perceptual ability on the students' interest in Physics was moderate. However, as a result of Bonferonni adjustment of alpha level to 0.05, the effect size was not taken into consideration.

Tables 4.13 and 4.14 present the adjusted mean scores of the students' scores in Physics practical test and interest in Physics. The results in Tables 4.13 and 4.14 show clearly that the interaction of numerical ability and perceptual ability did not significantly impact on the adjusted post- achievement test and interest in Physics.

Table 4.13: Adjusted Post- Achievement in Physics Mean Scores of the Numerical Ability* Perceptual Ability

Treatment	Numerical Ability	Number	Mean	Standard Error	95% Confidence Interval	
					Lower Bound	Upper Bound
CSE	Low	44	38.51	1.98	34.62	42.40
	Moderate	38	42.73	2.03	38.73	46.73
	High	46	44.22	1.87	40.55	47.89
CSE + H0E	Low	14	33.14	2.17	28.87	37.41
	Moderate	67	40.69	6.64	27.64	53.75
	High	24	39.61	1.93	35.81	43.40
Control	Low	48	33.78	1.30	31.30	36.34
	Moderate	30	35.02	1.06	32.93	37.10
	High	48	36.34	1.19	34.00	38.67

Note: Pre Physics Score = 19.7103

Table 4.14: Adjusted Interest in Physics Mean Scores of the Numerical Ability * Perceptual Ability

Treatment	Numerical Ability	Number	Mean	Standard Error	95% Confidence Interval	
					Lower Bound	Upper Bound
CSE	Low	44	84.75	2.48	79.87	89.62
	Moderate	38	91.58	2.55	86.57	96.58
	High	46	86.83	2.34	82.24	91.43
CSE +H0E	Low	14	89.84	2.72	84.50	95.19
	Moderate	67	80.91	8.31	64.57	97.26
	High	24	83.35	2.42	78.59	88.10
Control	Low	48	88.69	1.63	85.50	91.89
	Moderate	30	97.01	1.33	94.40	99.62
	High	48	92.79	1.49	89.86	95.71

Note: Pre Interest in Physics Score = 86.75

4.1.7 Hypothesis seven

Ho7: There is no significant interaction effect of treatment, numerical ability and perceptual ability on the combined dependent variable (students' achievement in Physics practical test items and interest in Physics).

In order to test the significance of the effect of the interaction of treatment, numerical ability and perceptual ability on the combined dependent variable (students' achievement in Physics practical and interest in Physics) a MANCOVA test was run. Table 4.1 shows the Composite table for the Multivariate Tests.

As seen in Table 4.1, there was no significant effect of interaction of treatment, numerical ability and perceptual ability on the combined dependent variable (students' achievement in Physics practical and interest in Physics), Wilks' Lambda = 0.97, F (8, 670) = 1.34, $p > 0.05$, partial $\eta^2 = 0.016$. The effect size (1.6 %) of interaction of treatment, numerical ability and perceptual ability was low.

The results in Table 4.2, using Bonferronni adjusted alpha level of 0.025, also revealed that there was no significant effect of interaction of treatment, numerical ability and perceptual ability on students' achievement in Physics Practical, F (4, 336) = 2.10, $p > 0.025$, partial $\eta^2 = 0.024$. The effect size (2.4%) of interaction of treatment, numerical ability and perceptual ability though high, was not considered in determining the impact. This is because of Bonferronni adjustment of alpha level to 0.025.

Table 4.2 also shows that there was no significant effect of interaction of treatment, numerical ability and perceptual ability on students' interest in Physics, $F (4, 336) = 0.43$, $p > 0.025$, partial $\eta^2 = 0.005$. The effect size (0.5%) of interaction of numerical ability and perceptual ability on the students' interest in Physics was not significant. However, as a result of Bonferronni adjustment of alpha level to 0.05, the effect size was not taken into consideration.

4.2.1 Effects of treatment on students' achievement in Physics Practical and Interest in Physics

The study revealed that the treatments (CSE, CSE+HOE, and Control) significantly affected the combined dependent variables (students' achievement and interest). Further steps taken to examine the effect of each of these dependent variables revealed that there is a significant effect of treatment on Physics practical; however, there was no significant effect of treatment on students' interest in Physics.

It was also discovered that the CSE group had the highest mean gain of scores (19.89) in Physics followed by CSE+HOE group with (18.77). The control group, which was the conventional laboratory group, had the lowest mean gain of scores (12.79). This is in agreement with Yang and Hey (2007), Podolefsky, Perkins and Adams (2010) and the assertion of the Physics Education Technology group of the University of Colorado USA. They posit that learners that are taught using CSE gain conceptual understanding more, compared to the learners taught by the conventional laboratory method.

This also implies that students' performance in Physics could be optimally improved through the use of CSE. This is in agreement with Yuan and Heg (2007). Adams et al. (2004) have shown through research findings that CSE has great potential for improving the learning outcome in Physics practical. A combination of CSE+H0E was equally of essence in the attempt to improve the learning outcome of Physics.CSE could be used in different modes, such as (i) for post laboratory activities, (ii) prior to laboratory activities, (iii) as a home work package on practical activities as well as distance learning or independent learning activities. It all depends on the objectives of the lesson. There existed a wide range of mean gain in score between CSE,CSE+H0E and control (laboratory) group. This is in agreement with Nadesky (1958), Potter and Burn (1984) and Thomas (2009), who discovered that the aims and objectives for the introduction of laboratory activities at secondary school level has not been realized. This could account for the low mean gain in score (12.81) recorded by the control group. In the same vein, Zacharia and Anderson (2003) and Akpan (2001); Micheal (2001) found that the use of combination of CSE + HOE simulated experiment, when compared to hands-on laboratory experiment alone, helped the students to make acceptable predictions and explanations of the phenomena in focus better than hands-on laboratory activities alone.

While there was no significant effect of treatment on students interest in Physics, group means scores of interest in Physics showed that the CSHE group had the highest mean gain of (5.56) in interest in Physics, while the control (laboratory) group had the lowest group mean score of (3.54). This is in agreement with Allessi and Trollip (2006), that categorized interest into two with four phases. Since interest development is characterized by affects and some form of knowledge or cognition processing which are more prominent in the later phases of interest, therefore that the phases of interest displayed by the learners triggered situational interest and maintained situational interest which lasted as long as the activities lasted, because they were phases of environmentally-triggered interest. This explains why there was combined significant effect of treatment on achievement and interest, but no significant effect of treatment on interest alone. This is evident in the characteristic behaviour of the students during the classroom activities, which resulted in their reluctance to leave the class even at the expiration of contact sessions. This shows that interest influences what people attend to, think about, discuss and learn more about. (Renninger, 2000; Hidi 2001; Stieff and Wilensky 2003). Researchers associated high interest to high academic performance because to recall increases with effort. A learner cannot learn except there is interest. For this study, lack of significant effect of treatment on interest could be attributed to the inability of the triggered and maintained situational to translate to a well- developed individual or personal interest which is characterized by not only positive feelings but stored up knowledge and value for a particular content measured in the study. Since the phase of individual or personal interest develops with time, it could be inferred that the learner might need a longer period to develop individual or personal interest depending on the individual differences in the learners. Therefore, the level of enthusiasm for the activities was not properly reflected in their performance. While individual interest develops slowly and tends to be long-lasting and associated with knowledge and value, on the other hand situational interest is evoked by something in the immediate environment and consequently may or may not have a long-term effect on individuals' knowledge and value. Expect it is sustained long enough to translate to personal or individual interest (Alexander and Murphy 2000). Hence there is need to engage the learner for a longer period in order to ensure that situational interest translate to individual interest and consequently reflect in their performance. Alexander and Murphy (2000) also posit that feelings regarding previous behaviour and perceptions about skills interact to either decrease or enhance interest.

4.2.2 Effects of numerical ability on students' achievement in Physics practical and interest in Physics

The study showed that there was a statistically significant effect of numerical ability on the combined dependent variables (students' achievement and interest in Physics). Further investigation revealed a significant effect of numerical ability on achievement in Physics practical and no significant effect of numerical reasoning ability on students' interest in Physics. It was also established through further testing that students rated as being low in numerical reasoning ability had the highest mean gain scores (31.33) in Physics practical, while students who were rated as high in numerical reasoning ability had the lowest means score. This is in disagreement with Apata (2011) and Adegboye (2007) that defined numerical proficiency as the strength of an individual to proffer numerical solution to mathematical problems. Adesoji (2008) also posited that numerical proficiency has been found to have practical implication to physics learning. Physicist must have a very good understanding of basic physical laws which are usually known to be established or acceptable only when they can be quantified numerically (Anyakoha 2008; Adegboye 2007). . However, it was also established through this result, that numerical reasoning ability affects achievement in Physics.

4.2.3 Groups' mean scores in interest compared with numerical reasoning ability groups and perceptual reasoning ability groups.

Although there was no significant effect of numerical reasoning ability on students interest in Physics, but the level of interest for each of the numerical reasoning ability group show that students with low numerical ability group had the highest mean gain (5.71) in interest in Physics than students with moderate (0.87) and high (4.01) numerical reasoning ability groups.

The result of this study could be attributed to the fact that with CSE, the effect of numerical ability is reduced to the barest minimum, because some numerical ability challenges or task usually carried out by the learner in a conventional physics class or in the laboratory have been subsumed by CSE This could probably be that with the use of computer, the positive correlation between numerical reasoning ability and mathematical proficiency is minimized especially in the area of manual measurement, drawing of graphs ,taking of readings, mathematical connotations and calculations therefore, the interest of low numerical ability students automatically goes higher than other ability groups hence, learning is enhanced more in this group than in the high numerical ability group.

Also, table 4.8, shows that students with moderate (6.51) and low (4.67) perceptual reasoning ability group had higher mean gain in scores than students with high (1.43) perceptual reasoning ability group.

Research has proved that perception enhances learning. This is because perception is the ability to organize, identify, interprete information in order to construct a mental representation of this information through the process of transduction .perception has been proved to be very important to sciences and technology especially in physics practicals in particular. But with computer simulations, students with lower perceptual reasoning ability performed better than students with high perceptual reasoning ability group. This is because in the practical activities, three dimensional objects are involved and one's perception about the physical and chemical properties of the material during interaction in experimental procedures goes a long way to determine the extent of success recorded in those activities. However, in computer simulated experiment, attempts were made to simulate not only the concrete three dimensional objects but also the modeling of abstract component in a way that virtual cues, prompts, and graphical representations make perception easier and hence students in the lower perceptual reasoning ability group tends to gain more when computer simulated experiment are used than those in high perceptual reasoning ability group.

4.2.4 Effects of perceptual reasoning ability on students' achievement in Physics practical and interest in Physics

The study revealed a significant effect of perceptual ability on combined dependent variables (students' achievement in Physics practical and students' interest in Physics). When each dependent variable was further examined at difference levels, it was revealed that there was a significant effect of perceptual ability on students' achievement in Physics practical. However, there was no significant effect of perceptual ability on students' interests in Physics. Further investigations on the three levels of perceptual reasoning ability showed that the students with high level of perception scored highest in practical Physics, while the students with low level of perception scored lowest. The range of scores were High = 17.28, Moderate=16.84 and Low = 7.40. This result established that students need perceptual ability to carry out practical sessions and the higher the perceptual ability, the better the performance.

This is in agreement with the findings of Shaw and Okey (1985) which revealed that students at higher and middle level of logical reasoning ability performed better than students at the low level of logical reasoning ability. This is also in agreement with Keller, Finkelstein, Perkins and Pollock (2005) on the superiority of computer simulations in enhancing students' manipulative skills and also with respect to mastery of Physics concepts in comparison with real equipment. They discovered that, in the experiment on electricity, students who used explicitly modelled electron flow through simulation outperformed their counterparts that used real equipment. Zacharia and Anderson (2003) assert that a variety of visual cues in computers simulations make concepts which are otherwise invisible to students visible. The ease of perception is very vital in learning especially in the science class: since it is the ability of the learner to perceive a given pieces of information that determines the level of assimilation and learning. When a concept which ordinarily looks abstract is made as concrete as possible by the use simulations, colour, size, high level of details and cues and mode of perception becomes easy.

Another factor that affects ease of perception is repeatability. Information is more likely to be retained if the learner can repeat it. Hence, computer simulated experiment provides the learner with as many repetition as any learner would need unlike the hands-on experiment which is sparingly carried out because of lack of fund and equipment. Another factor that affects the ease of perception is pace. When information is presented too quickly or too slowly it would either increase or release the rate of perception. For perception to occur there is need to attract, and sustain the attention of the learner throughout a lesson. Hence, interest affects perception and achievement. This shows that perceptions are very important in experimental activities.

4.2.5 Effects of treatment and numerical reasoning ability on students' achievement in practical Physics and interest in Physics

The study showed that there was no significant effect of interaction of treatment and numerical reasoning ability on the combined dependent variables (students' achievement in Physics practical and interest in Physics). There was also no significant effect of interaction of treatment and numerical reasoning ability on students' achievement in Physics practical. The result equally showed clearly that there was no significant interaction effect of treatment and numerical ability on the adjusted post-practical Physics achievement score and interest in Physics. This implies that the level of numerical ability of the learner does not significantly affect the performance of the learner in carrying out laboratory practical. This may be attributed to the fact that the numerical ability required for practical activities has been taken care of by the simulated software.

4.2.6 Effect of treatment and perceptual reasoning ability on the students' achievement in Physics practical and interest in Physics

The study showed that there was significant effect of interaction of treatment and perceptual ability on both the students' achievement in Physics practical and interest in Physics. The study also showed that there was significant effect of interaction of treatment and perceptual reasoning ability and students' interest in Physics. Although the effect was moderate (η^2= 0.030) the effect was not taken into consideration as a result of the adjusted alpha level of 0.025. The adjusted mean scores of the students in Physics practical test and interest in Physics indicated that the interaction of treatment and perceptual ability had impact on the adjusted post-practical Physics achievement score but no significant impact on interest in Physics. This implies that interest does not affect the level of perception singly, but, when combined with achievement, there is a significant effect since learning begins with attention which automatically aids perception. This is in agreement with Allessi and Trollip (2006) view that, for perception to occur, the attention of the learner must not only be initially attracted but maintained throughout the lesson. The interactive computer simulation was able to do this by proper positioning of images, providing the repetitive ability through the computer: this has further made perception easier through dynamic technique such as animation, background colouring, and periodic presentation of information. This has made the level of learners' involvement to be so high that topical interest was captured and sustained enough to affect learning. At this level, the learner would be able to encode information which result to achievement. Hence, the level of engagement of the learner which involves attention (interest) is affected by the learners' perception.

Allessi and Trollip (2006) categorize situational and individual (personal) interest into four phases. These phases are characterized by affects and some form of knowledge or cognition processing which are more prominent in the later phases of interest.

4.2.7 Effect of treatment and perceptual ability on the adjusted post-achievement test

A graph was plotted in order to show the effect of treatment and perceptual ability on the adjusted post-Physics achievement test and also to disentangle the observed interaction.

The result showed that CSE worked best for students who were classified as being moderate in perceptual ability. The graph also indicated that achievement in Physics practical for students could be improved through the use of computer-simulated experiments, the tendency which cut across all levels of perceptual ability groups of the students. This is so because the three main principle relevant for perception which are: information (visual and aural), positioning of information (spatial or temporal) and differences and changes that attract and maintain attention are all present as result of interactive - based computer simulation used in this study.

4.2.8 Effect of adjusted interest in Physics mean scores of the treatment and perceptual ability/numerical ability

The study showed that there was no significant interaction effect of treatment, numerical ability and perceptual ability on the students' achievement in Physics practical test and interest in Physics. Further analysis also showed that there was no significant effect of interaction of treatment and perceptual ability on students' achievement in Physics practical. Also, the effect size of numerical and perceptual ability was negligible and was not taken into consideration as a result of Bonferronni adjustment of alpha level of 0.025. There was no significant effect of interaction and numerical ability on students' interest.

4.2.9 Effect of treatment, numerical ability and perceptual ability on combined dependent variable

The result showed that there was no statistically significant effect of interaction of treatment, numerical ability and perceptual ability on students' achievement in Physics practical and interest in Physics. On further analysis using Bonferronni adjustment of alpha level of 0.025, there was also no significant effect of interaction of treatment, numerical ability and perceptual ability on students' achievement in Physics practical. The effect size of interaction of treatment, numerical ability and perceptual ability, though high, was not considered in determining impact because of Boniferonni adjusted alpha level of 0.025. The result also showed that there was no significant effect of interaction of treatment, numerical ability and perceptual ability on the students' interest in Physics. The effect size of interaction was n^2 =0.028. Numerical ability, perceptual ability on the students' interest in Physics was moderate. The effect size was not taken into consideration as a result of Bonferronni adjustment of alpha level of 0.025. All these attest to the facts there was no form of unwanted invention between variables.

CHAPTER FIVE

SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATION

5.1 Summary of findings

The findings of the study revealed the following:

(1) There was a significant effect of treatment (CSE, CSE+HOE and Control) on students' achievement and interest in Physics practical, with effect size of 4.7 %

(2) There was a significant effect of numerical ability (high, moderate, low) on students achievement and interest in Physics practical, with effect size of 2%

(3) There was a significant effect of perceptual ability (high, moderate, low) on students' achievement in Physics practical and interest in Physics, with effect size of 2.8%.

(4) There was no significant effect of interaction of treatment and numerical ability on students' achievement in Physics practical and students' interest in Physics.

(5) There was significant effect of interaction of treatment and perceptual ability on students' achievement in Physics practical and interest in Physics. The effect size was 2.6%.

When graph was used to disentangle the interaction, it was clear that CSE worked best for students in moderate perceptual ability. The graph also showed that achievement in Physics practical can be improved through the use of computer- simulated experiment CSE. This tendency cut across all levels of perceptual ability group.

(6) There was no significant interaction effect of numerical ability and perceptual ability on students' achievement in Physics practical test and interest in Physics.

(7) There was no significant interaction effect of treatment, numerical ability and perceptual ability on students' achievement in Physics practical and interest in Physics.

5.2 Conclusion

This study showed that whatever could be achieved with hands-on experiment could better be achieved using computer-simulated experiment provided the lesson is properly carried out. This is evidenced by the mean gain score in Physics practical tests. It could also be concluded that achievement in Physics practical could be improved through the use of CSE and this tendency cut across all levels of perceptual ability group of students. This implies that schools that lack equipment could actually substitute with simulations provided the experiments were demonstrated for the class, while schools with well-equipped laboratory could actually enrich their practical classes through a combination of computer-simulated experiment and hands-on laboratory activities (CSE+HOE). Also, instead of repeating ritualistic laboratory procedure to verify physical concept, experiments could be carried out by the students and followed up completely through simulations.

Hands-on is only possible with fixed school schedule. In other words, it cannot be carried out outside school environment. It is also without the prospect to explore and discover because the experiment has been stereotyped towards a given results. CSE provides the opportunity for exploration. The study has shown that CSE is more effective for conceptual understanding. It is also interesting to note that numerical ability is not a means to an end because the effect has been cautioned by in built technique of CSE. However, there are some goals of hands-on experiment that simulations do not address, such as specific skills relating to the experiment. Nevertheless, depending on the goal of experiment, it may be more effective to use simulation or a combination of simulation and real equipment.

Research implications on interest as an aid to affect and cognition in learning process

Each phase of the four-phase model of interest development is characterized by affect and each phase also includes some form of knowledge or cognition processing. Although, this component are more pronounced in the later phases of interest. The cognitive and affective domain should be considered when interest is being measured. Once the first phase of triggered situational interest has been elicited, it can last for short or long period of time and may provide a basis for a person to begin to form a connection to content. In the second phase of interest, referred to as maintained situational interest, a person is typically supported by the environment (others, tasks) to continue to develop a basis for connecting to content and to find ways to relate this information with other available information. At this stage, computer simulated could be introduced to arrest and sustain the interest of the learner as well as assist the learner to carry out cognitive exercise that will enable the learner to explore a topic with constant feedback and encourages a case-based learning while making the abstract as concrete as possible. It will equally facilitate easy translation to the third phase of emerging individual interest where the learner begins to seek repeated engagement with content and continued reengagement without explicit external support and consolidates knowledge. The learner begins to pose curiosity questions and engages in self regulated activities, and hence translates to the fourth phase of well-developed individual interest where the person continues to seek for repeated opportunities for reengagement. It has also been observed that interest has both affective and cognitive aspect which could be interwoven and became more visible as it progressively translate to different phases of situational and individual interest. Therefore, every research should explain the levels and phases of interest under investigations.

5.3 Recommendations

The following recommendations are imperative based on the findings of this experiment. There is need to incorporate CSE into the school syllabus if laboratory must return to its original aim and objectives which are: complementing the classroom teaching and learning at the end of every module instead of being organized as a body of isolated and unrelated facts, but rather as a highly unified and consistent picture of the world.

There is need for the ministry of education to be more serious with the learning of computers in schools. The educational system must all be geared towards electronic learning for laboratory activities and effective classroom instruction generally. Teachers should be trained and encouraged to use computer-simulated experiment as an instructional strategy.

With the introduction of CSE, sciences could be introduced into distance learning or part-time learning programmes. Curriculum planners should consider the inclusion of simulations for laboratory activities to encourage electronic classroom. Examination bodies should consider the use of simulation in the place of alternative to practical during examinations.

The Nigeria government should be encouraged to provide constant power supply in order to create conducive environment for more meaningful learning through the use of computers and electronic classrooms so that Nigeria can stand out with the rest of the world in academic excellence.

5.4 Contributions to knowledge

The research work has made the following contributions to knowledge:

1. This probably is the first time that we have a study that made use of a Computer-Simulated Instructional package which is highly interactive for SSS Practical Physics in Nigeria.
2. The package exposes Teachers and students to new ways of doing practical work in Physics using computer-simulated instructional packages.
3. The actual online involvement of Physics students carrying out the Experiments themselves has made them have ‘a feel of the phenomenon’
4. The introduction of perceptual and numerical abilities in the understanding of practical work to improve achievement in physics is equally new.

5. It exposes the teacher and the students to a new way of learning by simulation of the experiment.
6. It has shown that laboratory type of activities could be carried out outside laboratory experiment.

5.5 Areas for further study

Many researchers have posited that learning could be better through the use of CSE. There is need to investigate further the effect of interest considering various levels of interest as well as the knowledge/cognition aspects along with affects using a longer period of time, since time is a factor for acquiring individual or personal interest. The main and interactive effect of numerical ability and perceptual ability of learning of Physics through CSE could further be investigated. This experiment could also be repeated in the areas of Chemistry and Biology. The effect of CSE on distance learning as well as carrying out laboratory activities outside the classroom should equally be investigated.

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APPENDIX I

Lesson note for instructional strategy I –Computer Simulated Experiment (CSE)

Lesson note I

Subject: Physics

Topic: Introduction to Concept of Pendulum

Duration: 1hr: 20mins

Instructional Objectives

At the end of the lesson, pupils, should be able to:

i. Define a simple Pendulum

ii. Give a brief history on the origin of pendulum and uses

iii. Explain terms associated with simple pendulum

iv. Explain factors affecting the movement of simple pendulum

v. Explain the properties of a simple pendulum setting motion

vi. Explain the time taken for a complete cycle as $= 2\pi\sqrt{\frac{L}{g}}\ \theta o = \ll 1 \ldots \ldots (1)$

(for small amplitude)

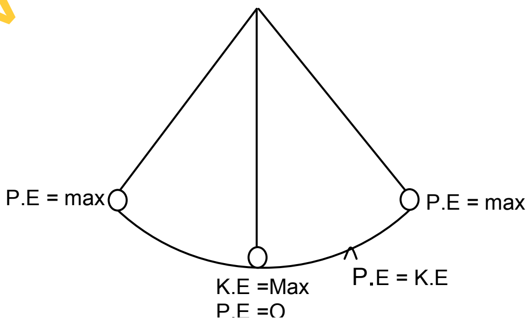
vii. Explain simple harmonic motion

viii. Explain the properties of simple pendulum set in motion.

Introduction: The teacher will ask the students to describe the movement of a pendulum, if they have seen one before. Then link it to the day's lesson

Content

1. Definition of a pendulum with example.
2. Brief history and origin of pendulum and their uses.
3. Simple harmonic motion



4. Time for complete cycle as: $= 2\pi\sqrt{\frac{L}{g}}$ $\theta o = \ll 1 \ldots \ldots (1)$

Where L = Length of pendulum

g =Acceleration due to gravity

Presentation of Content by the Teacher

STEP I: Introduction

STEP II: Define pendulum and give a brief history of it's origin and their uses.

STEP III: List and explain the terms associated with simple harmonic motion.

STEP IV: Explain the terms affecting the movement of simple pendulum

STEP V: Explain properties of a simple pendulum set in motion

STEP VI: Entertain questions from the students and ask your own questions.

Teacher's Activities

1. Definition of simple pendulum
2. Teacher gives a brief history of the origin of pendulum and their use
3. Teacher mention and explain the factors that affects the a pendulumin motion with respect to time, acceleration due to gravity and length
4. Explain the properties of a simple pendulum in motion in terms of energy.

Students' Activities

1. Students will ask and answer questions.
2. Students will take readings for 20 oscillations at 5degree amplitude for three readings and find the average.

Lesson note for Instructional Strategy I - Computer Simulated Experiment (CSE)

Lesson note **II**

Subject: **Physics**

Topic: **Simple Pendulum Experiment**

Duration: **1 hr: 20mins**

Instructional Objectives

At the end of the lesson, students should be able to

1. Set up a simple pendulum bob experiment
2. Take reading independently for length; 20, 40, 60, 80 and 100cm.
3. Use the reading obtained to make a table for period, time, length $\frac{1}{Time}$ and $\frac{1}{Length}$
4. Plot a graph T against $\frac{1}{L}$
5. Find the slope of the graph.

Content

1. Setting up a simple pendulum experiment
2. Taking of independent readings for given values
3. Constructing a table of value
4. Plotting of graph and findings the slope
5. Finding intercept between X and Y axis

Presentation of Content by the Teacher

STEP I: Introduction

STEP II: Presentation of concept which includes demonstration using real apparatus

STEP III: Select programme from internet and set up the virtual experiment on simple pendulum by adjusting the necessary parameter

STEP IV: Demonstrate the simple pendulum experiment and take your readings using simulations

STEP V: Entertain questions from the students and also ask your own question

STEP VI: Peer the students in threes and ask them to take individual readings

STEP VII: The teacher to go round and monitor the activities of the students and give further instruction

Teacher's Activities

1. Teacher will entertain questions
2. Teacher will go round to assist the students when needed
3. Teacher will explain to the students how to plot graph, find slope and intercept

Student's Activities

1. Students will set up experiments
2. Students will take independent readings for given values
3. Students will constructs tables of values
4. Students will find slopes and intercepts of graphs

Lesson note for Instructional Strategy I –Computer Simulated Experiment (CSE)

Lesson note III

Subject: Physics

Topic: Determination of Acceleration due to gravity "g" using simple pendulum

Duration: 1hr 20 minutes

Instructional Objectives:

At the end of the lesson, pupils should be able to

i. Take readings and plot graphs with the obtained readings

ii. Carry out simple calculations involving simple pendulum

Introduction:

The teacher will throw an object up and allow it to land on the floor. The students will be asked to explain the activity. It will be linked to the lesson for the day.

Content

Setting up a simple pendulum experiment

You are provided with a pendulum bob, retort stand and clamp and meter rule, stop watch, in extensive thread and split cork.

1. Set up the experiment as demonstrated previously with the length of string at 20cm.
2. Set up a reference point at the equilibrium position of the bob. Measure and record the height "h" of the bob from the cork (20cm)
3. Set the bob to oscillation through a small angle of about (5^0) equilibrium position and record the time for 20 oscillation
4. Repeat the procedure for (1-3) for the length and find the average time "T". calculate the period of oscillation "T"
5. Repeat the procedure (1-4) for four more different length "h" = 40, 60, 80 and 100cm.
6. Plot a graph of T^2 against "l" as abiscissa. Determine the slope of the graph on both vertical (y) and horizontal (X) axis
7. If h, t, l, are related by h $= \mathcal{l} - \frac{g}{4\pi^2} T^2$, find "g".

Presentation of Content by the Teacher

STEP I: Introduction

STEP II: Select programme from the internet and set up the virtual experiment on simple pendulum by adjustment of necessary parameters

STEP III: Ask the students to set up the simple pendulum in the virtual laboratory and use it to obtain readings for length 20, 40, 60, 80 and 100cm

STEP IV: Ask the students to prepare a table of readings for l, t,T, $\frac{1}{T}$, T^2 and e.

STEP V: Ask the students to plot a graph of T_2 against L and determine the slope of the graph on both axis (X and Y).

STEP VI: If h, t, l are related by $h = l - \frac{g}{4\pi^2} T^2$ find h.

STEP VIII: Papers will be submitted by the students and task will be reviewed

Teacher's Activities:

i. Take readings and plot graph with the obtained values.

ii. Explain the equation $T = 2\Pi\sqrt{\frac{L}{g}}$

iii. Carry out simple calculations involving simple pendulum.

Students Activities:

i Students will carry out experiments on simple pendulum

ii Students will plot graph, find the intercept on y and x axis

iii. Students will carry out simple calculation on simple pendulum.

Lesson note for Instructional Strategy I –Computer Simulate Experiment (CSE)

Lesson note IV

Subject: Physics

Topic: Elastic Properties of Solid

Duration: 1hr 20 minutes

Instructional Objectives:

At the end of the lesson, the students should be able to

i. Define elasticity

ii. Explain the elastic properties of solids

iii. Define an elastic material

iv. Define stress, strain, elastic limit, and young modulus

v. State Hook's law and demonstrate to the students

Introduction:

Summarize the previous lesson and link it to the day's lesson

Contents:

i) Definition of elasticity

ii) Elastic materials and their properties.

iii) Definition of: stress, strain, elastic limit, and young modulus

iv) State Hooke's law and demonstrate it to the students.

Presentation of Content by the Teacher

STEP I: Introduction

STEP II: Define elasticity, elastic properties of materials

STEP III: Explain stress, strain, elastic limit and young modulus

STEP IV: State Hooke's law and use the simulation to demonstrate it using simulation.

STEP V: Group the students and let the group leader demonstrate Hooke's law

STEP VI: Ask questions to see if set objectives have been achieved and also entertain questions from the students

Teacher's Activities:

i) Teacher will define elasticity

ii) Teacher will explain elastic properties of solids

iii) Teacher will define elastic materials

iv) Teacher will explain the term: stress, strain, elastic limit and young modulus

v) Teacher will state and demonstrate Hooke's law.

Students' Activities:

i) Students will ask and answer questions

ii) Students will use values obtained during demonstration involving Hooke's law to determine elastic constant.

Lesson note for instructional strategy I –Computer Simulate Experiment (CSE)

Lesson note **V**

Subject: **Physics**

Topic: **Simple Harmonic Motion (SHM)**

Duration: **1hr 20 minutes**

Instructional Objectives:

At the end of the lesson, the students should be able to

1. Explain the concept of simple harmonic motion (SHM)
2. Define speed and acceleration in SHM
3. Explain period, frequency and amplitude in simple harmonic motion
4. Explain energy in simple harmonic motion
5. Explain the concept of forced vibration and resonance

Introduction

Ask the students to describe what happens to a string when the bird perches on it. Link the experience to simple harmonic motion.

Content

1. Concept of simple harmonic motion
2. Definition of speed, Acceleration, period, in SHM
3. Explanations on frequency, period, and amplitude of energy
4. Concept of energy
5. Forced vibration and resonance
6. Demonstration of resonance, forced vibration and SHM.

Presentation of Content by the Teacher

STEP I: Introduction

STEP II: Explain the concept of simple harmonic motion with displayed simulations

STEP IV: Go further to explain the terms involve with the same illustrations such terms as: period, frequency amplitude, speed, acceleration

STEP V: Explain and demonstrate the concept of forced vibration and resonance

STEP VI: Place the students in group with a good leader to demonstrate force vibration and resonance

STEP VII: Entertain questions from the students and ask your own questions too

Teachers Activities

1. Asking and answering of question
2. Explanations and demonstrations of the following concept
   i. Simple harmonic motion
   ii. Frequency, period, amplitude
   iii. Speed and acceleration in SHM
   iv. Energy
3. Explanations and demonstrations of the concept of forced vibration and resonance

Students' Activities

1. Students will ask and answer questions
2. Students will explain in their own words the concept of force vibration and resonance
3. Students will explain in their own words the following: (a) speed (b) acceleration (c) energy

4. Students will engage in activities to demonstrate simple harmonic motion, forced vibration and resonance

Lesson note for instructional strategy I –Computer Simulated Experiment (CSE)

Lesson note VI

Subject: Physics

Topic: Determination of elastic constant of a Spring using Hooke's law

Duration: 1hr 20 minutes

Instructional Objectives:

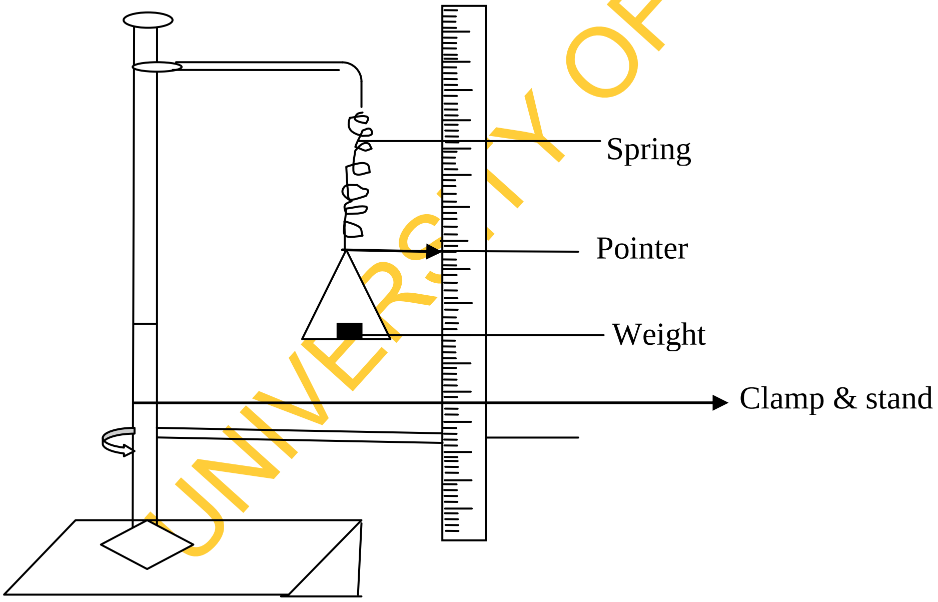
At the end of the lesson, the students should be able to

1. Take readings on verification of Hooke's law
2. Record readings to correct number of decimal
3. Prepare table for readings
4. Plot and interpret graph

Content

You are provided with a simulation pack for Hooke.s law experiment: spiral spring, cork, pointer; porcelain, meter rule, clamp and stand and variable masses.

1. Set up the virtual as shown in the diagram



2. Note the initial pointer reading on the meter rule
3. Add 50g to the scale and record your reading with the aid of the pointer.
4. Take reading for 100g 150g and 250g and record your readings respectively

5. Remove the load from the scale pan in equal steps also and note and record the corresponding reading
6. Prepare your table as shown:

Load (g)	Scale Reading Load increasing X_1 (cm)	Load decreasing X_2 (cm)	Average Reading $\frac{x_1 + x_2}{2}$	Extension x- L (cm)

7. Plot a graph of extension against load and find the slope of the graph
8. Comment on the graph

Presentation of Content by the Teacher

STEP I: Introduction

STEP II: Presentation of concept which includes demonstration of experiment using real apparatus

STEP III: Select programme from the internet and set up a virtual experiment on verification of Hooke's law by adjusting the necessary parameter

STEP IV: Demonstrate the experiment on verification of Hooke's law and take readings

STEP V: Entertain questions from the students and also ask your own questions

STEP VI: Peer the students in threes and ask them to take readings individually (of masses 100, 150 and 200g).

STEP VII: The teacher will go round to monitor the activities by the students and give further directions

Teacher's Activities

1. Teacher will set up the experiment as described
2. Teacher will move round to guide the student as they take their individual reading
3. Teacher will entertain questions from students and give necessary clarification

Students Activities

1. Students will set u the apparatus
2. Students will take readings and prepare the table

3. Students will plot graphs
4. Students will do calculations
5. Students will ask and answer questions

Lesson note for instructional strategy I –Computer Simulated Experiment (CSE)

Lesson note VII

Subject: Physics

Topic: Verification of Hooke's Law

Duration: 1hr 20 minutes

Instructional Objectives:

At the end of the lesson, the students should be able to

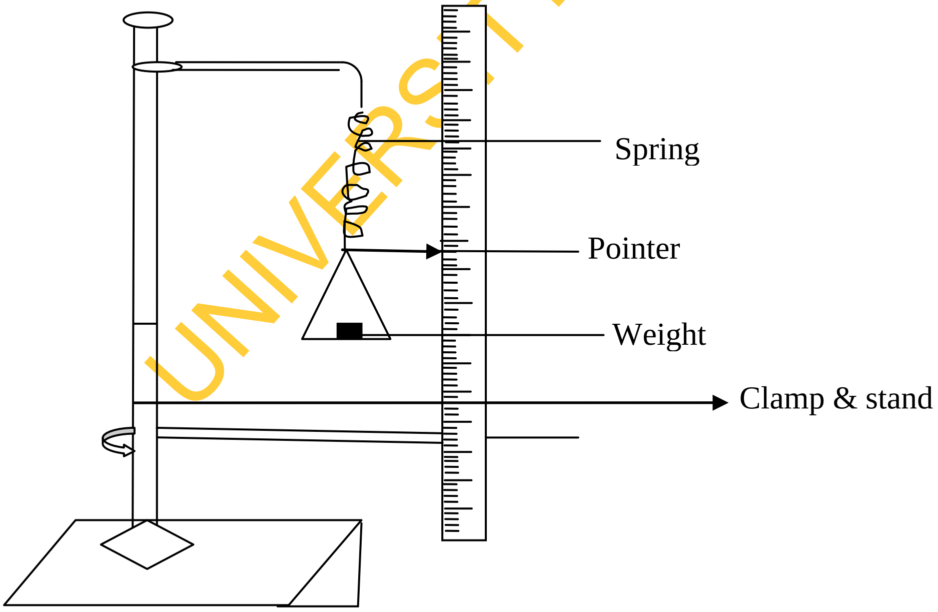
1. Set up experiment on verification of Hooke's law
2. Collect readings with the apparatus
3. Plot graph and interpret
4. Carry out any others operations using Hooke's law

Introduction

Summarize the previous lesson and link it to today's topic

Content

1. Using virtual apparatus, suspend the given spiral spring vertically as shown in the diagram. Attach a scale pan and note the position of the pointer on the metre rule



2. Add a mass of 50g to the scale pan and note the new position of the pointer
3. Determine the extension "e" produced
4. Repeat the experiment for m= 100g, 150g, and 250g. In each case, determine the extension produced
5. Ignore the mass of the scale pan and tabulate your readings
6. If a hanger is used, both the mass of the hanger and the added slotted masses should be equal to100, 150 and 250g.
7. Plot the graph of "e" on the vertical axis and "m" on the horizontal axis, starting both axis from the origin (O,O)
8. Determine the slope of the graph and the intercept on "e" axis.
9. Determine the difference in extension when the mass was increased from 100-150g
10. Set the spring into small oscillation and determine the time for 10 complete oscillation
11. Calculate the "T" of the oscillation
12. Evaluate the expression: $k = \frac{39.5x}{T12-T22}$

Presentation of Content by the Teacher

STEP I: Introduction

STEP II: Select the programme from the internet and set up the virtual experiment on simple pendulum by adjustment of necessary parameters

STEP III: Ask the students to set up experiments on Hooke's law in the virtual laboratory and use it to obtain readings for 50g, 100, 150 and 250g.

STEP IV: Set the spring into oscillation and determine the "T" oscillation for 10 oscillations.

STEP V: Students will use the readings obtained to make a table for mass, length, time and period.

STEP VI: Student will plot a graph of e against m and determine the slope of the graph on both axis

Teachers activities

1. The teachers monitors the students and guides them through each steps
2. The teacher offers assistance when necessary
3. The teacher entertains questions from the students

Students Activities

1. The students will set up the apparatus themselves

2. The students collects readings
3. The students will plot graph
4. The students will carry out other operations using Hooke's law

Lesson note for instructional strategy I -Computer Simulated Experiment (CSE)

Lesson note VIII

Subject: Physics

Topic: Determination of refractive Index of prism

Duration: 1hr 20 minutes

Instructional Objectives:

At the end of the lesson, pupils should be able to

i. Draw a diagram to show the formation of image
ii. Measure the angle of incidence and refraction and hence deduce a value for refractive index
iii. Trace light rays through prisms and obtain graphically the value of the angle of Minimum deviation.
iv. Explain the meaning of critical angle and total internal reflection stating the conditions under which it occurs.
v. Use the experiment with triangular prism to obtain ***i***, r, sini, and sinr show its relationship with the refractive index of glass

Introduction:

List some sources of light that is seen in everyday life. Link it to the day's lesson.

Content

i. Sources of light
ii. Transmission of light
iii. Rays and beams
iv. Laws of refraction
v. Tracing light rays through prisms
vi. Measurement of angle of incidence, angle of refraction, emergence and internal by virtual apparatus.

Presentation of Content

STEP I: Introduction

STEP II: Presentation of concept which includes demonstration of experiment on prism using real apparatus

STEP III: Select programme from the internet and set up the virtual experiment on prism by adjusting the necessary parameters

STEP IV: Demonstrate the measurement of angle incidence and angle refraction taking your readings

STEP V Peer the students in threes and asked them to take individual readings

STEPVI: The teacher to go round to monitor the activities by the students and give further instructions

Teacher's Activities:

i. The teacher will trace light rays through prism.

ii. Demonstrate the relationship between $\boldsymbol{i}$, r, sin $\boldsymbol{i}$, sin $\boldsymbol{i}$

iii. Trace light rays through prisms to obtain the graphical value of angle of deviation and emergence

Pupils' Activities

i. Students will set up experiment on determination of refractive index of a prism.

ii. Students will plot graph and find angle of refraction, angle of emergence and angle of Deviation

iii. Students will carry out simple calculation on refraction.

Home work

1. Tabulate your readings or i, r, sin i, sin r, $\frac{1}{sini,}\frac{1}{sini}$
2. Plot a graph sin i against sin r and find the slope

Lesson note for Instructional Strategy II – CSE+H0E

Lesson note **I**

Subject: **Physics**

Topic: **Introduction to Concept of simple pendulum**

Duration: **1hr 20 minutes**

Instructional Objectives:

At the end of the lesson, pupils should be able to

1. Define a simple pendulum

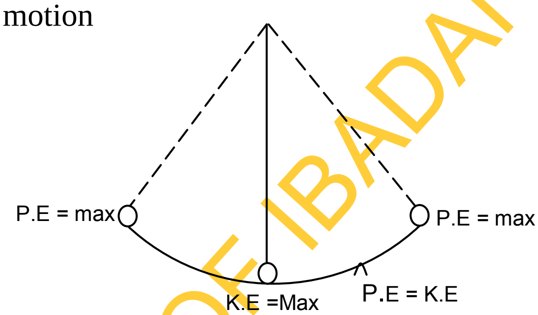
2. Give a brief history on the origin of pendulum and their uses
3. Explain the terms associated with simple pendulum
4. Explain factors affecting the movement of simple pendulum
5. Explain the properties of simple pendulum set in motion
6. Explain the time taken for a complete cycle as $T = 2\pi\sqrt{\frac{L}{g}}$ $\theta o = \ll 1 \ldots \ldots (1)$

   (for small and large amplitude)
7. Explain simple harmonic motions

Introduction: The teacher will ask the students to describe the movement of a pendulum, if they have seen one before. Then link it to the day's lesson

Content

1. Definition of a pendulum with examples
2. Brief history and origin of pendulum
3. Simple harmonic motion



4. Time for complete cycle as: $= 2\pi\sqrt{\frac{L}{g}}$ $\theta o = \ll 1 \ldots \ldots (1)$

   Where L = Length of pendulum

   g =Acceleration due to gravity

Presentation of content

STEP I: Define pendulum and give brief history of its origin

STEP II: Explain simple harmonic motion using real experimental set up and simulations.

STEP III: Explain the terms affecting the movement of simple pendulum using real experimental set up and simulations.

STEP IV: Explain the properties of simple pendulum set in motion in term of energy.

Teachers Activities

1. Teacher display simple pendulum in the computer and define what pendulum is
2. Teacher gives a brief history of the origin of pendulum

3. Teacher mention the uses of pendulum and display where it is used in the computer
4. Teacher mentions and explain the factor that affects the swing as being displayed by the computer with respect to time, Acceleration due to gravity and length
5. Simple harmonic motion and energy in a system.
6. Teacher also takes corresponding readings with the simulations

Students' Activities

1. Students will take reading to learn how to count oscillations manually and find average readings
2. Students will take readings to learn how to count oscillation using the computer and find average readings
3. Students will compare both readings

Lesson note for Instructional Strategy II – CSE+H0E

Lesson note II

Subject: Physics

Topic: Simple Pendulum Experiment

Duration: 1hr 20 minutes

Instructional Objectives:

At the end of the lesson, pupils should be able to

1. Set up a sample of pendulum bob experiment
2. Take readings independently for length 20, 40, 60, 80and 100cm
3. Use the readings to obtained to make a table for period, time, length $\frac{1}{T}$ and $\frac{1}{L}$
4. Plot a graph of T against $\frac{1}{L}$
5. Find the slope of the graph

Content

1. Setting up a simple pendulum experiment
2. Taking of independent readings for the given value
3. Constructing a table of value
4. Plotting of graph and findings the slope
5. Findings the intercept

Presentation of content

STEP I: Introduction

STEP II: Presentation of concept which includes demonstrate using real apparatus

STEP III: Performance of task which involves taking of readings by the teachers using real apparatus

STEP IV: Entertain questions from the students and ask your own questions

STEP V: Students will be grouped in threes to obtain individual readings for 20, 40, 60, 80 and 100cm

STEP VI: Students will set up the experiment and obtain their readings

STEP VII: presentation of the second task which is taking of readings using computer simulation

STEP VIII: Students will take readings using computer simulations for 20, 40, 60, 80 and 100cm

STEP IX: prepare a table of value for L, t, T, $\frac{1}{T}$ and $\frac{1}{L}$

STEP X: Plot a graph of T against $\frac{1}{L}$

STEP XI: The teacher will to round to monitor activities of the student and give further instruction

Teachers Activities

1. Teachers will go round to assist the students when needed in setting up experiment
2. Teacher will go round also assist students to assess the virtual laboratory
3. Teacher will entertain questions from students
4. Teachers will explain to the students how to plot graph, find slope and intercept

Student Activities

1. Students will set up experiment
2. Students will access the virtual laboratory
3. Students will take independent readings for given values
4. Students will construct table of value
5. Students will find slope and intercept of the graph

Lesson note for Instructional Strategy II – CSE +H0E

Lesson note III

Subject: Physics

Topic: Determination of Acceleration Due to Gravity

Duration: 1hr 20 minutes

Instructional Objectives:

At the end of the lesson, pupils should be able to

1. Take readings and plot graphs with the obtained readings.
2. Carry out other simple calculations involving simple pendulum.

Introduction

The teacher will throw an object up and allow it to land on the floor. Ask the students explain the concepts, and link it with the days lesson.

Content

Setting up a simple pendulum experiment

You are provided with a pendulum bob, retort stand, clamp and meter rule, stop watch, inextensive thread and split cork.

i. Set up the experiment on your own with the length of the string at 20cm
ii. Set up a reference point at the equilibrium position of the bob. Measure and record the height "h" of the bob from the cork (20cm)
iii. Set the bob to swing through a small angle of about (5^o) equilibrium position and record the time for 20 oscillations
iv. Repeat the procedure (I-III) for the same length and find the average time "T". Calculate the period for Oscillation "T".
v. Repeat the procedure (i-iv) for four more different lengths "h" = 40, 60, 80, and 100cm
vi. Access the internet virtual laboratory on simple pendulum
vii. Use the simulation to obtain readings for 20 oscillations at an implitude of 5^o (degree) and record your readings thrice and find average value.
viii. Take more readings for h = 40, 60, 80 and hundred
ix. Plot a graph of T^2 against "l" as a biscissa, determine the slope of the graph on both vertical and horizontal axis.

Presentation of Content

STEP I: Introduction

STEP II: Presentation of concept which includes demonstration by the teacher using real apparatus

STEP III: Ask the students to set up an experiment for simple pendulum activities use the same experiment on simple pendulum to obtain readings for 20, 40, 60, 80 and 100 cm

STEP IV: Presentation of the second task which is taking of readings using computer simulation on simple pendulum

STEP V: Entertain questions from the students and ask your own questions

STEP VI: Students will obtain readings using computer simulation for length 20, 40, 60, 80, 100 cm and also prepare table of value for L, t, T, T^2 and e.

STEP VII: Students will be asked to plot a graph of T^2 against $\frac{1}{T}$ and determine the slope of the graph on both axis

STEP VIII: If h, t, L, are related by $h=L-\frac{g}{4\pi^2}T^2$, find h.

Teacher's Activities:

i. Teacher will move round to assist students in setting up experiment
ii. Teacher will entertain questions from the students
iii. Teacher will assist students to assess the virtual laboratory
iv. Teacher will also explain concepts involved in the experiment

Students Activities:

i. Students will set up experiment
ii. Students will access the virtual laboratory
iii. Students will take independent readings for given values
iv. Student will construct table of value
v. Students will find slope and intercept of the graph
vi. Student will carry out other activities and calculation involved in the experiment

Lesson note for instructional strategy II – CSE+ H0E

Lesson note IV

Subject: **Physics**

Topic: **Elastic Properties of Solid**

Duration: **1hr 20 minutes**

Instructional Objectives:

At the end of the lesson, the students should be able to

- **i.** Define elasticity
- **ii.** Explain the elastic properties of solids
- **iii.** Define an elastic material
- **iv.** Define stress, strain, elastic limit, and young modulus
- **v.** State Hook's law and demonstrate to the students

Introduction: Summarize the previous lesson, link it to the day's lesson

Content

1. Definition of elasticity
2. Elastic properties of material
3. Define of elastic properties of materials
4. Stress, strain, elastic limit, and young modulus
5. Hooke's law definition
6. Demonstrations involving Hooke's law; manually
7. Demonstration of Hooke's by simulations

Presentation of Content

STEP I: Introduction

STEP II: Define elasticity and elastic properties of solids

STEP III: Explain, stress, strain, young modulus and elastic limit

STEP IV: State Hooke's law and demonstrate it both with real equipment and simulation

STEP V: Put students in group of threes and ask each to demonstrate Hooke's laws using real equipment and simulation

STEP VI: Entertains questions and ask your own questions

Teacher's Activities

- i) Teacher will demonstrate hooke's using laboratory apparatus
- ii) Teacher will demonstrate of hooke's law by simulation
- iii) Teacher will ask and answer questions

Students Activities

1. Students will ask and answer questions
2. Students will use the values obtained during demonstrations involving hooke's law to determine elastic constant

Lesson note for instructional strategy II – CSE + H0E

Lesson note V

Subject: Physics

Topic: Simple Harmonic Motion (SHM)

Duration: 1hr 20 minutes

Instructional Objectives:

At the end of the lesson, the students should be able to

1. Explain the concept of simple harmonic motion (SHM)
2. Define speed and acceleration in SHM
3. Explain period, frequency and amplitude in simple harmonic motion
4. Explain energy in simple harmonic motion
5. Explain the concept of forced vibration and resonance

Introduction

Ask the students to describe what happens to a string when the bird perches on it. Link the experience to simple harmonic motion.

Content

1. Explain the concept of simple harmonic motion verbally and through simulation
2. Definition of speed, Acceleration in SHM
3. Explanations on term frequency, period, and amplitude in SHM
4. Concept of energy
5. Forced vibration and resonance
6. Demonstration of resonance, forced vibration through simulation

Presentation of Context

STEP I: Introduction

STEP II: Explanation of concept of SHM with illustration

STEP III: Explain further, the terms involved in such illustration such as: period sequences, amplitude, speed, acceleration

STEP IV: Explain and demonstrate the concept of forced vibration and resonance

STEP V: Place the students in groups of three to demonstrate forced vibration and resonance

STEP VI: Go round to monitor the activities and entertain questions

Teacher's Activities

1. Teacher will ask and answer questions

2. Teacher will explain the following concept
    (a) Simple harmonic motion
    (b) Frequency, period, and amplitude
    (c) Speed and acceleration in SHM
    (d) Energy
3. Teacher will demonstrate simple harmonic motion, manually and through CSE
4. Teacher will demonstrate force vibration and resonance through CSE

Students Activities

i) Students will asked and answer questions

ii) Students will explain the terms and concept being studied in the own words

iii) Students will demonstrate simple harmonic motion manually and through the CSE

iv) Students will demonstrate forced vibration and resonance manually and through CSE

Lesson note for instructional strategy II – CSE + H0E

Lesson note VI

Subject: Physics

Topic: Determination of elastic constant of a spring using Hooke's law

Duration: 1hr 20 minutes

Instructional Objectives:

At the end of the lesson, the students should be able to

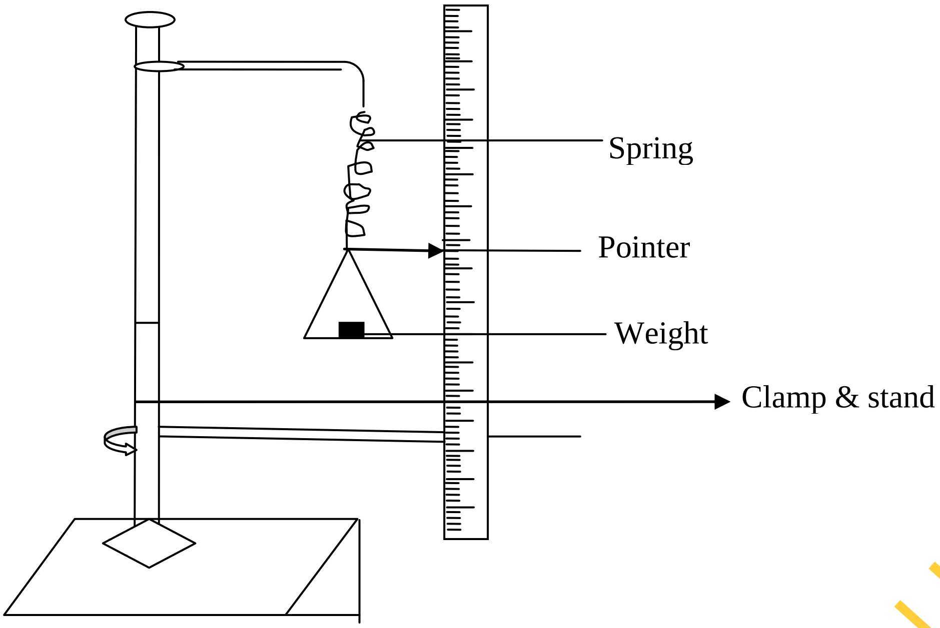
1. Set up apparatus for Hooke's law experiment manually and through simulation
2. Take readings during such experiment
3. Record readings to correct number of decimal
4. Prepare table for readings
5. Plot and interpret graph

Introduction: Summarize the previous lesson. Link it to the days lesson

Content

You are provided with spiral spring cork and pointer; porcelain, meter rule, clamp and stand and variable masses.

1. Set up the apparatus as shown in the diagram



ii. Note the initial pointer reading on the meter rule

iii. Add 50g to the scale and record your reading with the aid of the pointer.

iv. Take reading for 100g 150g and 250g and record your readings respectively

v. Remove the load from the scale pan in equal steps also and note and record the corresponding reading

vi. Use simulations to obtain reading for 50g, 100g, 150g and 250g respectively

vii. Prepare your table as shown:

Load	**Scale Load increasing X_1 (cm)**	**Reading Load decreasing X_2 (cm)**	**Average Reading $\frac{x_1 + x_2}{2}$**	**Extension x- L (cm)**

viii. Plot a graph of extension against load and find the slope of the graph

ix. Comment on the graph

Home work: Complete the table and plot a graph using data obtained from the simulation. Find the slope of the graph.

Presentation of Content

STEP I: Introduction

STEP II: Presentation of concept which includes the teacher's demonstration using real apparatus

STEP III: Teacher will take readings using real apparatus

STEP IV: Entertain questions from the students and ask your own questions

STEP V: Ask students to set up experiment on verification of Hooke's law using real apparatus to obtain readings for 20, 40, 60, 80 and 100g

STEP VI: Ask students to take similar readings using computer simulations on Hooke's law for 100g, 150, and 250g

STEP VII: Complete the table of value as indicated

STEP VIII: Students will plot a graph of "e" against "m" and obtain the slope of the graph.

Teacher's Activities

1. Teacher will set up experiment as described manually and simulation
2. Teacher will move round to guide the students as they take their readings
3. Teacher will entertain questions from students and give necessary clarifications

Students' Activities

1. Students will set up the experiment
2. Students will take readings and prepare the table
3. Students will plot graphs
4. Students will do calculations
5. Students will ask and answer questions

Lesson note for instructional strategy II – CSE + H0E

Lesson note VII

Subject: Physics

Topic: Verification of Hooke's Law

Duration: 1hr 20 minutes

Instructional Objectives:

At the end of the lesson, the students should be able to

1. Set up manual and simulated experiment on verification of Hooke's law
2. Collect readings with the apparatus

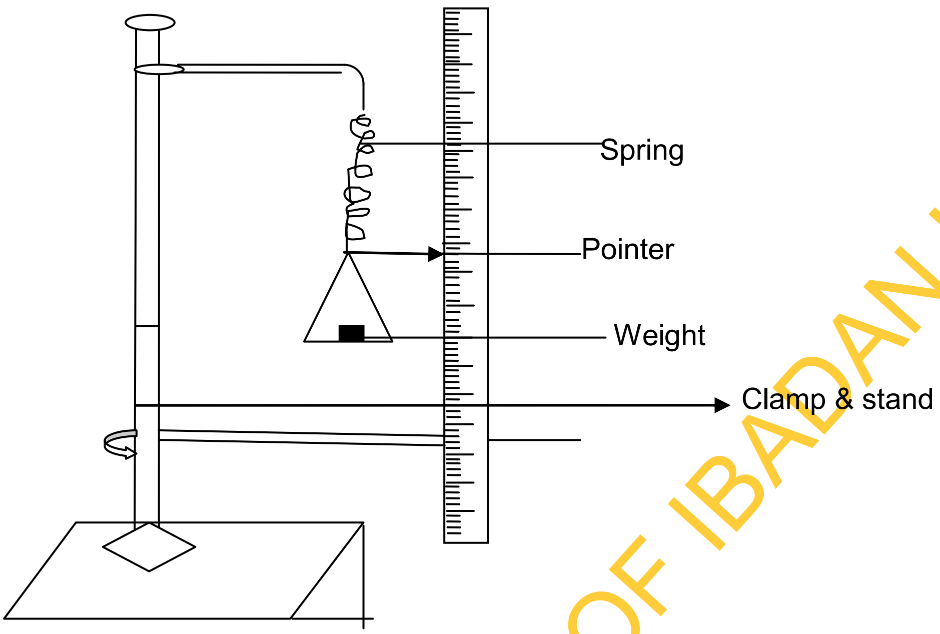
3. Plot graph and interpret it
4. Carry out any others operations using Hooke's law

Introduction

Summarize the previous lesson and link it to today's topic

Content

1. Suspend the given spiral spring vertically as shown in the diagram. Attach a scale pan and note the position of the pointer on the metre rule.



2. Add a mass of 70g to the scale pan and note the new position of the pointer
3. Determine the extension "e" produced
4. Repeat the experiment for m= 90, 110, 130 and 150g respectively. In each case, determine the extension produced
5. Ignore the mass of the scale pan and tabulate your readings
6. If a hanger is used, both the mass of the hanger and the added slotted masses should be equal to 70, 90, 110, 130, and 150g respectively
7. Access the simulation and take your readings 70, 90, 110, 130, and 150g and record the corresponding extension 'e'
8. Plot the graph of "e" on the vertical axis and "m" on the horizontal axis, starting both axis from the origin (O,O)
9. Determine the slope of the graph and the intercept on "e" axis.
10. Determine the difference in extension when the mass was increased from 100-150g

11. Set the spring into small oscillation and determine the time for 10 complete oscillation
12. Calculate the "T" of the oscillation

Presentation of Content

STEP I: Introduction

STEP II: Presentation of concept which includes the teacher's demonstration using real apparatus

STEP III: Ask students to set up the experiments on verification of Hooke's law without assistance and obtain readings for 70, 90, 110, 130 and 150g.

STEP IV: Presentation of second task which is taking of reading using computer simulations on Hooke's law for 100g, 150g, 250g.

STEP V: Set the spring into oscillation and determine the " e" for ten oscillations for each mass

STEP VI: Use the readings obtained to make a table of value and plot a graph of "e" against "m".

Teachers activities

4. The teachers monitors the students and guides them through each steps
5. The teacher offers assistance when necessary
6. The teacher entertains questions from the students

Students Activities

5. The students will set up the apparatus themselves
6. The students collects readings
7. The students will plot graph
8. The students will carry out other operations using Hooke's law

Lesson note for instructional strategy II – CSE + H0E

Lesson note **VIII**

Subject: **Physics**

Topic: **Determination of refractive Index of prism**

Duration: **1hr 20 minutes**

Instructional Objectives:

At the end of the lesson, pupils should be able to

i. Draw a diagram to show the formation of image

ii. Measure the angle of incidence and refraction and hence deduce a value for refractive index

iii. Trace light rays through prisms and obtain graphically the value of the angle of Minimum deviation.

iv. Explain the meaning of critical angle and total internal reflection stating the conditions under which it occurs.

v. Use the experiment with triangular prism to obtain minimum angle of deviation and show its relationship with the refractive index of glass

Introduction

List some sources of light that is seen in everyday life. Link it to the day's lesson.

Content

i. Sources of light

ii. Transmission of light

iii. Rays and beams

iv. Laws of refraction

v. Tracing light rays through prisms

vi. Measurement of angle of incidence, angle of refraction, emergence and internal reflection

Presentation of Content

STEP I: Introduction

STEP II: Presentation of concept which includes taking of readings by the teacher using real apparatus

STEP III: Ask students to set up experiment involving refraction of prisms using real apparatus, obtain the readings for the angle of incidence: 30^o, 40^0, 50^0, 60^0, 70^0

STEP IV: Entertain questions from the students and ask your own question

STEP V: Presentation of the second task which is determination of refractive index of prism. Using computer simulations, to obtain readings for incident angle (i) = 30^0, 40^0, 50^0, 60^0, 70^0

STEP VI: Plot a graph of sin i against sin r and determine the slope.

Teacher's Activities:

i. The teacher will trace light rays through prism.

ii. Demonstrate the incidence ray, the normal and reflected rays on the same plane.

iii. Trace light rays through prisms to obtain the graphical value of angle of deviation and emergence

iv. Teacher will ask and answer questions

Pupils' Activity

i. Students will set up experiment on determination of refractive index of a prism.

ii. Students will plot graph and find angle of refraction, angle of emergence and angle of Deviation

iii. Students will carry out simple calculation on refraction.

Home Work

1. Use the readings obtained from simulation to prepare a table of value for i, r, sin i, sin r.
2. Use it to plot a graph of sin i against sin r.

Lesson note for instructional strategy III - Hands-on Laboratory Group

Lesson note I

Subject: **Physics**

Topic: **Introduction to Concept of Pendulum**

Duration: **1hr: 20mins**

Instructional Objectives

At the end of the lesson, pupils, should be able to:

i. Define a simple Pendulum

ii. Give a brief history on the origin of pendulum and their uses

iii. Explain terms associated with simple pendulum

iv. Explain factors affecting the movement of simple pendulum

v. Explain the time taken for a complete cycle as $= 2\pi\sqrt{\frac{L}{g}}\,\theta o = \ll 1 \ldots\ldots (1)$

(for small amplitude)

vi. Explain simple harmonic motion

vii. Explain the properties of a simple pendulum set in motion

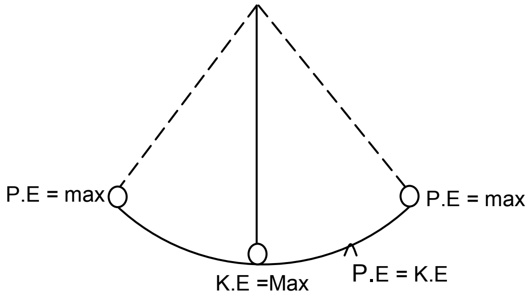
Introduction: The teacher will ask the students to describe the movement of a pendulum, if they have seen one before. Then link it to the day's lesson

Content

1. Definition of a pendulum with examples

2. Brief history and origin of pendulum

3. Simple Harmonic motion



4. Time for complete cycle as: $= 2\pi\sqrt{\frac{L}{g}}$ $\theta o = \ll 1 \ldots \ldots (1)$

Where L = Length of pendulum

g =Acceleration due to gravity

Presentation Content

STEP I: Introduction

STEP II: Define pendulum, give the brief history of its origin and their uses

STEP III: List and explain the terms associated with simple harmonic motion

STEP IV: Explain terms affecting the movement of simple pendulum

STEP V: Explain the properties of simple pendulum set in motion

STEP VI: Entertain questions from the students

Teacher's Activities

5. Definition of simple pendulum
6. Teacher gives a brief history of the origin of pendulum
7. Teacher mention uses of pendulum
8. Teacher mention and explain the factors that affects the swing of pendulum with respectto time, acceleration due to gravity and length
9. Teacher takes 20 oscillation of a bob at 20cm of length, and 5 degree amplitude. Record the length

Students' Activities

3. Students will ask and answer questions.
4. Students will take readings for 20 oscillations at 5degree amplitude for three readings and find the average.

Lesson note for instructional strategy III - Hands-on Laboratory Group

Lesson note II

Subject: **Physics**

Topic: **Experiment Using Simple Pendulum**

Duration: **1 hr: 20mins**

Instructional Objectives

At the end of the lesson, students should be able to

1. Set up a simple pendulum bob experiment
2. Take reading independently for 20, 40, 60, 80 and 100 cm
3. Use the reading obtained to make a table for period, time, length $\frac{1}{Time}$ and $\frac{1}{Length}$
4. Plot a graph T against $\frac{1}{L}$
5. Find the slope of the graph.

Content

1. Setting up a simple pendulum experiment
2. Taking of independent readings for given values
3. Constructing a table of value
4. Plotting of graph and findings the slope
5. Finding intercept between X and Y axis

Presentation of Content

STEP I: Introduction

STEP II: Presentation of concept which includes demonstration of the movement of a simple pendulum using real apparatus

STEP III: Taking of readings by the teacher using the set up apparatus

STEP IV: Students will be grouped in threes to obtain individual readings for length 20, 40, 60, 80 and 100 cm

STEP V: Prepare a table of value for t, T,L $\frac{1}{T}$ and $\frac{1}{L}$

STEP VI: Plot a graph of T against $\frac{1}{L}$ and find the slope

Teacher's Activities

1. Teacher will entertain questions
2. Teacher will go round to assist the students when needed
3. Teacher will explain to the students how to plot graph, find slope and intercept

Student's Activity

1. Students will set up experiments
2. Students will take independent readings for given values
3. Students will constructs tables of values
4. Students will find slopes and intercepts of graphs

Lesson note for instructional strategy III - Hands-on Laboratory Group

Lesson note III

Subject: **Physics**

Topic: **Determination of Acceleration due to gravity using simple pendulum**

Duration: **1hr 20 minutes**

Instructional Objectives:

At the end of the lesson, pupils should be able to

iii. Take readings and plot graphs with the obtained readings

iv. Carry out simple calculations involving simple pendulum

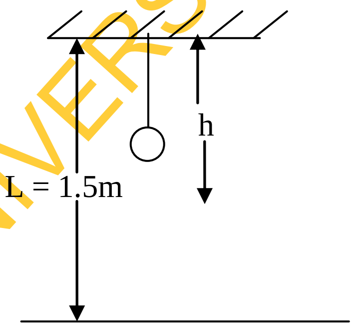
Introduction:

The teacher will throw an object up and allow it to land on the floor. The students will be asked to explain the concept. It will be linked to the lesson for the day.

Content

Setting up a simple pendulum experiment

You are provided with a pendulum bob, retort stand and clamp and meter rule, stop watch, in extensive thread and split cork.



1. Set up the experiment as shown in the length of string at 20cm.
2. Set up a reference point at the equilibrium position of the bob. Measure and record the height "h" of the bob from the cork (20cm)

3. Set the bob to oscillation through a small angle of about (5^0) equilibrium position and record the time for 20 oscillation
4. Repeat the procedure for (1-3) for the length and find the average time "T". calculate the period of oscillation "T"
5. Repeat the procedure (1-4) for four more different length "h" = 40, 60, 80 and 100cm.
6. Plot a graph of T^2 against "L" as abiscissa. Determine the slope of the graph on both vertical (y) and horizontal (X) axis
7. If h, t, l, are related by $h = l = \frac{g}{4\pi^2} T^2$

Presentation of Content

STEP I: Introduction

STEP II: Presentation of concept which includes demonstration by the teacher using real apparatus

STEP III: Ask students to set up an experiment for simple pendulum activities use the same experiment on simple pendulum to obtain reading for 20, 40, 60, 80 and 100 cm

STEP IV: Plot a graph of T^2 against L and determine the slope of the graph on both axis

STEP V: If h,t,L are related by $h=L - \frac{g}{4\pi^2} T^2$ find h.

Teacher's Activities:

x. Take readings and plot graph with the obtained value

ii. Explain the equation $T = 2\Pi\sqrt{\frac{L}{g}}$

iii. Carry out simple calculations involving simple pendulum

Students Activities:

i Students will carry out experiments on simple pendulum

ii Students will plot graph, find the intercept on y and x axis

iii. Students will carry out simple calculation on simple pendulum.

Lesson note for instructional strategy III - Hands-on Laboratory Group

Lesson note IV

Subject: **Physics**

Topic: **Elastic Properties of Solid**

Duration: **1hr 20 minutes**

Instructional Objectives:

At the end of the lesson, the students should be able to

vi. Define elasticity

vii. Explain the elastic properties of solids

viii. Define an elastic material

ix. Define stress, strain, elastic limit, and young modulus

x. State Hook's law and demonstrate to the students

Introduction:

Summarize the previous lesson and link it to the day's lesson

Contents:

v) Definition of elasticity

vi) Elastic properties of material

vii) What is elastic materials

viii) Definition of: stress, strain, elastic limit, and young modulus

ix) Hook's law: definition and demonstration

Presentation of content

STEP I: Introduction

STEP II: Definition of elasticity and elastic properties of solids

STEP III: Explain stress, strain, young modulus and elastic limit

STEP IV: State Hooke's law and demonstrate it both with real equipment and simulation

STEP V: Put students in the group of three and ask each one to demonstrate Hooke's law using real equipment and simulations

STEP VI: Entertain questions and ask your own question

Teacher's Activities:

vi) Teacher will define elasticity

vii) Teacher will explain elastic properties of solids

viii) Teacher will define elastic materials

ix) Teacher will explain the term: stress, strain, elastic limit and young modulus

x) Teacher will demonstrate Hooke's law and give the definition

Students' Activities:

iii) Students will ask and answer questions

iv) Students will use values obtained during demonstration involving hooke's law to determine elastic constants.

Lesson note for instructional strategy III - Hands-on Laboratory Group

Lesson note V

Subject: **Physics**

Topic: **Simple Harmonic Motion (SHM)**

Duration: **1hr 20 minutes**

Instructional Objectives:

At the end of the lesson, the students should be able to

1. Explain the concept of simple harmonic motion (SHM)
2. Define speed and acceleration in SHM
3. Explain period, frequency and amplitude in simple harmonic motion
4. Explain energy in simple harmonic motion
5. Explain the concept of forced vibration and resonance

Introduction

Ask the students to describe what happens to a string when the bird perches on it. Link the experience to simple harmonic motion.

Content

1. Concept of simple harmonic motion
2. Definition of speed, Acceleration, period, in SHM
3. Explanations on frequency, period, and amplitude of energy
4. Concept of energy
5. Forced vibration and resonance
6. Demonstration of resonance, forced vibration and SHM.

Presentation of content

STEP I: Introduction

STEP II: Explain of the concept of SHM with illustration

STEP III: Explain further the terms involved in such illustrations such as period, frequently, amplitude, speed and acceleration

STEP IV: Explain and demonstrate the concept of forced vibration and resonance

STEP V: Place the student in groups of threes to demonstrate force vibration and resonance

STEP VI: Go round to monitor activity and entertain question

Teachers Activities

1. Asking and answering of question
2. Explanations and demonstrations of the following concept
    v. Simple harmonic motion
    vi. Frequency, period, amplitude
    vii. Speed and acceleration in SHM
    viii. Energy
3. Explanations and demonstrations of the concept of forced vibration and resonance

Students' Activities

1. Students will ask and answer questions
2. Students will explain in their own words the concept of force vibration and resonance
3. Students will explain in their own words the following: (a) speed (b) acceleration (c) energy
4. Students will demonstrate simple harmonic motion, forced vibration and resonance

Lesson note for instructional strategy III - Hands-on Laboratory Group

Lesson note VI

Subject: Physics

Topic: Determination of elastic constant of a Springusing Hooke's law

Duration: 1hr 20 minutes

Instructional Objectives:

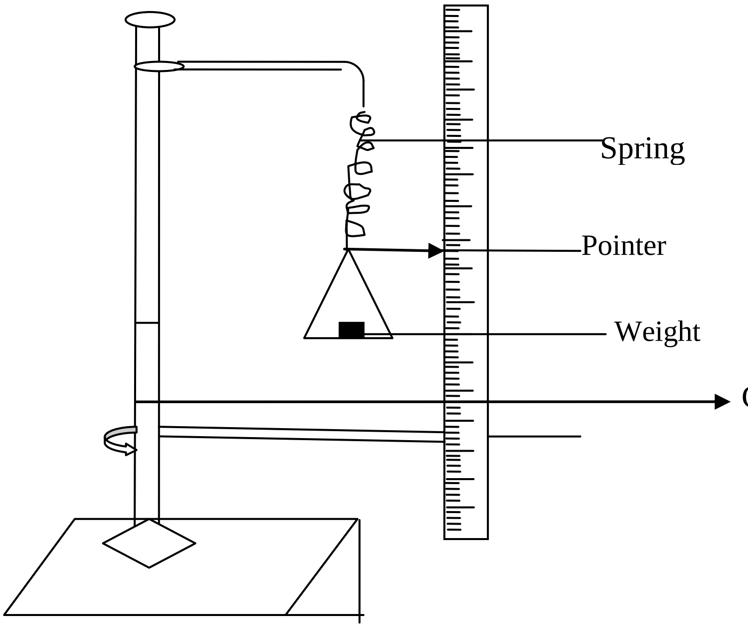
At the end of the lesson, the students should be able to

1. Set up apparatus for Hooke's law experiment
2. Take readings using the apparatus
3. Record readings to correct number of decimal
4. Prepare table for readings
5. Plot and interpret graph

Content

You are provided with spiral spring cork and pointer; porcelain, meter rule, clamp and stand and variable masses.

1. Set up the apparatus as shown in the diagram



2. Note the initial pointer reading on the meter rule
3. Add 50g to the scale and record your reading with the aid of the pointer.
4. Take reading for 100g 150g and 250g and record your readings respectively
5. Remove the load from the scale pan in equal steps also and note and record the corresponding reading
6. Prepare your table as shown:

Load	Scale Load increasing X_1 (cm)	Reading Load decreasing X_2 (cm)	Average Reading $\frac{x_1 + x_2}{2}$	Extension x- L (cm)

7. Plot a graph of extension against load and find the slope of the graph
8. Comment on the graph

Presentation of Content

STEP I: Introduction

STEP II: Presentation of concept which includes demonstration of Hooke's law using real apparatus.

STEP III: Teacher will take reading using real apparatus .

STEP IV: Ask the students to set up experiment on verification of Hooke's law using real apparatus to obtain reading for masses; 100, 150, 250

STEP V: Complete the table of value as indicated

STEP VI: Entertain questions from the students and ask your own question

STEP VII: Students will plot a graph of "e" against "M" and obtain the slope of the graph

Teacher's Activities

1. Teacher will set up the experiment as described
2. Teacher will move round to guide the student as they take their individual reading
3. Teacher will entertain questions from students and give necessary clarification

Students Activities

1. Students will set u the apparatus
2. Students will take readings and prepare the table
3. Students will plot graphs
4. Students will do calculations
5. Students will ask and answer questions

Lesson note for instructional strategy III - Hands-on Laboratory Group

Lesson note VII

Subject: Physics

Topic: Verification of Hooke's Law

Duration: 1hr 20 minutes

Instructional Objectives:

At the end of the lesson, the students should be able to

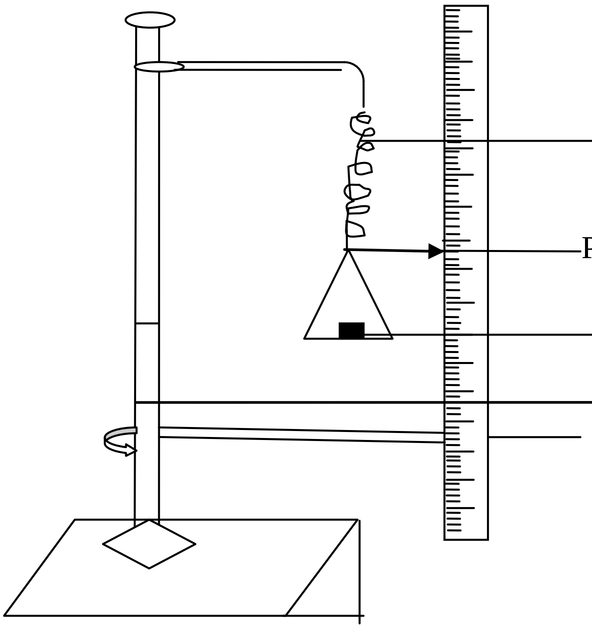
1. Set up experiment on verification of hooke's law
2. Collect readings with the apparatus
3. Plot graph and interpret
4. Carry out any others operations using hooke's law

Introduction

Summarize the previous lesson and link it to today's topic

Content

1. Suspend the given spiral spring vertically as shown in the diagram. Attach a scale pan and note the position of the pointer on the metre rule



2. Add a mass of 70g to the scale pan and note the new position of the pointer
3. Determine the extension "e" produced
4. Repeat the experiment for m= 90, 110, 130 and 150g respectively. In each case, determine the extension produced
5. Ignore the mass of the scale pan and tabulate your readings
6. If a hanger is used, both the mass of the hanger and the added slotted masses should be equal to 70, 90, 110, 130, and 150g
7. Plot the graph of "e" on the vertical axis and "m" on the horizontal axis, starting both axis from the origin (O,O)
8. Determine the slope of the graph and the intercept on "e" axis.
9. Determine the difference in extension when the mass was increased from 100-150g
10. Set the spring into small oscillation and determine the time for 10 complete oscillation
11. Calculate the "T" of the oscillation
12. Evaluate the expression: $k = \frac{39.5x}{T12-T22}$

Presentation of content

STEP I: Introduction

STEP II: Presentation of concept which includes the teacher's demonstration using real apparatus

STEP III: Ask students to set up the experiment on verification of Hooke's law without assistance and obtained readings for 70,90,110,130 and 150g

STEP IV: Use your readings to obtained a table of value and plot a graph of e against M

Teachers activities

1. The teachers monitors the students and guides them through each steps
2. The teacher offers assistance when necessary
3. The teacher entertains questions from the students

Students Activities

1. The students will set up the apparatus themselves
2. The students collects readings
3. The students will plot graph
4. The students will carry out other operations using Hooke's law

Lesson note for instructional strategy III - Hands-on Laboratory Group

Lesson note VIII

Subject: **Physics**

Topic: **Determination of refractive Index of prism**

Duration: **1hr 20 minutes**

Instructional Objectives:

At the end of the lesson, pupils should be able to

1. Draw a diagram to show the formation of image
2. Measure the angle of incidence and refraction and hence deduce a value for refractive index
3. Trace light rays through prisms and obtain graphically the value of the angle of Minimum deviation.
4. Explain the meaning of critical angle and total internal reflection stating the conditions under which it occurs.
5. Use the experiment with triangular prism to obtain minimum angle of deviation and show its relationship with the refractive index of glass
6. Carry out simple calculations involving simple pendulum

Introduction:

List some sources of light that is seen in everyday life. Link it to the day's lesson.

Content

1. Sources of light
2. Transmission of light

3. Rays and beams
4. Laws of refraction
5. Tracing light rays through prisms
6. Measurement of angle of incidence, angle of refraction, emergence and internal Reflection

Presentation of content

STEP I: Introduction

STEP II: Presentation of concept which includes taking of reading by the teacher using real apparatus

STEP III: Ask students to set up their experiment involving refraction of prisms using real apparatus to obtain "r" for the following angles 30^0, 40^0, 50^0, 60^0 and 70^0

STEP IV: Entertain questions from the students and asked your own question

STEP V: Ask students to make a table of reading for; i, r, sin r and sin r

STEP VI: Plot a graph as sin i against sin r and determine the slope

Teacher's Activities:

1. The teacher will trace light rays through prism.
2. Demonstrate the incidence ray, the normal and reflected rays on the same plane.
3. Trace light rays through prisms to obtain the graphical value of angle of deviation and emergence

Pupils' Activity

1. Students will set up experiment on determination of refractive index of a prism.
2. Students will plot graph and find angle of refraction, angle of emergence and angle of Deviation
3. Students will carry out simple calculation on refraction.

APPENDIX II

Instructional Guide for Computer Simulated Experimental Pack on Triangular Prism

AIM: To determine the refractive index of a triangular prism

You are provided with a simulation package on a triangular prism. Click the restart button to ensure that all parameters are on zero point.

Activity 1: Adjust the angle of incidence using the 'click' button to 45^0 and record the corresponding angle of refraction.

Activity II: using the menu on "degree" obtain the angle of refraction for four other angle of incidence 50, 55, 60 and 65^0 (Always return the menu to "restart" before taking each reading).

Activity III: Find the ratio of sin ί / sin r for each measurement taken using the table

I	R	Sin ί	Sin r	Sin ί / sin r

Activity IV: plot a graph of sin ί / sin r against sin r and a mean value for sin ί / sin r from the gradient

Activity V: State two precautions when taken your readings

Activity VI: State Snell's law of refraction

3.5.5 Instructional Guide for Computer Simulated Experimental Pack on Simple Pendulum

Aim: To determine acceleration due to gravity.

You are provided with a simulation package on simple pendulum.

Activity I: Click on the "restart" button to ensure that all parameters are on zero point.

Activity II: Adjust the length of the pendulum to 20 cm by clicking on the parameter for length and adjust the figure.

Activity III: Obtain the time (in seconds) for 20 oscillations for the length 20cm.

Activity IV: Repeat this exercise in "III" above for length 40, 60, 80 and 100 cm respectively.

Activity V: Plot the graph of T^2 against L

Activity VI: Determine the slope of the graph obtained and the intercept on the vertical axis.

Activity VII: State the precaution you took to obtain accurate result.

Activity VIII: If h, t and I are related to the equation $h = L - \frac{g^{T2}}{4\pi^2}$

use the equation and the value of your slope "s" to determine the value of "g"

Activity IX: Comment on the experiment and state the theory involved.

3.5.6 Instructional Guide for Computer Simulated Experimental pack on Verification of Hooke's law

Aim: Verification of Hooke's law

You are provided with a simulation package on spiral spring and variable masses. Click the restart button to ensure that all parameters are on zero point.

Activity I: Take the reading for the position of the pointer without any weight.

Activity II: Add mass 70g to the spiral spring and record the new position of the pointer and take the period for 20 oscillations.

Activity III: Repeat the procedure for 90g, 110g, 130g and 150g respectively and in each case record the extension "e" produced.

Activity VI: Tabulate your readings

Activity V: Plot a graph with "e' on the vertical axis and "m" on the horizontal axis starting both axis from origin.

Activity VI: Determine the slope of the graph and the intercept on the "e" axis

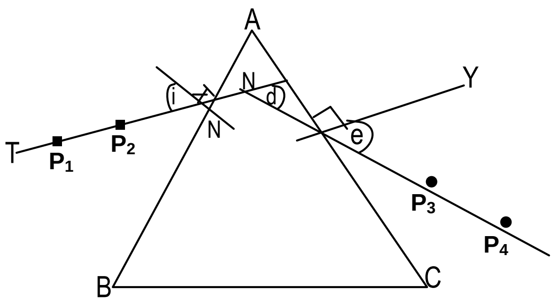
Activity VII: State Hooke's law

Activity VIII: Evaluate $K = \frac{39.5x}{T_1^2 - T_2^2}$

Instructional Guide for Computer Simulated Experiment + Hands – on Experimental Pack on Triangular Prism

AIM: To determine the refractive index of a triangular prism

You are provided with triangular prisms, optical pins, drawing pins, board and tracing paper.



Activity I: Place the prism provided on a tracing paper and draw the outline ABC.

Activity II: Remove the prism, measure and record the value of the angle A and draw the normal to AB at "N"

Activity III: Also draw another line TN to the normal such that i = $45^{0.}$

Activity IV: Erect two pins at P_1 and P_2 Replace the prisms and fix two other pins P_3 and P_4 such that the pins appear to be in a straight line with the images. When viewed from the side AC of the prism.

Activity V: Remove the prism, join P_3 and P_4 producing it to meet line TN at "Z"

Activity VI: Draw the normal X Y^4.

Measure and record the angle of emergence "e" and the angle of deviation "d".

Activity VII: Evaluate (d-e) and repeat the experiment for ί = 50, 55, 60, and 65^0

Activity VII: With a simulation package on a triangular prism provided. Click the restart button to ensure that all parameters are on zero point.

Activity VIII: Adjust the angle of incidence using the 'click' button to 45^0 and record the corresponding angle of refraction.

Activity IX: using the menu on "degree" obtain the angle of refraction for four other angle of incidence 50, 55, 60 and 65^0 (Always return the menu to "restart" before taking each reading).

Activity X: Find the ratio of sin ί / sin r for each measurement taken using the table

I	r	Sin ί	Sin r	Sin ί / sin r

Activity XI: plot a graph of sin ί / sin r against sin r and a mean value for sin ί / sin r from the gradient

Activity XII: State two precautions when taken your readings

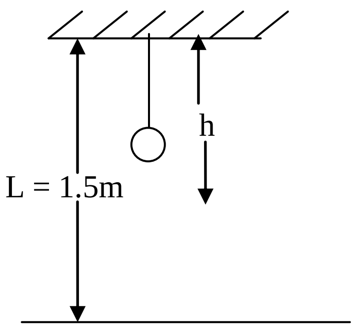
Activity XIII: State Snell's law of refraction

3.5.5 Instructional Guide for Computer Simulated Experiment + Hands –on Experimental Pack on Simple Pendulum

Aim: To determine acceleration due to gravity.

You are provided with a pendulum bob, retort stand and clamp, meter rule, stop watch, in extensive thread and a split cork.

Activity I: Set up the experiment as shown in the diagram



Activity II: Set up a reference point at the equilibrium position of the bob, measure and record the height "h" of the bob from the cork ((20cm)

Activity III: Set the bob swing through a small angle of (about 5^0) about the equilibrium position and record the time for 20 complete oscillations.

Activity IV: Repeat the procedure 1-3 for the same length and find the average time "t". Calculate the period of oscillation "T"

Activity V: Repeat procedure (1to 4) for 4 more different length "h" =40, 60, 80 and 100cm

Activity VI: With a simulation package on simple pendulum, Click on the "restart" button to ensure that all parameters are on zero point.

Activity VII: Adjust the length of the pendulum to 20 cm by clicking on the parameter for length and adjust the figure.

Activity XII: Determine the slope of the graph obtained and the intercept on the vertical axis.

Activity V III: Obtain the time (in seconds) for 20 oscillations for the length 20cm.

Activity IX: Repeat this exercise in "III" above for length 40, 60, 80 and 100 cm respectively.

Activity X: Plot the graph of T^2 against L

Activity XIII: State the precaution you took to obtain accurate result.

Activity XIV If h, t and I are related to the equation $h = L - \frac{g^{T2}}{4\pi^2}$

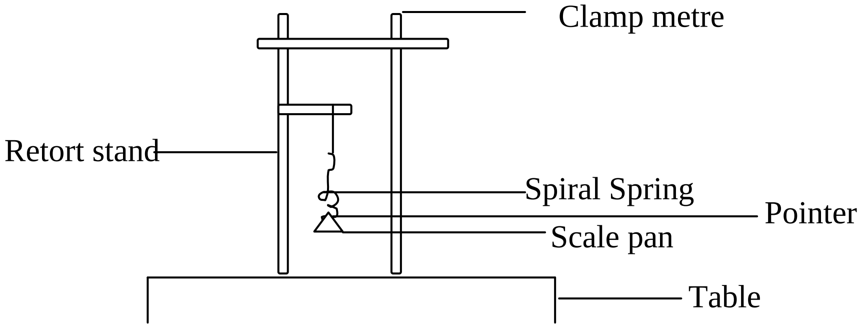
use the equation and the value of your slope "s" to determine the value of "g"

Activity XV: Comment on the experiment and state the theory involved.

3.5.6 Instructional Guide for Computer Simulated Experiment+ Hands –on Experimental pack on Verification of Hooke's Law

Aim: Verification of Hooke's law

You are provided with a spiral spring, scale pan, retort stand and clamp, meter rule, stop watch, in extensive thread and a split cork.



Activity I: Suspend the given spiral spring vertically as shown in the diagram

Activity II: Attach a scale pan and note the position of the pointer on the meter rule.

Activity III: Add a mass "m" = 70g to the scale pan and note the new position of the pointer and record the extension "e" produced

Activity IV: Repeat the experiment for m = 90, 110, 130, and 150g and record your reading

Activity V: With a simulation package on spiral spring and variable mass, click the restart button to ensure that all parameters are on zero point.

Activity VI: Take the reading for the position of the pointer without any weight.

Activity VII: Add mass 70g to the spiral spring and record the new position of the pointer and take the period for 20 oscillations.

Activity VIII: Repeat the procedure for 90g, 110g, 130g and 150g respectively and in each case record the extension "e" produced.

Activity IX: Tabulate your readings

Activity X: Plot a graph with "e' on the vertical axis and "m" on the horizontal axis starting both axis from origin.

Activity XI: Determine the slope of the graph and the intercept on the "e" axis

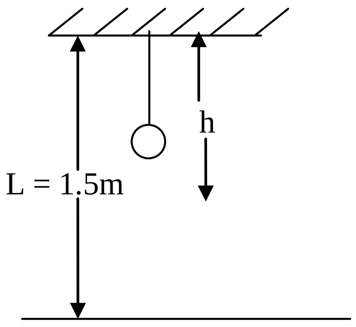
Activity XII: State Hooke's law

Activity XIII: Evaluate $K = \dfrac{39.5x}{T_1^2 - T_2^2}$

3.5.7 Instructional Guide for Hands-on Group on Determination of Acceleration due to gravity "g".

You are provided with a pendulum bob, retort stand and clamp, meter rule, stop watch, inextensive thread and a split cork.

Activity I: Set up the experiment as shown in the diagram



Activity II: Set up a reference point at the equilibrium position of the bob, measure and record the height "h" of the bob from the cork ((20cm)

Activity III: Set the bob swing through a small angle of (about 5^0) about the equilibrium position and record the time for 20 complete oscillations.

Activity IV: Repeat the procedure 1-3 for the same length and find the average time "t". Calculate the period of oscillation "T"

Activity V: Repeat procedure (1to 4) for 4 more different length "h" =40, 60, 80 and 100cm.

Activity VI: Plot a graph of T^2 as against "1" as abscissa. Determine the slope of the graph obtained and the intercept on the vertical axis.

Activity VII: State two precautions you took to ensure accurate result.

Activity VIII: h, t and I are related by the equation $\Rightarrow h = L - \frac{gT^2}{4\Pi^2}$

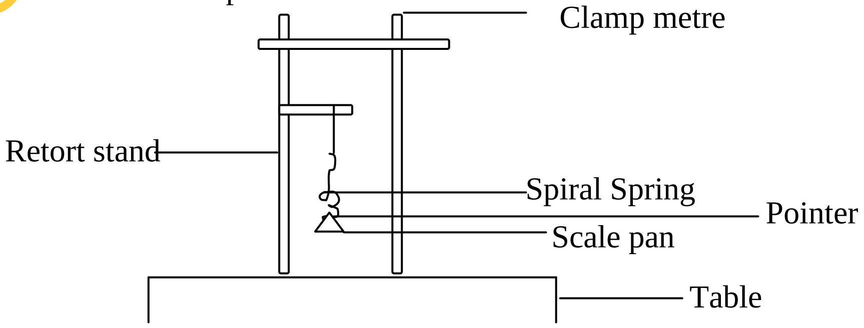
Activity IX: Using this equation and the value of your slope "s" determine the value of "g"

Activity X: Comment generally on the result of the experiment and state the theory involved.

3.5.8 Instructional Guide for Hands–on Experimental Group on Simple Harmonic Motion.

Aim: Verification of Hooke's Law

You are provided with a spiral spring, scale pan, retort stand and clamp, meter rule, stop watch, inextensive thread and a split cork.



Activity I: Suspend the given spiral spring vertically as shown in the diagram

Activity II: Attach a scale pan and note the position of the pointer on the metre rule.

Activity III: Add a mass “m” = 70g to the scale pan and note the new position of the pointer and record the extension “e” produced

Activity IV: Repeat the experiment for m = 90, 110, 130, and 150g and record your readings

Activity V: Plot a graph with “e” on the vertical axis and “m” on the horizontal axis starting both axis from the origin (0,0).

Activity Vi: Determine the slope of the graph and the intercept on the “e” axis.

Activity VII: Determine the difference on extension when the mass increased from 100g to 150g.

Activity VIII: State two precautions taken to ensure accurate result.

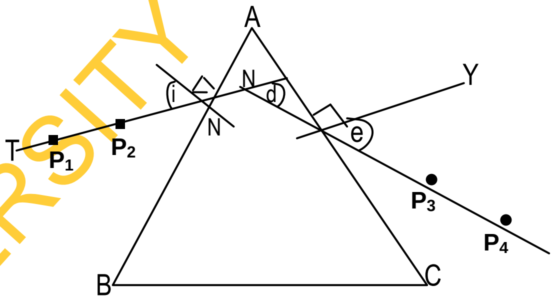
Activity IX: With the load of 150g on the scale pan or hanger, set the spring into small vertical oscillation and determine the time for 10 complete oscillations.

Activity X: Calculate the period T of oscillation.

3.5.9 Instructional Guide for Hand - on Experimental Group on Snell’s Law

Aim: To determine the refractive index of a triangular prism

You are provided with triangular prisms, optical pins, drawing pins, board and tracing paper.



Activity I: Place the prism provided on a tracing paper and draw the outline ABC.

Activity II: Remove the prism, measure and record the value of the angle A and draw the normal to AB at “N”

Activity III: Also draw another line TN to the normal such that i = $45^{0.}$

Activity IV: Erect two pins at P_1 and P_2 Replace the prisms and fix two other pins P_3 and P_4 such that the pins appear to be in a straight line with the images. When viewed from the side AC of the prism.

Activity V: Remove the prism, join P_3 and P_4 producing it to meet line TN at “Z”

Activity VI: Draw the normal X Y^4.

Measure and record the angle of emergence "e" and the angle of deviation "d".

Activity VII: Evaluate (d-e) and repeat the experiment for í = 50, 55, 60, and $65^{0.}$

Activity VIII: Measure and record corresponding values for r, e, (d-e). Tabulate your readings

Activity IX: Plot a graph of (d-e) on the vertical axis and 'í 'on the horizontal axis and start both axis from the origin

Activity X: Find the slope of the graph and intercepts, L_1, and L_2 on the vertical axis and horizontal axis respectively.

Activity XI: Evaluate $L_0 = \frac{(í_1 + í_2)}{2}$

Activity XII: State two precautions you took to ensure accurate result

APPENDIX III

DEPARTMENT OF TEACHER EDUCATION

UNIVERSITY OF IBADAN, IBADAN NIGERIA

THEORY OF PHYSICS PRATICAL TEST ON SIMPLE PENDULUM (TPPT)

OBJECTIVE QUESTIONS

1. Why is a spherical bob preferred to bob of the other shapes for use in a simple pendulum experiment?

   (a) It has a small size (b) It experiences least damping effect

   (c) It can move faster than other bobs of different shapes

   (d) It is not affected by friction

2. A simple pendulum makes 50 oscillations in one minute. What is its period of oscillation?

   (a) 0.02s (b) 0.20s (c) 0.83s (d) 1.20s (e) 50.00s

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

   (a) Increasing the mass of the bob (b) Increases the mass of the bob

   (c) Decreasing the length of the string (d) increasing the length of the string

   (e) Increasing the amplitude of oscillation

4. A student found out from a simple pendulum experiment that 20 oscillations were completed in 38 seconds. What is the period of oscillation of the pendulum?

   (a) 8.0s (b) 3.8s (c) 20s (d) 1.9s (e) 0.5s

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

   (a) 0.53s (b) 0.83s (c) 1.20s (d) 1.50s (e) 1.88s

6. In a simple pendulum experiment, a student observed that the times for 50 oscillations are 99.0, 99.5, 100.5 and 101.0s respectively. Calculate the mean period of oscillation of the pendulum

(a) 0.50s (b) 1.98s (c) 1.99s (d) 2.00s (e) 2.01s

7. The amplitude of the motion of a body performing simple harmonic motion decreases with time because

   (a) Frictional forces dissipate the energy of motion

   (b) The frequency of oscillation varies with time

   (c) The period of oscillation varies with time

(d) Energy is supplied by some external agencies

8. The period of an oscillatory motion is defined as the
   (a) Average of the times used in completing different numbers of oscillations
   (b) Time to complete a number of oscillation
   (c) Time to complete one oscillation
   (d) Time taken to move from one extreme position to the other.

9. The mass on a loaded spiral spring oscillates vertically between two extreme positions P and R equi-distant from the equilibrium position Q. Which of the following statements about the system is not correct?
   (a) The momentum of the mass is maximum
   (b) The elastic potential energy of the spring is maximum at Q
   (c) The kinetic energy of the mass is maximum at p
   (d) The total energy of the system is always constant

10. The frequency of a swinging pendulum is the
   (a) Number of complete oscillations the pendulum makes in one second
   (b) Number of amplitudes the bob makes in one seconds
   (c) Angle the bob swings through in one second
   (d) Distance the bob covers in one second

11. 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

12. 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

13. The period of a simple pendulum of length 80.0cm was found to have doubled when the length of the pendulum was changed by x. Calculate x
   (a) 26.7cm (b) 40.0cm(c) 160.0cm (d) 240cm

14. 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.

15. The motion of a body is simple harmonic if the (a) acceleration is always directed towards a fixed point. (b) Path of motion is a straight line (c) acceleration is directed towards a fixed point and is proportional to it's distance from the point. (d) Acceleration is constant and directed toward a fixed point

16. Which of the following statements is not correct about a loaded spiral spring?
    a. The extension is proportional to load applied provided the elastic limit is not exceeded.
    b. If the elastic limited is not exceeded, the contraction is proportional to the applied load.
    c. Beyond the elastic limit, extension is no longer proportional to the applied load.
    (d) if the spring regained it's shape or form after deformation it is said to be elastic.

17. One complete oscillation is called (a) Period (b) Vibration (c) Cycle (d) Frequency

18. One way by which the period of a spiral spring be increased is (a) length (b) load (c) Charge in length (d) vibration

19. A spiral spring on simple harmonic motion has 20 m and 12.0H_z as amplitude and frequency respectively. Calculate the period of the motion. (a) 0.083 sec (b) 0.5 sec (c) 0.05 sec (d) 0.83sec.

20. A loaded spring performs simple harmonic motion with amplitude of 5cm. If the maximum acceleration of the load is 20cm^{-2}. Calculate the angular frequency of the motion. (a) 2 rads^{--1} (b) 4 rads^{--1} (c) 5 rads^{--1} (d) 10 rads^{--1}.

21. A boy timed 20 oscillations of a certain pendulum, three times and obtained 44.35, 45.55 and 45.75 respectively. Calculate the mean period of oscillation of the pendulum (a) 1.13s (b) 2.22s (c) 2.26s (d) 44.30s (e) 45.17s

22. 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.

23. The period of oscillation of a particle executing simple harmonic motion is 4π seconds. If the amplitude of oscillation is 3.0m. Calculate the maximum speed of the particle. (a) 1.5 ms^{-1} (b) 3.0ms^{-1} (c) 4.5ms^{-1} (d) 6.0ms^{-1}

24. An object is situated within the earth's gravitational field. Which of the following factors does not affect the acceleration of freefall "g"? (a) The distance of the object

from the centre of the earth (b) The latitude of the earth on which the object is situated (c) the mass of the object (d) the rotation of the earth.

25. The amplitude of the motion of a body performing simple harmonic motion decreases with time because (a) frictional forces dissipates the energy of motion (b) the frequency of oscillation varies with time (c) the period of oscillations varies with time (d) energy is supplied by some external energy.

26. The frequency of a swinging pendulum is the (a) number of complete oscillations the pendulum makes in one second. (b) number of amplitudes the bob makes in one second (c) Angle the bob swings through in one second (d) distance the bob covers in one sound .

27. Which of the following statements about an object performing simple harmonic motion is correct it's acceleration. (a) is maximum at the extreme ends. (b) constant and directed towards a fixed point (c) is zero when displaced from an equilibrium position (d) varies linearly with the displacement from a fixed point and is directed towards the fix point.

28. Which of the following statements about simple harmonic motion is correct? (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.

29. A spiral spring on simple harmonic motion has 20 m and 12.H_z as amplitude and frequency respectively. Calculate the period of the motion. (a) 0.083 sec (b) 0.5 sec (c) 0.05 sec (d) 0.83sec.

30. In an experiment involving a loaded spiral spring. The period of vibration of 50 oscillations are 99.0, 99.5, 100.5, and 101.1 seconds respectively. Calculate the mean period of oscillation of the spiral spring (a) 0.50s (b) 1.98s (c) 1.99s (d) 2.00s.

31. The change of the direction of a wave-front because of a change in the velocity of the wave in another medium is called

(a) Reflection (b) refraction (c) diffraction (d)interference dispersion

32. The refractive index for a given transparent medium is 1.4. Which of the following is the minimum angle for total internal reflection to take place in the medium?

(a) 30^o (b) 36^o (c) 44^o (d) 46^o (e) 54^o

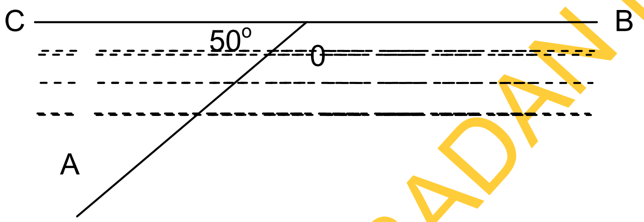
33. A transparent rectangular block 5.0cm thick is placed on a black dot. The dot when viewed from above, is seen 3.0cm from the top of the block. Calculate the refractive index of the material of the block

(a) $\frac{2}{5}$ (b) $\frac{3}{5}$ (c) $\frac{3}{2}$ (d) $\frac{5}{3}$ (e) $\frac{5}{2}$

34. The velocities of light in air and glass are 3.0 x $10^8 ms^{-1}$ and 1.8 x $10^8 ms^{-1}$ respectively. Calculate the sine of the angle of incidence that will produce an angle of refraction of 30^o for a ray of light incident on glass

(a) 1.2 (b) 1.0 (c) 0.8 (d) 0.6 (e) 0.3

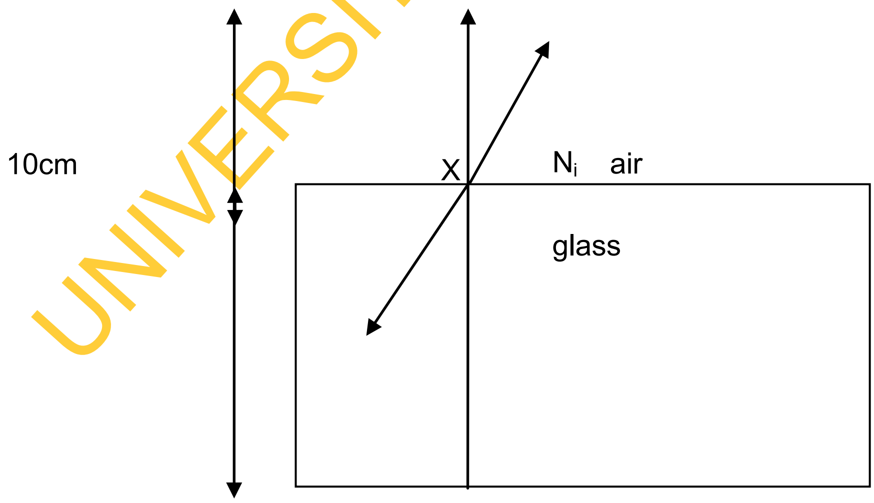
35. The diagram shows an incident ray AO inclined at an angle of 50^o to the interface CB. The refracted ray OB is found to lie along the surface. What is the refractive index of the medium x with respect to air?



(a) $\frac{\sin 50^0}{\sin 40^o}$ (b) $\frac{\sin 40^0}{\sin 50^o}$ (c) $\frac{\sin 90^0}{\sin 50^o}$ (d) $\frac{\sin 40^0}{\sin 90^o}$ (e) $\frac{\sin 90^0}{\sin 50^o}$

Y

36. Calculate the refractive index of the material of the glass block shown in the diagram if yx = 4cm



(a) 0.40 (b) 0.60 (c) 1.50 (d) 1.67 (e) 2.50

37. A ray of light is incident at an angle of 30^o on a glass prism of refractive index 1.5 calculate the angle through which the ray is minimally deviated in the prism (the medium surrounding the prism is air)

(a) 10.5^o (b) 19.5^o (c) 21.1^o (d) 38.9^o (e) 40.5^o

38. Which of the following statements is not correct for a light ray passing through a rectangular glass block which is surrounded by air? It

(a) Suffers a displacement at the point of emergence

(b) Emerges parallel to the incident ray C

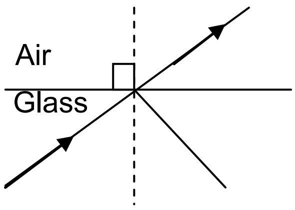
(c) Is partly reflected at the point of incidence

(d) is deviated at the point of emergence

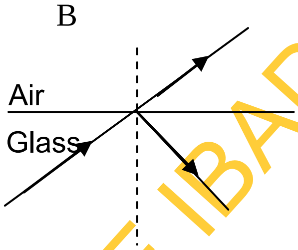
(e) Is refracted in the block

39. Which of the following diagrams correctly illustrates refraction and partial reflection of light travelling from glass to air?

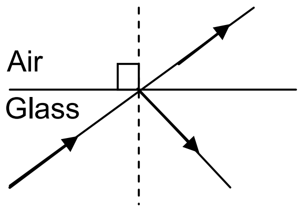
A



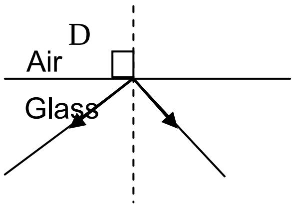
B



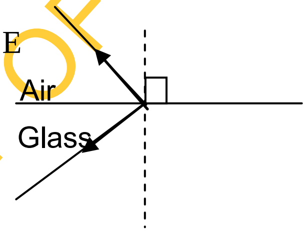
C



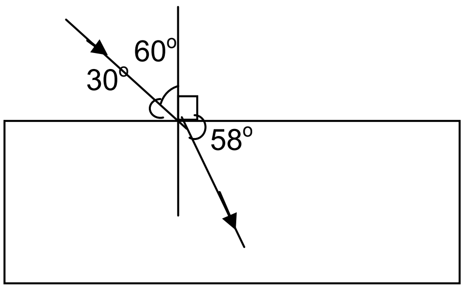
D



E



40. A ray of light is incident on a body x as shown in the diagram. What is the refractive index of the body?

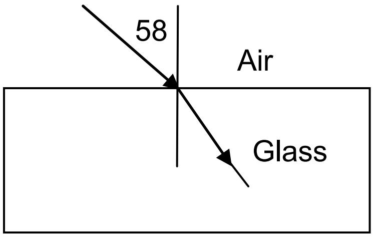


(a) 1.63 (b) 1.50 (c) 1.49 (d) 1.33 (e) 3.00

41. When a ray of light is incident normally on an air-glass interface, its angle of refraction is

(a) 0^o (b) 42^o (c) 45^o (d) 60^o (e) 90^o

42. A ray of light is incident on a glass block as shown in the diagram below.



If the reflected and refracted rays are perpendicular to each other, what is the refractive index of the glass relative to air?

(a) 1.65 (b) 1.58 (c) 1.52 (d) 1.50 (e) 1.48

43. The refractive index of a medium relative to air is 1.8. Calculate the critical angle for the medium to the nearest degree.

(a) 18^o (b) 34^o (c) 45^o (d) 68^o (e) 90^o

44. A fish appears to be 2m below the surface of a pond when viewed directly from above. How far is the fish below the surface of the pond? (Refractive index of water = 1.33)

(a) 2.66m (b) 2.00m (c) 1.67m (d) 1.50m (e) 0.66m

45. Which of the following conditions is necessary for the occurrence of total internal reflection of light?

(a) Light must travel from an optically less dense to a denser medium
(b) The angle of incidence must be greater than the critical angle
(c) The angle of incidence must be less than the critical angle
(d) The angle of refraction must be 90^o

46. A point object placed in contact with one surface of a glass block of thickness 1.6cm and refractive index 1.61 is viewed along the normal to the opposite surface. By how much does the point object appear to be displaced?

(a) 0.69cm (b) 0.61cm (c) 1.0cm (d) 0.75cm

47. The refractive index of a glass is 1.61, and thickness of the glass block (actual depth) is 1.6. what is the refractive index of the glass

(a) 0.99cm (b) 0.94cm (c) 0.90cm (d) 1.5cm

48. As light passes the border between two media the following occur depending the relative refractive index

(a) Light bends towards the normal (b) Lights bends away from the normal (c) Light is refracted and reflected (d) none of the above

49. Total internal reflection always occurs when light travels from

(a) Less dense to denser medium (b) more dense to less dense medium

(c) all of the above (d) none of the above

50. Which of this is true about refraction

(a) It is reversible (b) it occurs between two medium

(c) it occurs at a given angle (d) all of the above

APPENDIX IV

DEPARTMENT OF TEACHER EDUCATION

UNIVERSITY OF IBADAN, IBADAN NIGERIA

STUDENTS INTEREST IN PHYSICS QUESTIONNAIRE (SIPQ)

QUESTIONNAIRE

The questionnaire is to measure your interest in physics lessons and activities. There is no right or wrong answers. Please think deeply, understand the questionnaire and provide honest answer as this will go a long way to improve students' performance in practical physics.

Name:____

School:____

Age:____

A. My disposition to practical class (content and context)

	Not Interest	fairly Interest	interested	Very interested
1. I feel interested each time I am learningphysics ___	☐	☐	☐	☐
2. I do physics practical work in the school laboratory at my own at free period ___	☐	☐	☐	☐
3. I go to the physics laboratory after a practical session for some practical verifications/clarifications	☐	☐	☐	☐
4. I love my physics teacher's method of teaching Physics.	☐	☐	☐	☐
5. I have been frustrated during some physics practical Sessions	☐	☐	☐	☐
6. to the point of abandoning the work for my group and I copy the readings later	☐	☐	☐	☐
7. I always lead the group when a physics practical work is carry out in groups	☐	☐	☐	☐
8. I abandon a physics problem during private study when I cannot find solution to it	☐	☐	☐	☐

9. I am studying physics because I am interested in it ☐ ☐ ☐ ☐

10. I try to study physics and solve problems at my leisure ☐ ☐ ☐ ☐

11. I study physics with a study group sometimes in physics and sciences ☐ ☐ ☐ ☐

What I want to learn

B. How interested are you in carrying out the following activities

	Not Interest	fairly Interest	interested	very interested
1. Determination of initial and final velocity of a moving objects –	☐	☐	☐	☐
2. Collisions of moving objects and their final and initial momentum	☐	☐	☐	☐
3. Penetration of x-rays Gamma-rays	☐	☐	☐	☐
4. Determination of refractive index in water and other liquids	☐	☐	☐	☐
5. Atom, Electron, and molecules	☐	☐	☐	☐
6. Demonstrating the use of simple machine and their use in day to day life	☐	☐	☐	☐
7. How different musical instruments produce difference sounds	☐	☐	☐	☐
8. How to measure object distance, Image distance and focal length	☐	☐	☐	☐
9. How to measure incidence ray and refracted Rays in prisms	☐	☐	☐	☐

10. The effect of strong electric shocks and lightning on the human body ☐ ☐ ☐ ☐

What I want to learn

C. How interested are you in the following laboratory activities?

	Not Interest	fairly Interest	interested	very interested
1. Refractive index of prism.	☐	☐	☐	☐
2. Determination of the resistance of a wire	☐	☐	☐	☐
3. Resistivity of a wire	☐	☐	☐	☐
4. Calorimeter and specific heat capacity	☐	☐	☐	☐
5. Determination of velocity of sound in air through Sonometer Electromagnetism	☐	☐	☐	☐
6. Moving coil galvanometer	☐	☐	☐	☐
7. Determination of acceleration due to gravity	☐	☐	☐	☐
8. Resonance tube	☐	☐	☐	☐
9. Focal length of lenses, mirrors, image distance, object distance and magnification	☐	☐	☐	☐
10. Gamma ray detection	☐	☐	☐	☐

APPENDIX V
DEPARTMENT OF TEACHER EDUCATION
UNIVERSITY OF IBADAN, IBADAN NIGERIA
NUMERICAL REASONING ABILITY TEST (NRAT)

Time: 15 Minutes

Introduction: This test assesses how easily you can think with numbers. The test consists of numbers which go together in some way to form series. You have to see how they go together. Choose the next number from the four options lettered A,B,C,D, then shade it in pencil on your answer sheet.

Example
2, 4, 8, 16, 32
(a) 56 (b) 64 (c) 72 (d) 144

The correct option is lettered B and therefore answer space B is shaded as shown below.

A	B	C	D

Now do these

1. 2, 2, 4, 6, 10.
   (A) 10 (B) 14 (C) 16 (D) 20
2. 1, 4, 9, 16, 25
   (A) 32 (B) 36 (C) 48 (D) 49
3. 15, 9, 24, 35, 57
   (A) 80 (B) 90 (C) 110 (D) 120
4. 4, 5, 7, 11, 19
   (A) 27 (B) 33 (C) 35 (D) 37
5. 5, 9, 17, 33, 65
   (A) 101 (B) 108 (C) 129 (D) 143
6. 10, 25, 12, 30, 14
   (A) 35 (B) 24 (C) 20 (D) 18
7. 5, 9, 17, 33, 65
   (A) 129 (B) 108 (C) 101 (D) 75
8. 1, 8, 27, 64, 125,
   (A) 250 (B) 216 (C) 196 (D) 185
9. 5, 7, 11, 17, 25
   (A) 27 (B) 31 (C) 35 (D) 39
10. 4, 5, 7, 11, 19
   (A) 27 (B) 33 (C) 35 (D) 37
11. 0, 3, 2, 5, 4
   (A) 6 (B) 7 (C) 8 (D) 9
12. 0, 8, 8, 16, 24
   (A) 24 (B) 32 (C) 40 (D) 48
13. 15, 9, 24, 33, 57
   (A) 48 (B) 80 (C) 89 (D) 90
14. 0, 3, 8, 15, 24
   (A) 30 (B) 31 (C) 35 (D) 36
15. 243, 81, 27, 9, 3
   (A) 0 (B) 1 (C) 2 (D) 3

APPENDIX VI
TEACHER EDUCATION UNIT
DEPARTMENT OF EDUCATION
UNIVERSITY OF IBADAN
IBADAN. (2012)

PERCEPTUAL REASONING ABILITY TEST (PRAT)

Instruction

This test assesses how easily you can reason with symbols and shapes. After each question there are six or eight options. When you have found the correct answer put a cross on the number which correspond to it on the answer sheet provided. What is the best pattern that will fit the design. The first three items (A1-A3) have been completed for you to serve as examples. The full test begins on the next page. Now do as much as you can do.

	Options							
	1	2	3	4	5	6	7	8
A1				✓				
A2					✓			
A3	✓							
A4								
A5								
A6								
A7								
A8								
A9								
A10								
A11								
A12								
B1								
B2								
B3								
B4								
B5								
B6								
B7								
B8								
B9								
B10								
B11								
B12								

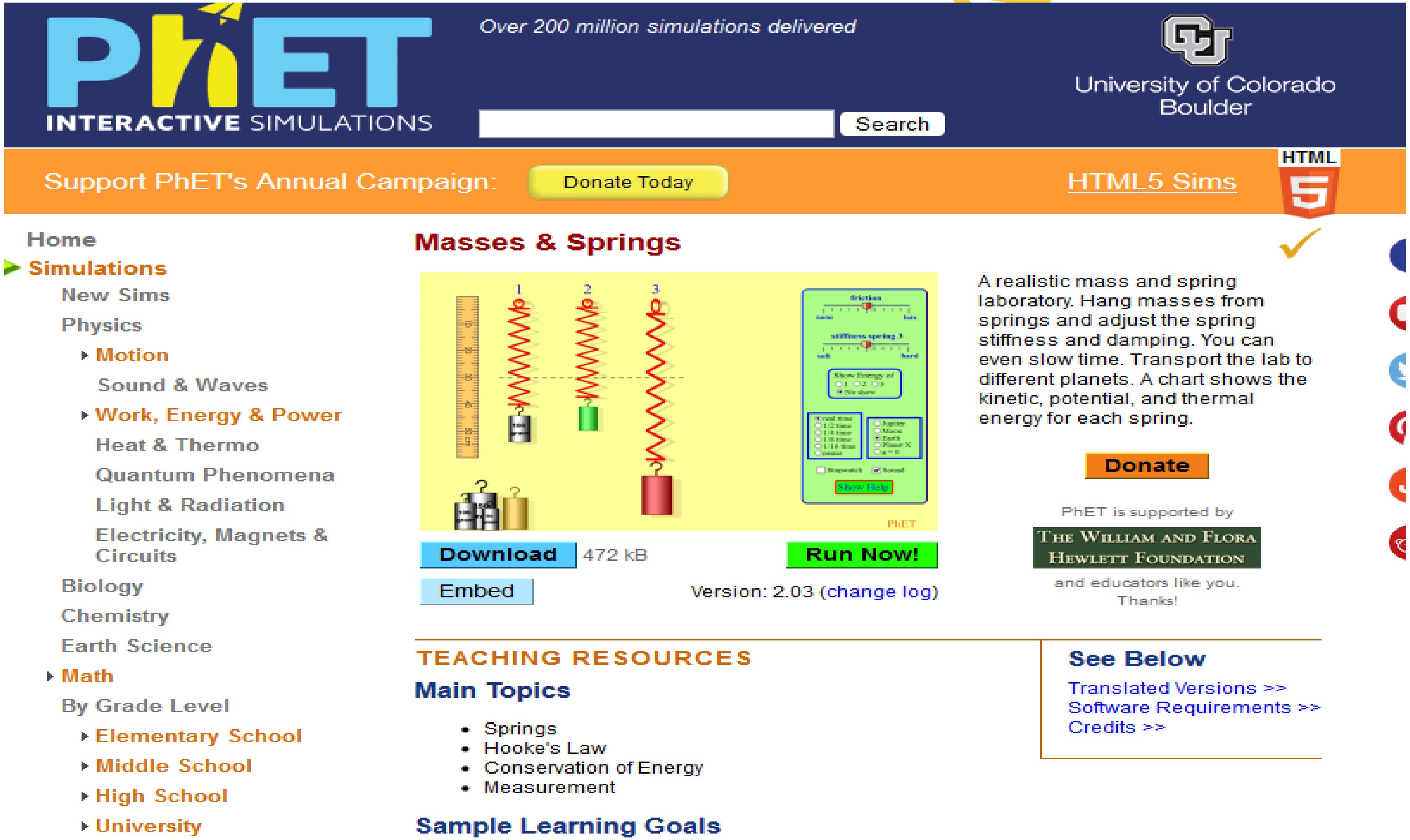
Options								
	1	2	3	4	5	6	7	8
C1								
C2								
C3								
C4								
C5								
C6								
C7								
C8								
C9								
C10								
C11								
C12								
D1								
D2								
D3								
D4								
D5								
D6								
D7								
D8								
D9								
D10								
D11								
D12								

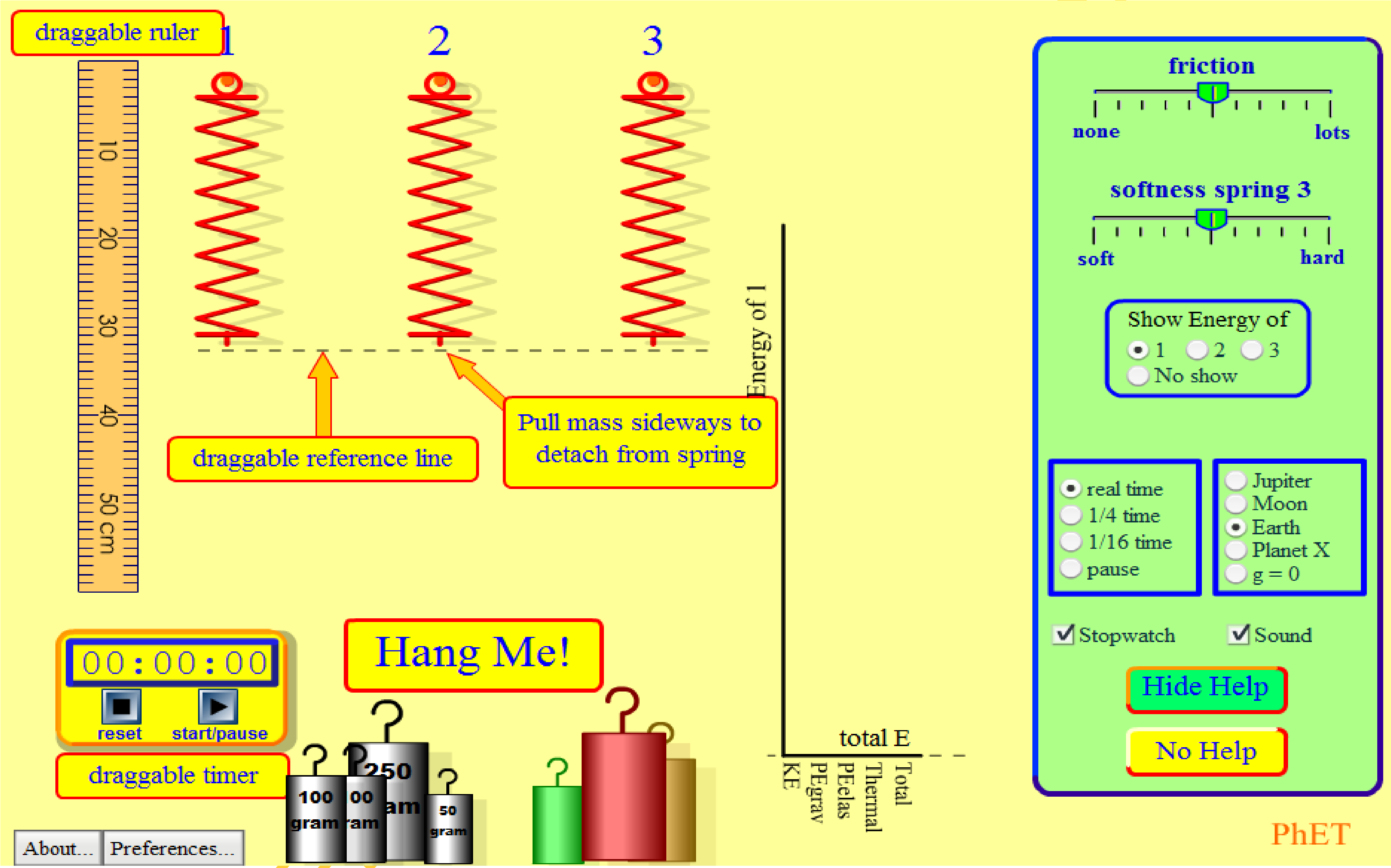
Options								
	1	2	3	4	5	6	7	8
E1								
E2								
E3								
E4								
E5								
E6								
E7								
E8								
E9								
E10								
E11								
E12								

APPENDIX VI

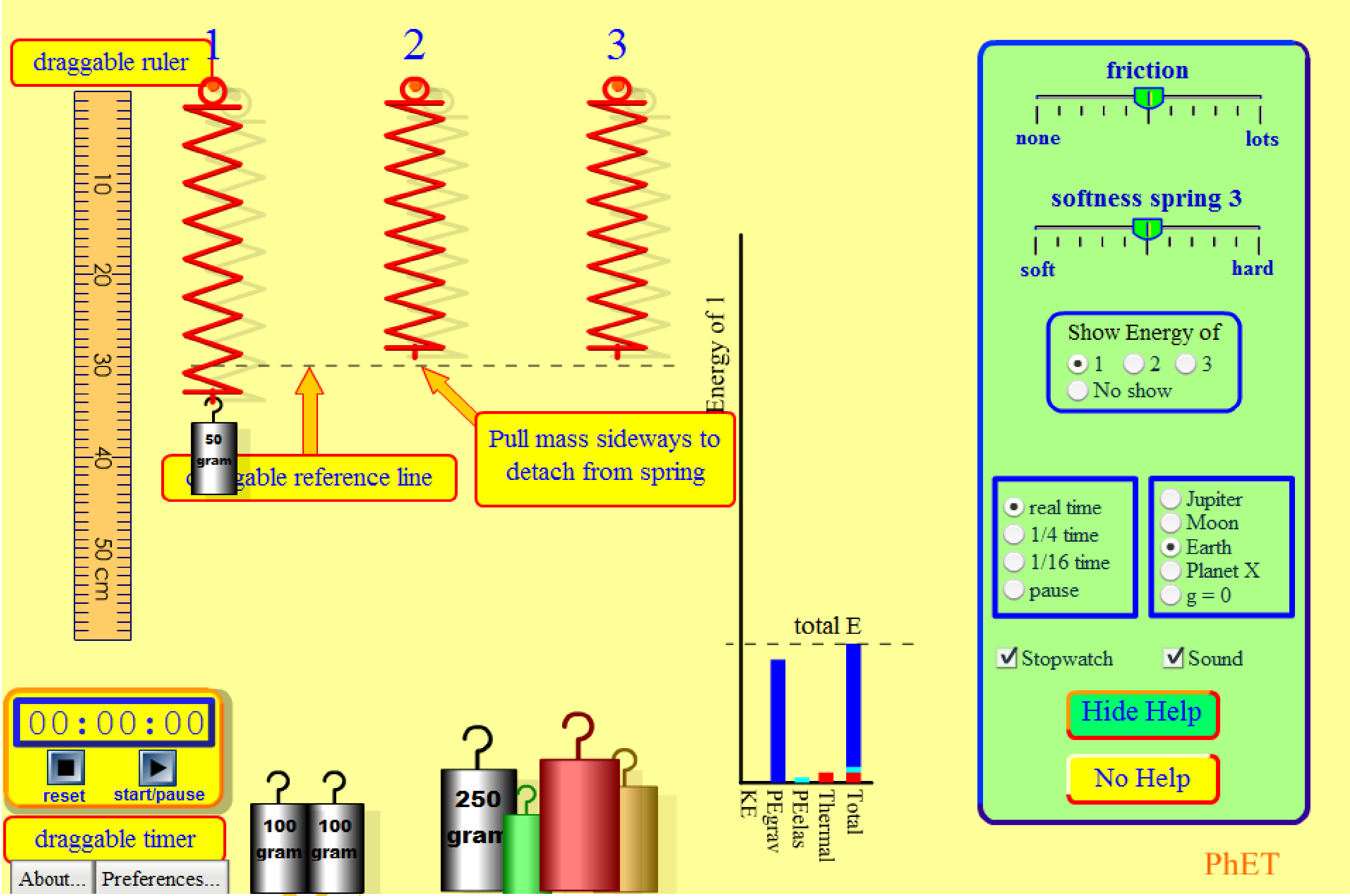
APPARATUS USE FOR THE EXPERIMENT ON VERIFICATION OF HOOKES LAW FOR GROUP ONE (COMPUTER SIMULATED EXPERIMENTAL GROUP)

SOURCE: **http://phet.colorado.edu/en/simulation/mass-spring-lab**

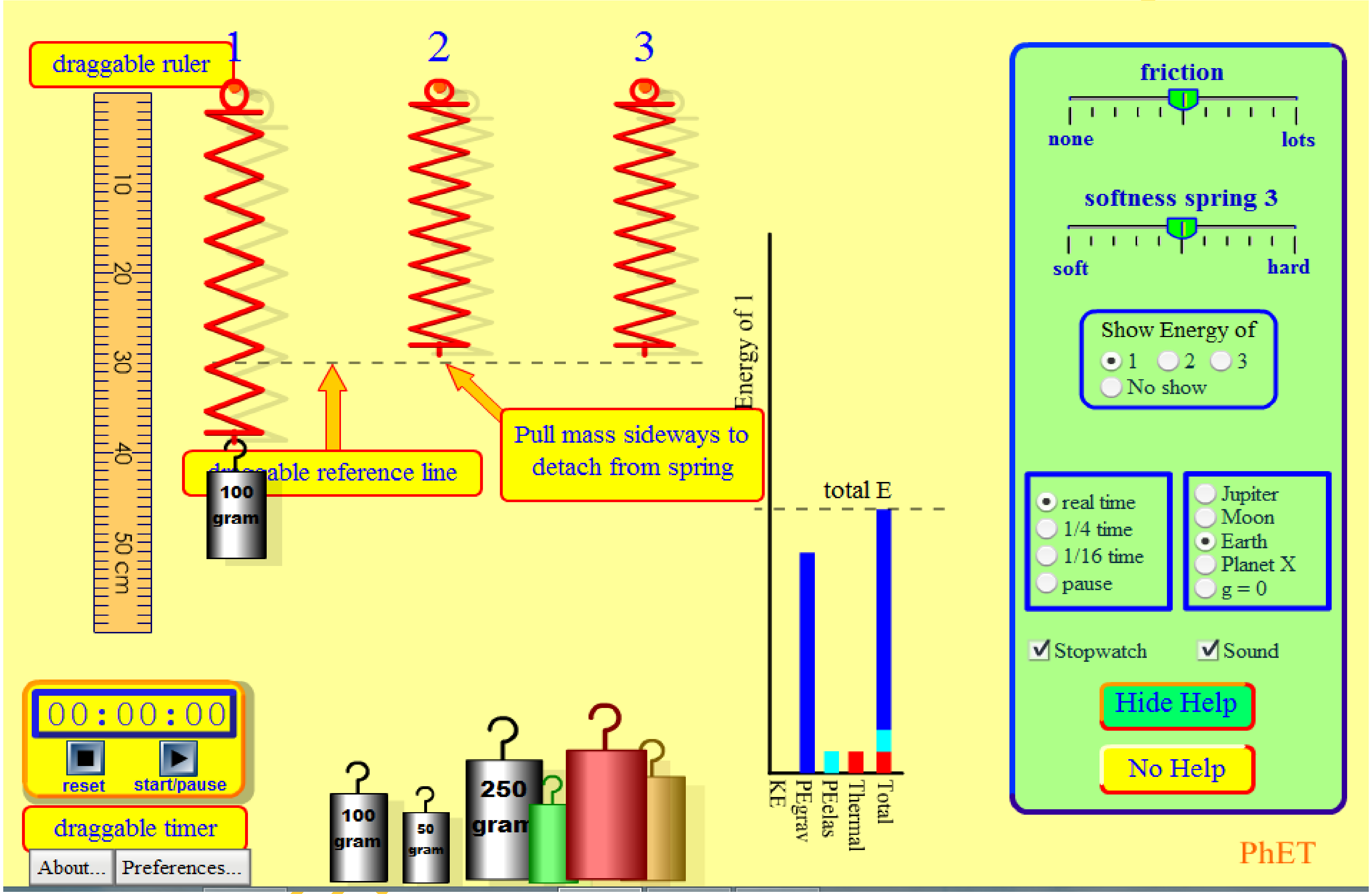




THE APPARATUS BEFORE HANGING OF MASSES WITH REFERENCE POINT AT 30.20CM

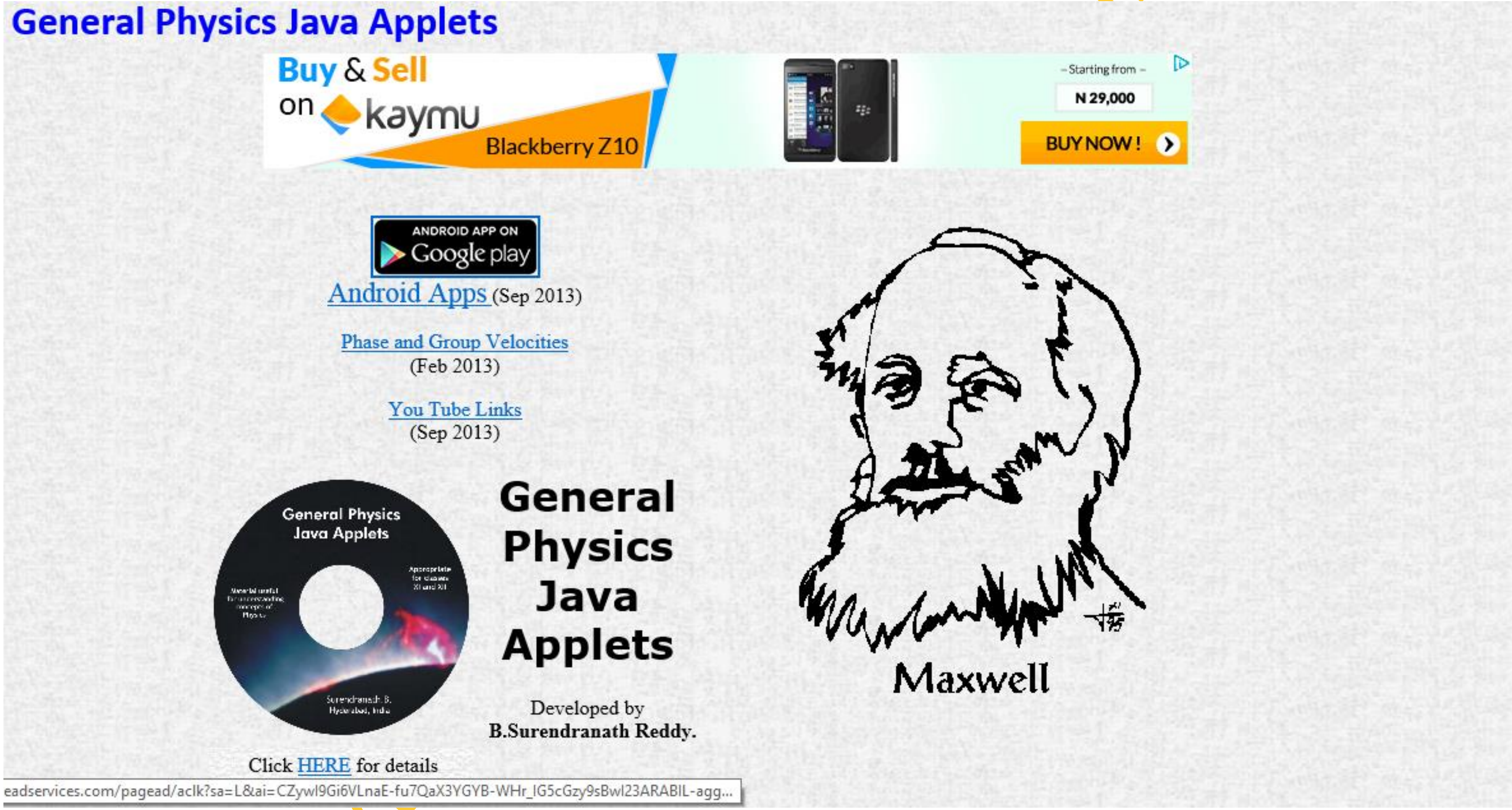


THE APPARATUS WITH MASS 50 GRAM AND NEW LENGTH = 30.40 - 30.20 CM = 0.20CM



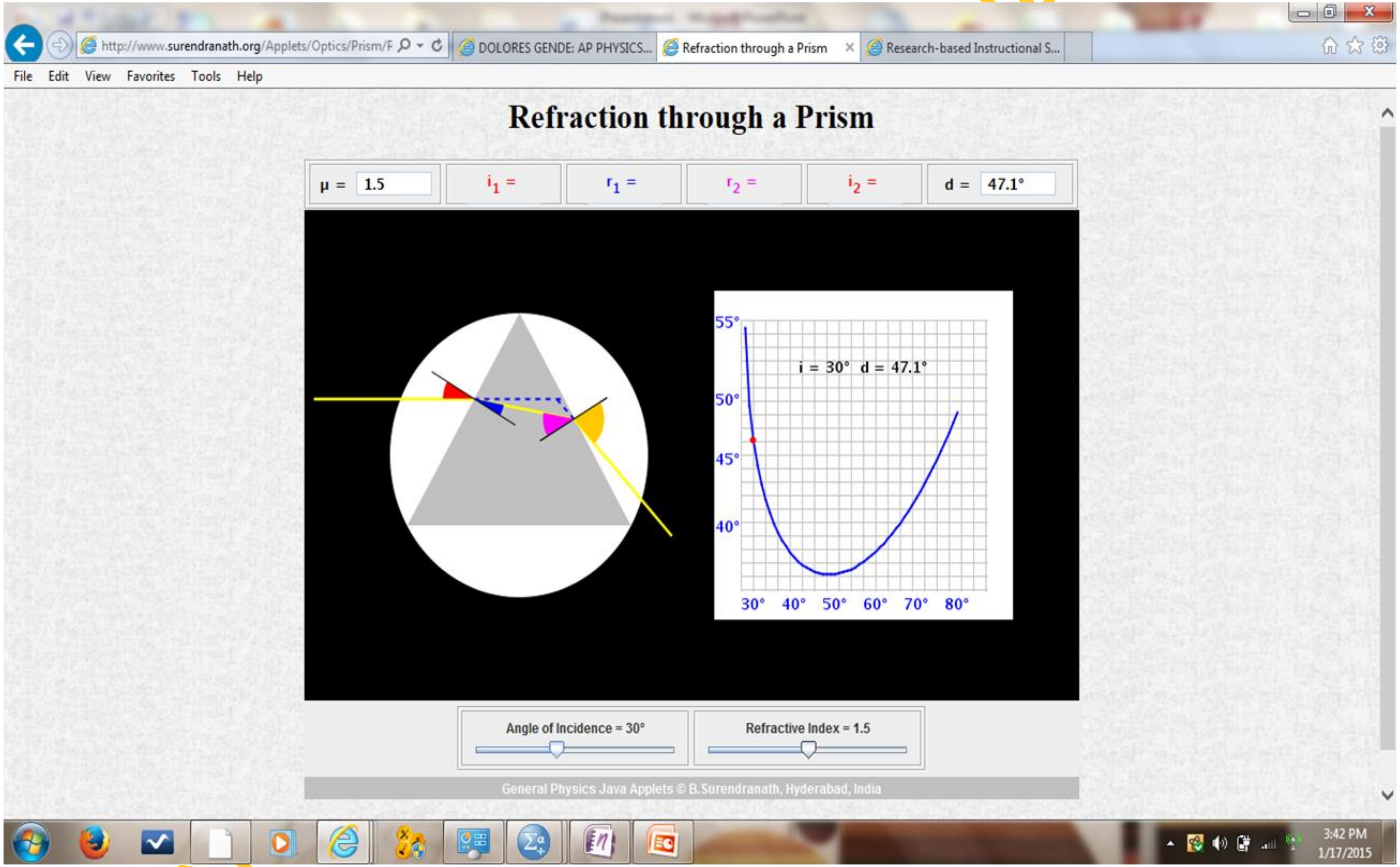
THE APPARATUS WITH MASS 100 GRAM AND NEW LENGTH = 30.80 - 30.20 CM = 0.40CM

SOURCE: SOURCE : **http://www.surendranath.org/**



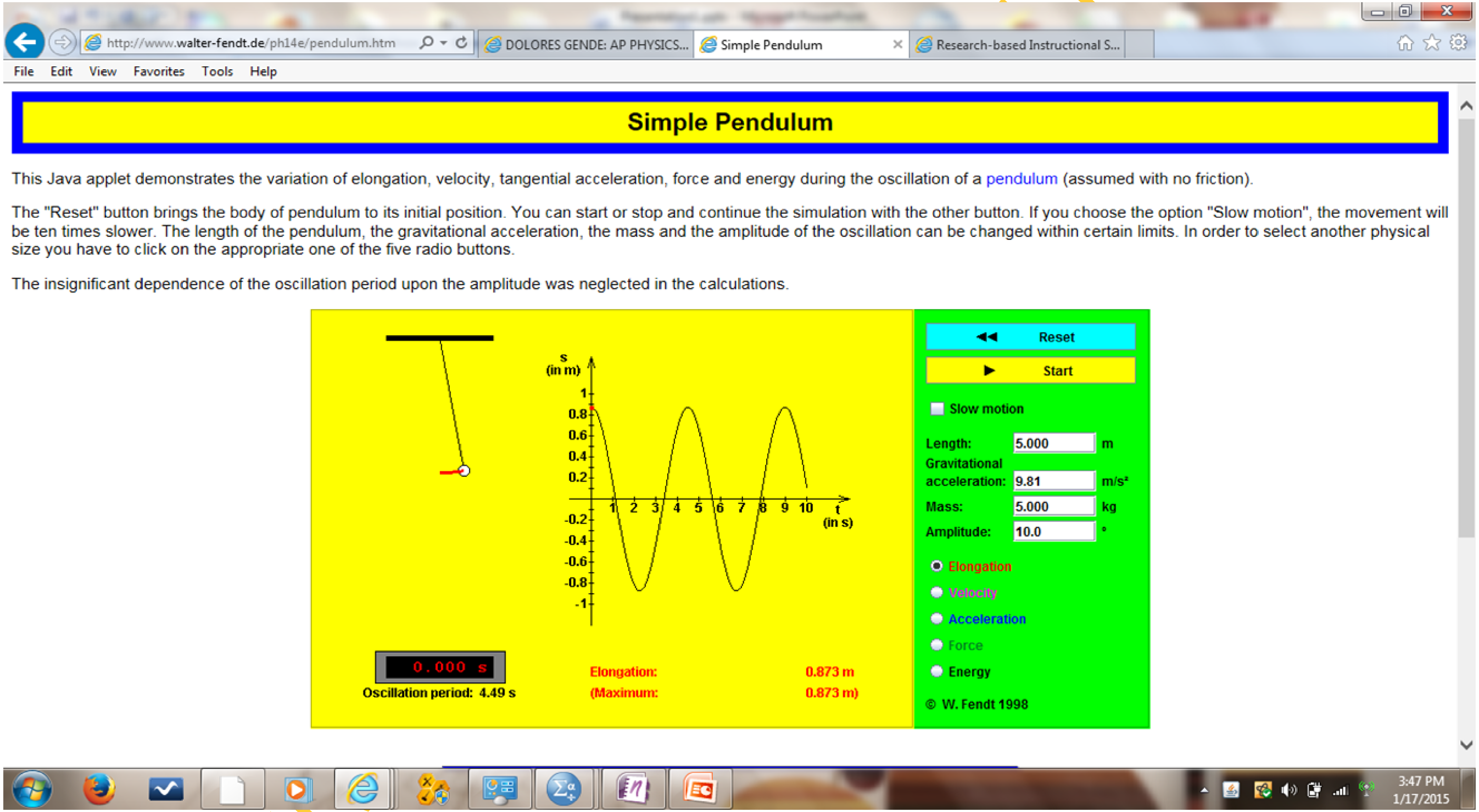
EXPERIMENT ON DETERMINATION OF REFRACTIVE INDEX OF RECTANGULAR PRISM

SOURCE : **http://www.surendranath.org/Applets/Optics/Prism/Prism.html**



EXPERIMENT ON DETERMINATION OF ACCELERATION DUE TO GRAVITY USING SIMPLE PENDULUM

SOURCE: http://www.walter-fendt.de/ph14e/



ONE OF THE TEACHERS WATCHING THE STUDENTS PERFORM THE ACTIVITIES IN ONE OF THE FEMALE SCHOOLS IN EXPERIMENTAL GROUP TWO (COMPUTER SIMULATED EXPERIMENTAL GROUP)

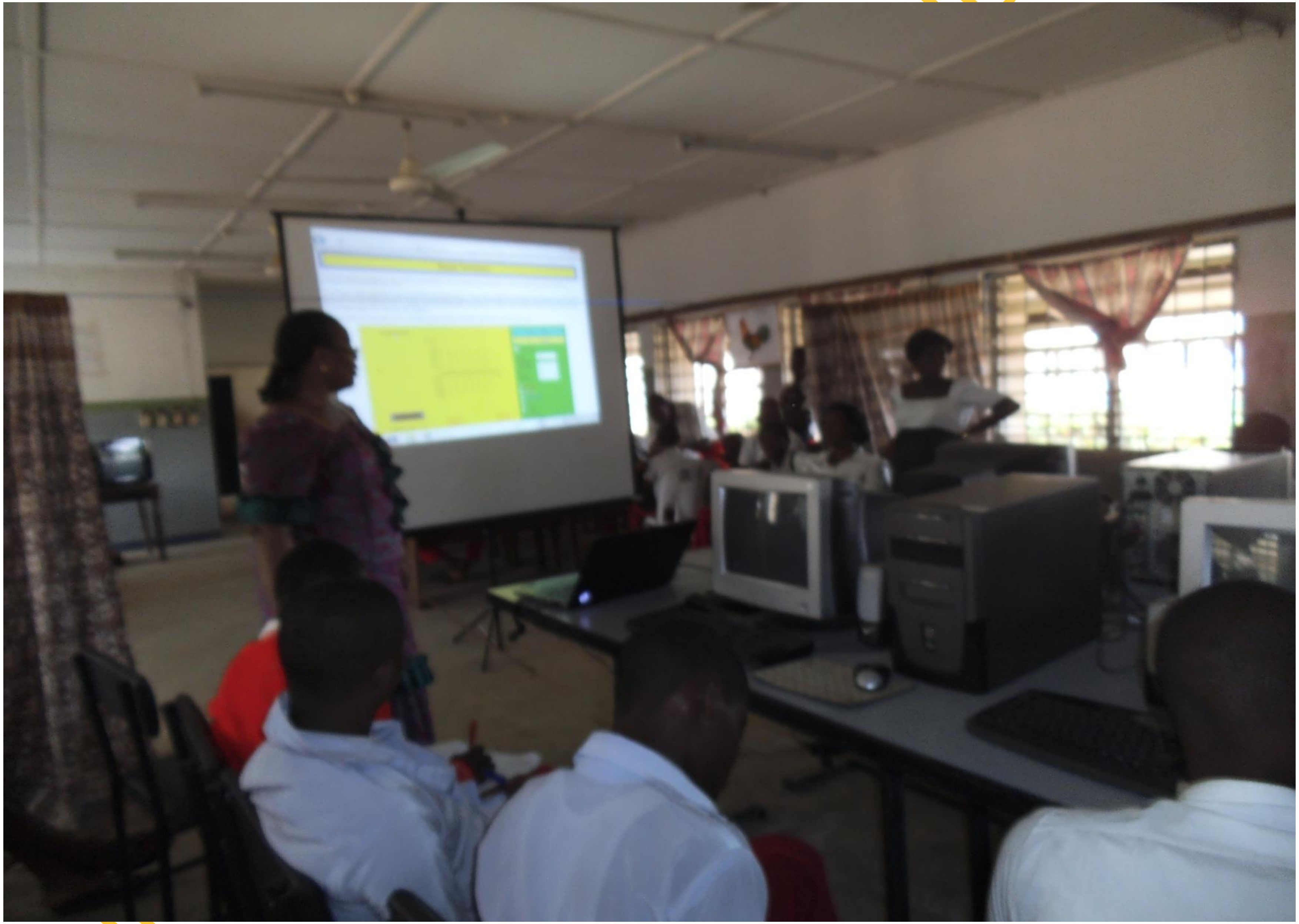
SOME STUDENTS IN AN INTRODUCTORY CLASS SESSION

A STUDENT PERFORMING ACTIVITIES WITH A LAPTOP IN A PRACTICAL SESSION

THE RESEARCHER WITH SOME OF THE STUDENTS IN A TRAINING SESSION

STUDENTS IN EXPERIMENTAL GROUP ONE (COMPUTER SIMULATED EXPERIMENT) PERFORMING THE ACTIVITIES ON DETERMINATION OF REFRACTIVE INDEX OF PRISM

THE TEACHER IN A SESSION OF PRACTICAL ACTIVITIES WITH HER STUDENTS WHILE THE RESEARCHER STOOD BY.



A CLASS IN SESSION

A CLASS IN SESSION

THE RESEARCHER IN A REVIEW SESSION WITH THE STUDENTS

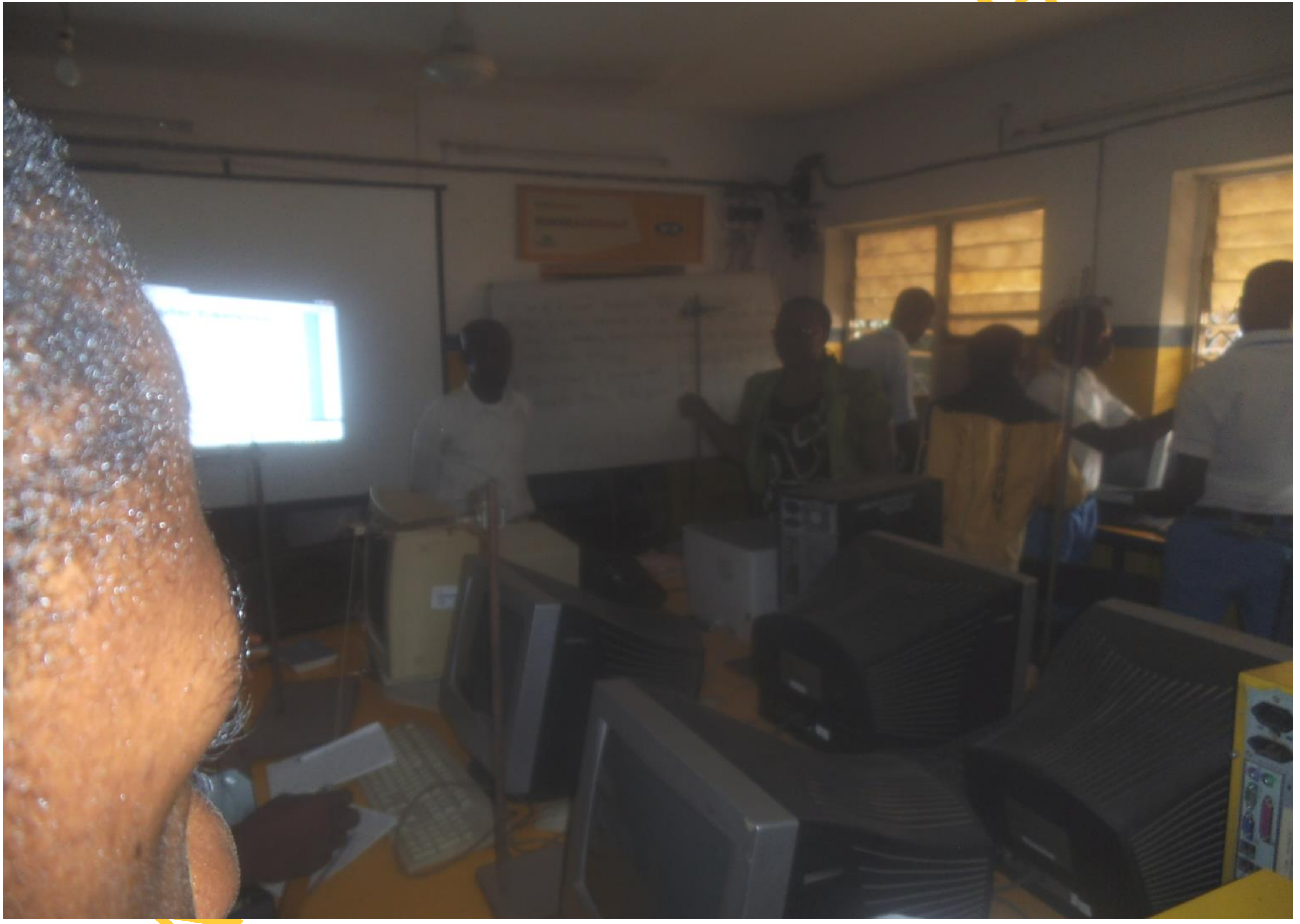
EXPERIMENTAL GROUP TWO (COMPUTER SIMULATED EXPERIMENT AND HANDS-ON GROUP) CARRYING OUT THE EXPERIMENT

A STUDENT VERY BUSY WITH ACTIVITIES ON SIMPLE PENDULUM

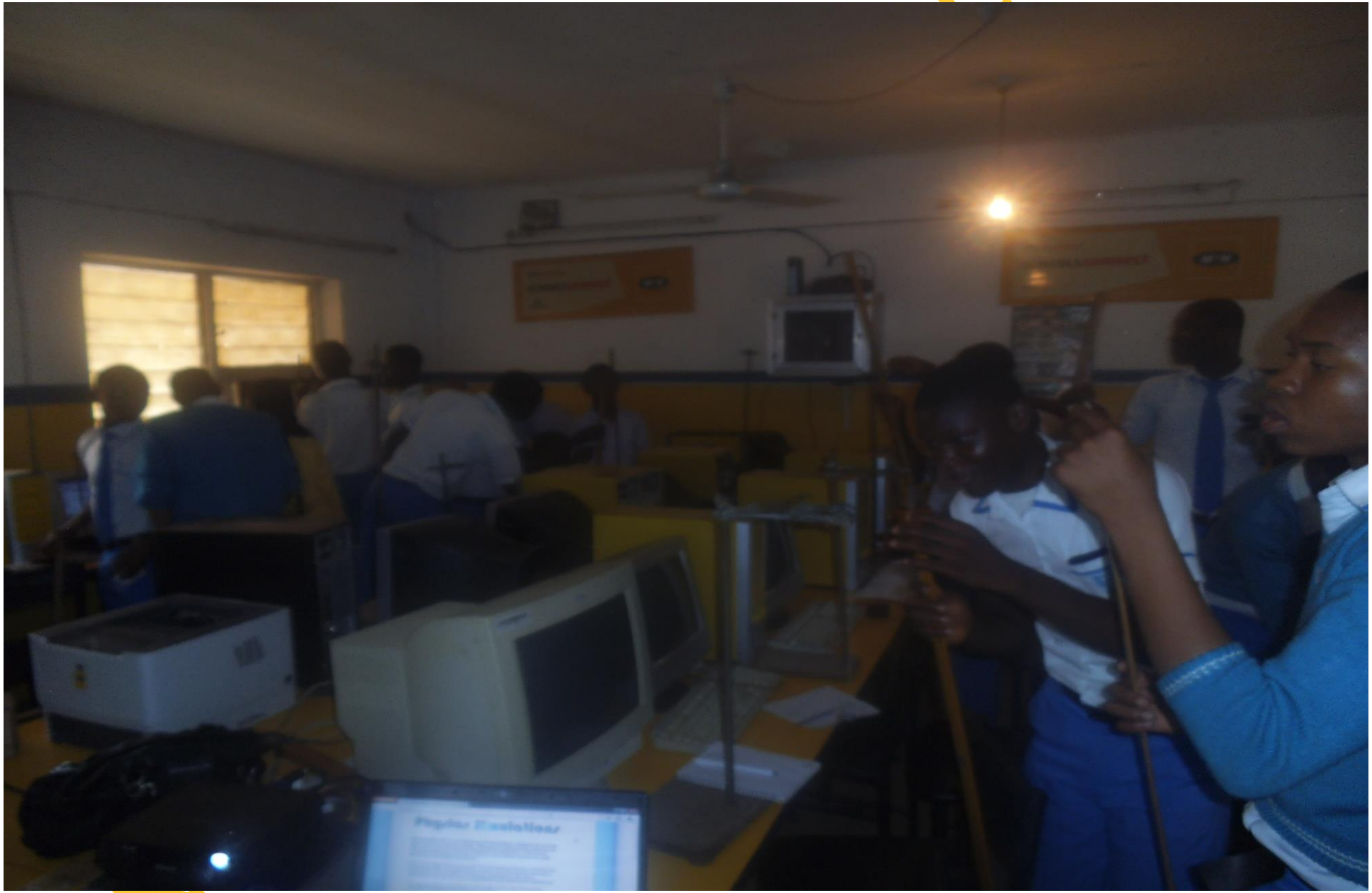
STUDENTS TAKING THEIR READINGS USING STOP-WATCHES IN EXPERIMENTAL GROUP TWO

(COMPUTER SIMULATED EXPERIMENT AND HANDS-ON GROUP)

THE TEACHERS AND THE STUDENTS IN A PRACTICAL SESSION



PRACTICAL SESSION



THE TEACHER ILLUSTRATING POINTS TO A GROUP OF STUDENTS IN A PRACTICAL SESSION

THE REVEREND GENTLE MAN WITH A VIDEO CAMERA IN THE CLASS RECORDING THE ACTIVITIES DURING THE FIELD WORK

APPENDIX VIII

Training Manual on Assessing the Computer Simulated Experiment through the Internet Facilities

Activities One: Assessing Walter Fendz Simple Pendulum for Determination of Acceleration Due to Gravity

Step one: Boot your Computer.

Step Two: Login to the internet through goggle.

Step Three: Type www.walter – fendz de/ph14e/refraction.

Step Four: Move to Java Applets on Physics (Java 1- 4) – Walter fendz and click on it.

Step Five: When lists of simulations appear, locate and select oscillations and waves.

Step Six : Click on simple pendulum and a java applet by Walter Fendz will appear.

Step Seven: Fix in your value and take your readings.

Activities Two: Assessing the Internet for Masses and Springs on Verification of Hooke's. Law

Step one: Boot your Computer.

Step Two: Login to the internet through goggle.

Step Three: Type www.Phet.Colorado.edu/sims/mass - spring lab/mass - spring.

Step Four: Move the cursor to masses and springs – mass, springs, Force – Phet or move to Masses and springs 2.03 Phet.

Step Five: When masses and springs appear, and click on on "run now".

Step Six: The actual simulation will be displayed on the screen. Click and drag to hang any mass then, click on "stop watch" and "show help"

Step Seven: Fix in your values and take your readings.

Activities Three: Assessing the Internet for Simulations on Determination of Refractive Index of Prism

Step one: Boot your Computer.

Step Two: Login to the internet through goggle.

Step Three: Type in www.surendranath/Applets/optics/prism/prism -html.

Step Four: Move to “refraction through prisms directly to take your readings

Step Five: If interest is to assess through the CD, from step three move to “General physics java Applet” and access the whole content of the CD and go to “refraction through prism”

Step Seven: Fix in your values and take your readings.