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Computer-Simulate Experiment As A Tool For Reducing Phobia In Mathematics For Low Numerical Reasoning Ability Students In Learning Secondary School Physics

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Abstract

Computer-Simulated Experiment (CSE) is a high interactive method of carrying out practical in Physics which is very rare in Nigeria secondary schools but very effective and could also assist learners that have phobia for Mathematics to perform better. The study investigated the effect of Computer-Simulated Experiment as an instructional strategy to cushion the effect of phobia in Mathematics in Senior secondary schools in Nigeria. It adopted a pre-test-post-test, control group, quasi-experimental design. A multi-stage random sampling was used to select 359 students of intact class of SSII students from six secondary schools in Owerri. Participants were assigned to treatment groups; Computer-Simulated Experiment (CSE), Computer-Simulated and Hands-on Experiment (CSHE) and Conventional Hands-on Experiment ((HoE) with numerical reasoning ability as moderating variable. The result showed that the students in the CSE group performed better ((x ; 38.67; SD; 6:68), than those in CSHE ((x =38.56; S.D = 6:85) and HoE (x = 33.37; S.D = 7.51) respectively. Also, students with low Numerical Reasoning Ability performed better than high Numerical Reasoning Ability (NRA). The study has implications for improvement in curriculum development and teaching-learning process in the secondary educational system.

Keywords: Computer-Simulated Experiment, Hands-on Experiment, Numerical-Reasoning Ability, Mathematics Phobia.

INTRODUCTION

Physics is at the centre of human existence in the society. It asks fundamental questions and tries to provide answers through observations and experimentation. That is why it is defined as the study of matter, energy and the interaction between them (Institute of Physics, 2015). Many physicists work in pure research with the aim of finding answers to questions using equations, graphs and other Mathematical principles and connotations.

Physics attempt to uncover simple Mathematical relationships through observations, creating Mathematical models and testing them through experiments (Institute of Physics, 2015). Hence, Mathematics is commonly referred to as language of Physics (Adesoji 2008; Redish 2005). The study of Physics is made easier by the understanding of the concept of Mathematics (Adesoji 2008; Obafemi and Ogunkunle 2013). However, students generally are known to have a level of phobia for Mathematics (Obafemi and Ogunkunle 2013).

Statistics of WAEC results 2005 -2013 from Test Aministrative Department show that 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, about 37.7% of the total enrolment did not make the acceptable grade that can qualify them to enter higher institutions of learning to pursue courses that are Physics related. A pertinent question that arises is; what went wrong?

The poor achievement in Physics according to WAEC Chief Examiners Report 2007 -2013 could be attributed to the students' inability to carry out some calculations and manipulative skills that involve numerical processes. Other reasons were; inability of the students to finish their work at stipulated time, wrong response to questions bordering on theory of experiment and inability of the students to plot correct graph amongst other reasons.

Numerical reasoning ability is the skills required to apply arithmetic operations either singly or in sequence (Adeleke 2010). The concept of numerical literacy was posited in 1959 by Department of Education and Skill, United Kingdom and Ireland. A report of the Central Advisory Council for Education submitted to Department of Education and Skills in 1959 with the aim to promote equity, inclusion, lifelong learning and education that is relevant to personal, social, cultural and economic need, coined the word numeracy. Numeracy is interpreted as equipping school leavers with the basic skills of arithmetic which is regarded as a subset of Mathematics. According to the Department of Education and Skills in United Kingdom and Ireland, numeracy proficiency is developed mainly in Mathematics and other related subjects. Adeleke (2010) stated that numerical reasoning ability test involve 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. Furthermore, 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" (Adesoji 2008; Apata 2011). The "un- learned Mathematics ability" according to them is as a result of innate numerical ability of the learner and Mathematics is the language of Physics.

Adesoji (2008) and Adegoke (2010) stated that many students appear to lack numerical reasoning proficiency required to study Physics and hence have problem with logical Mathematical presentations in the Physics classroom. This view is also in agreement with the findings of Obafemi and Ogunkunle (2013) in which many students complained of the rigorous nature of Physics concept in which problem solving is impossible without the use of Mathematical connotations.

One of the promising applications of computer in education today is the use of computer to carry out experiment in science education and particularly Physics. Computer- simulated experiments seems to have the capacity to simplify reality by changing details or omitting it (Allesi and Trollip 2001). This omitted detail sometimes could be represented at the end of the process.

The singular characteristic of computer-simulation made it possible for the computer to present many Mathematical processes for (manual) verification at the end of the experiment. This process reduces to a large extent the onerous task which scares the students away from Physics, the task which the teacher may represent for verification.

Many researchers have investigated the use of computer to carryout experiments (Computer-simulated experiment). They compared the effectiveness of Computer-simulated experiment with hands-on-laboratory experiment. Some discovered that computer –simulated experiment are as effective as hands-on experiment (Sahin 2006;Choi and Gennaro 2006). Other studies revealed that computer-simulated experiment could be more effective than hands-on experiences depending on the objective of the lesson and the mode of use. Chukwunenye and Adegoke 2013; Chukwunenye 2014, described computer simulated experiment as the use of visual laboratory to carry out virtual experiment. Allesi and Trollip (2001) described simulation as a powerful technique that teaches about the systems by imitating or replicating the system in such a way that the learner learns to interact with the system in a manner similar to the way they interact with real situations. Other scholars from the constructivist point of view described simulation as real life scenario displayed on the computer (Adams,Keller,and Reid 2005) in which the student plays an authentic role carrying out complex tasks. (Alkhalifah, 2005).

From the above definitions, simulations should reflect the complexity of the real life situation or concept in a simplified manner that the student will carry out higher order cognitive processes involving inquiry and exploration which is viewed as the essentials of science learning. (Adams, Keller and Reid 2005). Simulations are useful for modeling laboratory practical that are expensive, impossible or too dangerous to run and hence contributes to conceptual change (Adegoke and Chukwunenye 2013; Sahin 2006).

It is against this background that this study investigated the effect of computer-simulated experiment and its implications for low numerical reasoning ability students and level of phobia for Mathematics in learning Physics.

Statement of the Problem: From the fore-going, it could be made clear that students with low numerical reasoning ability do not perform very well in Physics because of their Phobia for Mathematics. Hence, this study investigated whether the use of computer-simulation experiment could cushion the effect of students' phobia for Mathematics by performing better in Physics by low numerical reasoning ability students.

THEORETICAL FRAMEWORK: This study is anchored on Engagement theory.

This theory was first propounded in 1999 by Greg Kearsley and Ben Shneidermann (Abimbade 2007). The theory posits that for learning to occur, there must be engagement. Engagement is said to have occurred when the learners 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 arrests the interest of the learner and therefore engages them freely even beyond the classroom, especially for those that have access to internet facilities.

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 is difficult to achieve otherwise. Therefore, engagement theory is intended to be a model or framework for technology based learning (Kunda, Greggor and Geol, 2009). The three components 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.

Conceptual framework:

Concept of Numerical Literacy

The concept of numerical literacy was propounded in 1959 by United Kingdom Committee on Education. The concept of numerical literacy was 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 number system, a repertoire of Mathematical techniques and ability to solve quantitative or spatial problems in a range of context. It appears that learners with high numerical literacy will perform very well in Mathematical related courses.

According to Iroegbu 1998; Adesoji 2008; and Apata 2011, achievement in school Mathematics which is applied to some science subjects is related to "un- learned Mathematical ability". The "un- learned Mathematics ability according to them, is as a result of innate numerical ability of the learner. Numerical reasoning ability test is an instrument used to measure numerical reasoning ability. According to Adegoke 2010, it was developed by Hamley 1934, and has been used elsewhere (Beret and Williams, 1997). 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 four processes which are; the recognition of constant, variable classification, ordering and recognition of constant correspondence in dealing with arithmetical numbers.

Research Hypotheses

Two hypotheses were tested at 0.05 level of significant. These were:

Ho_1: There is no significant main effect of treatment (CSE, CSE+H0E and control) on students' achievement in Physics.

$H0_2$: There is no significant mains effect of treatment (CSE, CSE+ H0E, + control) on numerical reasoning ability.

METHODOLOGY OF RESEARCH

A 3x3 pre-test, post-test, control group quasi-experimental design was adopted for this study. Where treatment (CSE, CSE+HoE and HoE) and numerical reasoning ability were three levels of independent variables respectively and achievement was the dependent variabless.

Participants: A Multistage random sampling was used to select 359 students of intact classes in SSS II from six secondary schools from Orlu Educational Zone. Participants were randomly assigned to treatment groups. Treatment lasted for eight (8) weeks. Computer-Simulated

Experiment (CSE) group = 128, Computer-Simulated and Hands-on Experiment (CSE+HoE) group = 105 and Conventional Hands-on Experiment (CHE) group = 126.

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.

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 and verification of Hooke's law. 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. 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.

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 "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.

Research Instruments: Instruments used to collect data for this study were:

1. Theory of Physics Practical Tests (TPPT).
2. Numerical Reasoning Ability Test (NRAT)
3. Physics Practical Test (PPT)
4. Software Package of Computer-Simulated Experiment from web site (SCSE)

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. It consisted of 25 multiple choice items which were drawn from the initial pool of 60 test 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 was on optics (Snell's law). It also provided information on duration of the test. These items were evaluated for suitability; item difficulty level and discrimination level of the test items were also ascertained to lie between 40% -60% and reliability index as 0.99 and 0.88 respectively.

Numerical Reasoning Ability Test (NRAT): This is an instrument used to measure numerical reasoning ability. According to Adegoke 2010, the test was developed by Hamley 1934, and has been used elsewhere (Beret and Williams, 1997). It is an objective test consisting of 15 items with options A, B, C, D. Students' scores in numerical reasoning ability test provides 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%. The instrument was administered to a set of students that were not part of the study and the reported reliability for numerical reasoning ability test (**NRAT**) was 0.92 (Lee, 1967; Beret and William, 1997; Adegoke 2010).

Physics Practical Tests (PPT): This was Physics practical test items on determination of acceleration due to gravity, Hooke's law and simple harmonic motion in general adapted from past WAEC questions of years 2003 to 2011. Twenty-five items were teased out of initial pool of sixty questions. These items were used to assess the students' problem-solving skills which included manipulation, observation, identification of problems, planning, doing experiment, recording data, explaining results and evaluating results, while verifying Hooke's law and determining acceleration due to gravity. In modifying the items, the researcher reflected items that specifically dealt with period, time, amplitude, oscillation, force, motion, angles, refraction, reflection and related equations to suit the cognitive level of students that were sampled in the study. The items were developed to reflect some of Bloom's taxonomy of learning outcome which are knowledge, comprehension, application and analysis, in line with the content area. These twenty-five items were teased out of sixty items which were evaluated and the reliability co-efficient of 0.90 was obtained using Kuder Richardson (KR20).

Laboratory Equipment: This consisted of physical materials used in laboratory activities, such as pendulum bob, clamp and stand, meter rule, cork, string.

Method of Data Analysis:

Data was analyzed using group mean gain in scores for pretest and posttest as well as standard deviation . Charts and graphs were also used to represent the outcome.

RESULTS

Ho1: There is no significant effect of treatment [CSE + (CSE + HoE) + HoE] on students' achievement in Physics.

Table 1 presents the descriptive statistics of each of the treatment groups' scores in Physics practical test items**.**

Table 1: Groups' Mean Score in Achievement Test in Physics

Treatments Group	Number of students	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 +HoE	105	19.79	11.00	38.56	6.85	18.77
Control	126	20.58	11.15	33.37	7.51	12.79

Figure 1: Mean Gain Score in Achievement in Physics among the Treatment Groups

The results showed 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 gain in score (12.79).

Hypothesis two

Ho2: There is no significant effect of treatment and numerical reasoning ability on students' achievement in Physics.

Table .2: 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

Table 2 shows that the students who were rated as being low in numerical ability had the highest mean gain (31.33) in Physics practical, while the students who were rated as high had the lowest mean score (9.61). Figure 2 shows the graphical representation of the groups' mean gain.

Figure 2: Mean Gain in Score in Physics Practical among Numerical reasoning Ability Group.

Discussions, Conclusions and Recommendations

The results reveal 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 learners with high numerical proficiency perform better than learners with low numerical reasoning ability. Adesoji (2008) also posited that numerical proficiency has been found to have practical implication to Physics learning. A 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). Through the use of computer-simulated experiment, students with low numerical reasoning ability has a high mean gain in scores compared with those of high numerical reasoning ability. This is because there are cues and prompts made visible by the computer which otherwise cannot be visible but has reduced the numerical challenges to the barest minimum. This is evidenced by the mean gain score in Physics practical tests.

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. 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

Most hands-on experiment are only possible with fixed school schedule because of the apparatus involved and other logistics. 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 or known fact and the learners work towards verifying this facts but 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 always 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 because it provides the confident in the learner to deal with novel situation and also caution the effects of Mathematical phobia in science teaching. Pilot study could also be embarked upon to see how science programme could be introduced to distance learning and also how computer-simulated experiment could be used as alternative to practical in WAEC and NECO examinations.

This study recommends that Computer-Simulated experiment should be adopted in the teaching and learning of senior secondary school Physics for better performance because students with low numerical reasoning ability gains more from it.

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