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EFFICACY OF COMPUTER-BASED SIMULATION ON STUDENTS ACHIEVEMENT IN PHYSICS EDUCATION.

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Abstract

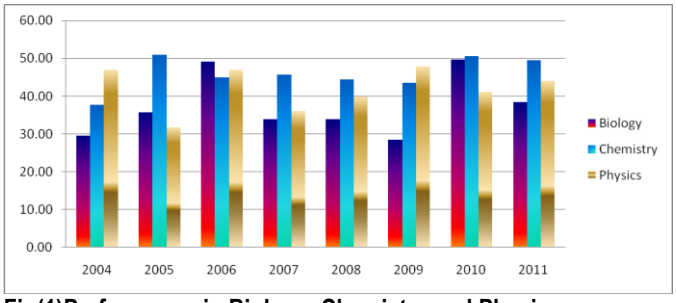
The efficacy of Authors' developed computer-based simulation instructional package for teachingphysics concepts was examined using Pretest – Posttest Experimental group design. Sixty students (30 males and 30 females) SSII students from two secondary schools in Minna, Nigeria, made-up the sample. The schools were randomly assigned to experimental and control groups. The experimental group was taught selected concept of physics using computer-based simulation package (CBSP) and traditional method was used for the control group. Physics Achievement Test (PAT) was used for collecting data for this study. PAT is a 10-item multiple-choice objective type achievement test covering two selected topics in physics. It was administered to the student as pretest and posttest. The data collected were analyzed with the t-test statistics. Results revealed that the students taught with CBSP performed better than the control group. The CBSP was found also to be gender friendly.Based on the findings, it was recommended that physics teachers should used computer-based simulation for improving the students performance in physics education.

Keywords: *Computer-Based Simulation; Physics Education; Motion; Achievement.*

INTRODUCTION

Technological development of any nation lies in the study of science. Science and technology would be incomplete without physics (Michael, 2006). The importance of physics in science and technology instruction cannot be over emphasized. Physics is applied to almost every human activity, and virtually every profession involves some element of physics. It has indeed permeated all strata of life such as: medicine, communication or space sciences. It has proved its effectiveness for the benefit of mankind (Javed, 2005). An American scientist said that when someone is ill, the doctor is called by phone,he visits the patient by automobile, measure his temperature with a thermometer and his pulse with watch, and examines his heart and lungs with a stethoscope and his throat with a light reflector. All these instruments are produced and supplied by physicists(Gambari, 2004).

The significance of physics in all fields of science and technology has therefore made it imperative to be included in the curriculum of senior secondary school to be offered by science oriented students. Unfortunately, in spite of the importance of physics as a requirement for many specialized science and engineering courses at the universities, students' performance at the secondary school level in the subject has been quiet unsatisfactory over the years (WAEC, 2004 - 2011).



Fig(1)Performance in Biology, Chemistry and Physics (2004 – 2011)

Fig(1) reveal that the percentage of students that passed physics at credit level and above (A1-C6) was consistently less than 50% for the past 8 years (2004-2011) in Nigeria. The desire to know the causes of the poor performance in biology has been the focus of researchers for some time now. It has been observed that poor performance in the sciences is caused by the poor quality of science teachers, overcrowded classrooms, and lack of suitable and adequate science equipment, among others (Adegoke, 2011; Kareem, 2003). Students perform poorly in physics has been attributed to poor instructional strategy employed by physics teachers (Rafiu&Adetona, 2007;Gambari, 2010).Many researchers have traced the poor performance in physics to persistent use of teacher-centred instructional methods; lack of innovative teaching techniques such as computer technology, multimedia, hypermedia and many others (Chukwu, 2000;Rafiu&Adetona, 2007;Gambari, 2010).

As computer technology continues to enhance the teaching and learning of all science disciplines, computer simulations, in particular, have become exceptionally beneficial in physics education. In addition to the manner in which physics instructors integrate

computer simulations into their instructional practices, the design of a simulation may also determine its potential for influencing a student's conceptual development and understanding (Bryan & Slough, 2009). Computer simulation is a computer-generated version of real-world objects or processes. It can take many different forms, ranging from computer renderings of 3-dimensional geometric shapes to highly interactive computerized laboratory experiments (Gambari, Falode, Fagbemi&Idris, 2012). Computer-based simulation gives students the opportunity to take initiative when learning about a given topic. Incorporating simulations in science instruction facilitates learning. Using computer-based simulation, the cost associated with the chemicals and equipment necessary for laboratory experiments are drastically reduced, it saves time in situations where few variables are to be examined, it also make variables easier to control and may also prevent traditional classroom management problems (Bakaç, Kartal-Taşoğlu&Akbay, 2011; Pol, Harskamp&Suhre, 2005; Thavikulwat, 2009).Furthermore,key aspects of simulation education are the ability torepeat practice to consolidate learning and develop competence(Issenberg, McGaghie, Petrusa, Gordon &Scalese, 2005;Hogg, Pirie & Ker, 2006;Kardong-Edgren, Starkweather, & Ward, 2008), using instructor feedback and videodebriefing (Fanning &Gaba 2007;Kuiper, Heinrich, Matthias, Graham & Bell-Kotwall (2008).

Several researches had attested to the effectiveness of computer-based simulation, for instance, Yiğit (2005) found in his study that computer assisted instruction has had positive impact on students' perceptions about computer supported instruction as well as on to their academic achievement.Chang, Lin and Sung (2008) reported that students with higher abstract reasoning in physics benefit more from simulation-based learning. In a similar study, Mohammed (2006) found that the computer-based simulation courseware had given a positive effect on student's academic performance in visual art education. Spinello andFischbach (2004) reported that students participating in a simulation learning environment perceived the experience as being a motivating one.Bakaç, Kartal-Taşoğlu andAkbay (2011) found that computer assisted instruction with simulation in science and physics activities increase the academic successes of students in the subject of "Electric Current". In another physics study, Kara (2008) reported that students taught Force and Pressure units in the physics topics using computer-assisted instruction performed and retained more information than those taught using traditional method. Similarly, Ufondu (2008) found CAI lesson very effective tool for teaching and learning the concepts of force, work and machines.

Gender issues have been linked with performance of students in academic tasks in several studies but without any definite conclusion. Some findings indicated that significant differences existed between the performance of male and female students while other findings showed that gender factor had no influence on students performance (Yusuf, 2004). For instance, Annetta, Mangrum, Holmes, Collazo and Cheng (2009) reported that female students used computer more than their male counterparts, and males played video games more than females when exposed to forces and motion unit. Anagbogu and Ezeliora (2007) found girls performed better than boys in science process skills while Orabi (2007), Ifamuyiwa and Akinsola (2008), Gambari (2010),Yusuf and Afolabi (2010) and Achuonye (2011)reported that gender has no influence in the academic performance of male and female students exposed to computer-assisted instruction in science subjects.

The full potentials of computer in assisting or managing instruction are yet to be exploited in Nigeria. Many factors have been identified as hindrances to the use of computer in schools. Among these are cost of purchase, epileptic electricity supply, computer illiterate teachers. However, little is known about the use of computer simulation package in the Nigerian education system. In addition, very few empirical studies that exist in Nigeria regarding the use of CAI in physics were on drill and practice mode of computer-assisted instruction. Thus, much remain to be empirically studied on the effect of computer simulation in physics education in Nigeria. This study examined the effect of computer simulation on the achievement senior secondary students in physics in Minna, Nigeria.

Research Objectives

The objectives of this research are to:

(i)Develop and validate the Computer Assisted Instructional Package.

(ii)Determine the efficacy of Computer-Based Simulation instructional package in improving learning and understanding of physics concepts and its effect on male and female secondary school students.

Research Questions

The following research questions were raised to guide the study:

(i) Is there any difference in the mean achievement scores of students taught physics using computer-based simulation and those taught using traditional method?

(ii) Is there any difference in the mean achievement scores of male and female students taught physics using computer-based simulation?

Research Hypothesis

The following hypotheses were formulated and tested at 0.05 level of significant:

H_{O1}: There is no significant difference in the mean achievement scores of student taught physics using computer-based simulation and those taught without it.

H_{O2}: There is no significant difference in the mean achievement scores of male and female students taught physics using computer-based simulation.

RESEARCH METHODOLOGY

The research design adopted for the study is Pretest-Posttest experimental Control group design. Two levels of independent primary variable (one treatment and a control), two levels of gender (male and female) were investigated on students' achievement in physics. The design layout is as shown in Table(1).

Table (1)Research design layout

Groups	Pretest	Treatment	Postest
Experimental group	O_1	Simulation	O_2
Control group	O_3	Conventional method	O_4

Sampling techniques were conducted in three stages. Firstly, purposive sampling procedure was adopted to obtain two secondary schools in Minna metropolis, Niger State Nigeria. These schools were purposely sampled based on facilities (computer laboratories and manpower), school type (public schools), gender composition (male and female), and school composition (co-educational schools). Secondly, the two schools with these criteria were randomly assigned to experimental group (simulation group) and control group (traditional teaching methods) respectively. Thirdly, stratified sampling technique was used to select the 60 SS1 students. The experimental group had 30 (15 male – 15 female) students and

control 30 (15 male – 15 female) students.

A Computer-Based Simulation Package (CBS) was developed for this study. The package consists of Three topics in Mechanics: mass, weight, and motion. The necessity for researcher-made CBS package was based on the fact that the commercially produced CBS instructional packages are not common. Even if they were available, they may not be directly relevant to the topic or objectives to be achieved in this study. As a result of this, developing a CBS package for use by the researcher was inevitable.

The CBS package (CAI) with the mechanics content served as treatment instrument and installed in the system at the beginning of the study. The computer presents information and displays animation to the learner on each of the units after which the students assessed themselves with objective questions at the end of each unit. The students could only proceed to the next unit, if they satisfactorily answered the questions. When a student fails a question, the CBS package returned the studentsto that particular concept and attempt the questionsagain until he/she is able to master the concept before moving to the next unit. The package automatically reshuffles the questions to discourage guess work.

The instrument that was used in collecting data for the study was researcher adopted Physics Achievement Test (PAT). The PAT consists of 30 multiple choice objective items with four options (A–D) adopted from past examinations of West African Examination Council (WAEC, May/June) and National Examination Council (NECO, June/July). PAT was validated by experts in Physics, computer and test and measurement units of national examination bodies and its reliability coefficient determined as 0.88 using Kuder Richardson (KR-21).

The study was for four weeks. The objectives and the modalities of the experiments were specified and operational guide was produced before the commencement of the treatment. The researcher administered the Physics Achievement Test (PAT) on sample students as pretest to ascertain the equivalence of the students before the treatment. Treatment was followed immediately, thereafter PAT was administered as posttest to measure the achievement of the sample students in each school. The scores obtained were subjected to data analysis. The data were analyzed based on the stated hypotheses, using t-test statistics. The significance of the various statistical analyses was ascertained at 0.05 alpha level.

ANALYSIS OF THE STUDY

The mean scores of students in the experimental and control groups on the pretest were calculated and the t-test computed for the two means. Table(2) shows the results of the analysis.

Table(2)t-test comparison of the experimental and control group at pretest

Variables	N	df	Mean	SD	t-value	p-value
Experimental Group	30	58	18.23	1.547	0.337	0.737
Control Group	30		18.10	1.517		

ns = not significant P>.05

Table (2) presents the t-test of experimental and control group, the mean scoresof the experimental group was 18.23 and 18.10 for the control. The calculated t-value of 0.337 was significant at the 0.05 level. This indicates that there is statistically significant difference between the experimental and control group (t= 0.337, df= 58, p = 0.737). This implies that there is no significant difference in the mean scores of experimental and control group at pretest.

HO_1: There is no significant difference between the mean achievement scores of students exposed to computer-based simulation and those taught using conventional method.

In order to test this hypothesis, t-test was used to analyze the achievement mean scores. The summary of this analysis is shown in table(3).

Table(3)Analysis of the mean achievement scores of experimental and control groups

Variables	N	df	Mean	SD	t-value	Sig.
Experimental Group	30	58	76.17	3.949	20.440	0.000
Control Group	30		57.40	3.114		

Table (3) presents the t-test of experimental and control group, the achievement mean score of the experimental group was 76.17 and 57.40 for the control. The calculated t-value of 20.440 was significant at the 0.05 level. This indicates that there is statistically significant difference between the experimental and control group (t= 20.440, df= 58, p = 0.000). Hence the null hypothesis one (Ho_1) was rejected, indicating that there is a significant difference in the mean scores of experimental and control group.

HO_2: There is no significant gender influence on the achievement of students taught using computer-based simulation.

To test this hypothesis, t-test statistic was also used to analyze the mean scores. The summary of this analysis is shown on table 4.

Table(4)t-test analysis of the posttest mean scores of male and female in the experimental group

Variables	N	df	Mean	SD	t-value	p-value
Male	15	28	76.20	3.858	0.045	0.964
Female	15		76.13	4.172		

ns = not significant P>.05

Table(4) presents the t-test of male and female students of experimental group. The achievement mean scores of the male students were 76.20 and 76.13 for the females. The calculated t-value of 0.045 was not significant at the 0.05 level. This indicates that there is statistically no significant difference between the male and female students taught with computer-based simulation (t= 0.045,df= 28, p = 0.964). Hence, HO_2 was upheld. Therefore, there is no significant difference between male and female students taught with computer-based simulation package.

Discussion

The results of this study showed that the use of computer-based simulationin the teaching of physics enhanced theachievement of the students. This was proved by thedifference in the mean scores of the control and experimentalgroups with the latter group performing significantlybetter. This finding is in line with the findings of Bakaç, Kartal-Taşoğlu and Akbay (2011) found that computer assisted instruction with simulation in science and physics activities increase the academic successes of students in the subject of “Electric Current”. In addition, it support the findings of Kara(2008) who reported that students taught Force and Pressure units in the physics topics using computer-assisted instruction performed and retained more information than those taught using traditional method. Similarly, it agreed with Ufondu (2008) findings that CAI was an effective tool for teaching and learning the concepts of force, work and machines. In general, the findings of this study also agreed with Mohammed (2002), Achinuonye (2011), Gambari, Yaki and Olowe

(2013) who concluded that computer-based simulation courseware had given a positive effect on student's academic performance in visual art education, science and biology respectively.

The superiority of computer-based simulation over conventional teaching method could attributed to students ability to visualize the objects in a 3-dimensional form, learning the concepts in form of drill and practice, receiving immediate feedback, move at their own pace, and ability to repeat practice to consolidate learning and develop competence. All these are not applicable in conventional teaching method.

The study also showed that there is no significantdifference in the performance of the boys and girls in theuse of computer-based simulation in the learning of physics. Inother words, gender does not affect the use of computerin the learning process. This finding agrees with that ofOrabi (2007), Ifamuyiwa and Akinsola (2008), Gambari (2010), Yusuf and Afolabi (2010) and Achuonye (2011)who reported that gender had no influence in the academic performance of male and female students exposed to computer-assisted instruction in physics, biology, and chemistry. The findings did not support the earlier findings of Annetta, Mangrum, Holmes, Collazo and Cheng (2009) who found that female students used computer more than their male counterparts, and males played video games more than females when exposed to forces and motion unit. The finding also contradicts the findings of Anagbogu and Ezeliora (2007) who found that girls performed better than boys in science process skills.

This present study,therefore, tends to give a glimpse of hope erasing genderbarriers against females in science and technology earlierhighlighted byAnagbogu and Ezeliora (2007), and Annetta, Mangrum, Holmes, Collazo and Cheng (2009).

CONCLUSION

The study showed that the use of computer-based simulation improved the academicachievement of students in the teaching and learning ofphysics; and that gender had no effect in the use ofcomputer among the students. In this a rapidly changing technological world, the use of computer-based simulation seems to be the answer in tackling the abstract and difficult concepts in physics. However, a lot still need to be done in the area of teaching and learning using computer-based simulation in Nigeria.

Recommendations

Based on these findingsthe following recommendations were made:

(i) Since this study showed that computer-basedsimulation enhancedacademic achievement, student should be encouraged toown their computers, possibly laptops, to enable themuse it more even in their individual studies.

(ii) Teachers should be encouraged to teach students with computer-based simulation to improved their academic performance in the science courses.

(iii) Design and development of computer-assisted instruction should be infused into pre-service teachers curriculum.

(iv) Both the in-service and pre-service teachersshould be trained to properly trained on the integrationof computer technology in theirdaily classroom processes.

(v) The government and non-governmental agenciesshould equip schools withcomputers and new technologies for easy access by bothteachers and students.

(vi) There should also be provision of functional computer laboratory in schools with regular supply ofelectricity at all times.

(vii) Teachers in schools should be given free computertraining by the government (State and Federal) to enablethem use these new technologies when supplied toschools.

(viii) There is the need to develop relevant "computerassisted instructional" packages for use within theNigerian school system.

Findings and Suggesetion

In this study mothers education and economic status of the family had an inverse relationship with perceived stress and family burden. All mothers reported strong feelings for their child immediately after receiving the news of the disabling condition. The most commonly expressed negative emotion was a feeling of grief or sorrow, which had lessened over time. There were also reports of the negative feeling of shock and guilt which had also lessened over time(Mary 1990).The mothers who are educated have knowledge about mental retardation though they were unhappy during the birth of the children later they accept their child with the disabilities and start to work for the development of their children but mothers who have low educational qualification who don't have knowledge about mental retardation are finding too difficult to accept and understand their children disability. This showed increased mean stress among mothers with less educational qualification. As the mothers' educational level increased the stress level was decreased. As only one fourth of the mothers were graduates, most of the mothers were not professionally occupied the analysis shows that there is a significant association between the level of stress and the mother's educational qualification and occupation. The initial stress in mothers appears to be sex-linked which shifted with time (Faber 1963). Mothers having female children experience more stress while comparing with mothers having male children. This may be because if girl children attained puberty the mothers have to take extra care but these problems do not occur for mothers of male children. Evelinesm sequiera(1990) in his study found that there was no significant difference in the perceived burden with reference to the sex of child among American mothers. The result varies due to cultural changes. It was clear from the results of the present study that there was a statistically significant difference between mothers stress level and their employment status and education. Low stress level was found common among working mothers and those who were educated. Educated mothers can be more helpful in the adaptation process, Jeprrett(1994) showed that the highly educated parents learned to manage their child's illness and move from the early struggle with adaptation to more competent care. These mothers had high level stress and they were also blamed for giving birth to intellectually challenged children. The siblings may feel jealous and even rejected, as the mentally retarded child demands the parent's attention. These feelings are exacerbated by the material deprivation they may also experience due to the increased financial responsibilities towards the disabled child. They may feel ashamed and as a result become socially isolated as they feel that they cannot invite their friends home, as other children often tease them. Frequent feelings of guilt, a tendency to blame the handicapped sibling for the problems in the family and depression may develop over a period of time (Ntombela 1991).This results in siblings rivalry and mothers who were frequently exposed to such situation has high level of stress. The study also says that there is also an association between level of stress and marital relationship of mothers.

The study says that there is an significant association between

mothers stress level and her education and occupation. These mothers also experience high family burden. The rehabilitation centre are giving good training for children's development but giving least importance to the mothers. Based on these conclusions, the rehabilitation institutes should shift their services from child-centered to family centered services by increasing awareness of health maintenance organizations. Rehabilitation centers must involve families in their services through providing psychological assessment for mothers and offering family psychological support service units within the institutes. They must provide educational activities for parents on parenting a disabled child, the availability of services, and how to utilize them. All these services should start once the mentally disabled child is born to help the parents in coping, and should be extensively provided for mothers at more risk to develop high level of stress. The findings can be utilized in developing supportive activities for mothers with disabled children. By recognizing the coping strategies used by the mothers, professionals and service providers can find the right ways to support their adaptation.

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