Efficacy of Virtual Laboratory on the Achievement and Attitude of Secondary School Students in Physics Practical

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Abstract
This study investigated the efficacy of virtual laboratory (VL) on the achievement of secondary students in physics practical in Minna, Niger State, Nigeria. It also examined the influence of gender, retention and attitude on the use of VL. The efficacy of authors developed virtual laboratory package (VLP) for teaching physics practical was determined using Pretest – Posttest Experimental group design. 56, SSII students (28 males and 28 females) were from two secondary schools in Minna Metropolis made-up the sample. The schools were randomly assigned to experimental and control groups (EG & CG). The EG (n =28) was exposed to VLP while the CG (n = 28) was exposed to physical laboratory method (PLM). Three research instruments were used in this study: (i) Physics Practical Achievement Test (PPAT) used as a testing instrument, comprised of 40-item multiple-choices physics achievement test; (ii) Virtual Laboratory Package (VLP) used as a treatment instrument, was made up of three components (text, video and simulated experiment); and (iii Physics Attitude Scale (PAS) comprised of 20, four point Likert type items used to elicit response from the two groups before and after the treatments. The instruments were validated by experts. The Kudar-Richardson (KR=21) formula yielded 0.92 reliability coefficient for PPAT and 0.89 for PAS. t-test statistics was used to test the hypotheses at 0.05 levels of significance. Results of this study showed that the application of the virtual laboratory had positive effects on students' achievements, retention and attitudes when compared to PLM. Gender had no influence on the students exposed to VLP during posttest and retention test. Recommendations were made based on the findings.

Keywords: Virtual laboratory, Physics, Achievement, Gender, Retention, Attitude

Introduction

Science and technology would be incomplete without physics. Physics is applied to almost every human activity, as every profession involves some elements of physics (Michael, 2006). The significance of physics has made it imperative for its inclusion in the Nigerian senior secondary school curriculum for science oriented students (FRN, 2004). In spite of the importance of physics as a requirement for many specialized science and engineering courses at the tertiary educational institutions, students' performance at the secondary school level (high school) in Nigeria is not encouraging (Adegoke, 2011, WAEC, 2012, Yusuf, Gambari & Olumorin, 2012).

The performances of students in physics as a subject in the Senior Secondary School Certificate Examinations (SSSCE) in Nigeria from 2007 to 2012 have been discouraging. The percentage of students that passed physics at credit levels (A1 - C6) had consistently been less than 50% (West African Examination Council [WAEC] Report, 2012). This can be traced to poor performance in physics practical which accounts for 40% of the total marks in SSCE physics examination.

Simple Pendulum, Momentum, Mass of Spring, and Geometric Optics were among the major practical concepts that are problematic. Research findings have confirmed that these concepts among the abstract and complex aspects of physics, which the students find difficult to learn, and some teachers find difficult to teach (NERDC, 1993; Okpala & Onocha, 1988; WAEC, 2005, 2007, 2008, 2009 & 2010).

Students need practical experiences to enable them understand some abstracts concepts in physics, therefore, effective use of laboratory equipment and facilities will improve the mastery of physics concepts. However, most of the public secondary schools in Nigeria are faced with insufficient of laboratory and equipment which limits the teacher to perform just simple laboratory activity (Adejoh & Ityokyaa, 2009). Physical experiments are rarely performed in some public secondary schools in Nigeria due to lack of equipment, facilities and other logistic problems (Adekunle & Hussaini, 2001). In addition, the cost of carrying out experiments, arranging the equipment and laboratory activities are laborious and much time consuming. Checking students' performance during the laboratory activities can be tasking and laborious especially when dealing with large class (Yuysuz, 2010). When taking these challenges into consideration, looking for appropriate alternatives is inevitable, hence, the use of virtual laboratory in supporting the traditional laboratory method or adoption in the absence of physical laboratory can be a logical one.

The potential benefits of virtual laboratory environment for physics practical cannot be underestimated in the contemporary world. Virtual laboratory makes students become active in their learning, provide opportunities for students to construct and understand difficult concepts more easily. Furthermore, it affords the learners some opportunities to overcome mistakes that occur as a result of such laboratory conditions or misuse of the laboratory and enable them to easily overcome the possible dangers that can be seen in the real laboratory conditions (Kerr, Rynearson, & Kerr, 2004; Karamustafaoglu, Aydin & Ozmen, 2005). Pyatt and Sims (2012) explain that using virtual laboratory increases motivation and desire for the lectures in the process of learning. It also provides an affordable, safe, easy and ideal working environment. Furthermore, Budhu (2000) asserts that the short-term purpose of virtual laboratory programme is to support actual physics laboratories, while their long-term purpose is to replace them.

In review of empirical studies on virtual laboratory, Tatli and Ayas (2012) and Shegog, Lazarus, Murray, Diamond, Sessions and Zsigmond (2012) found significant improvement in the performance of students exposed to virtual laboratory than their counterparts in the conventional laboratory method. Flint and Stewart (2010) reported that virtual laboratory was less expensive and ten times faster than a traditional laboratory exercise yet achieved the same learning outcomes for students who were already familiar with laboratory techniques. Tuysuz (2010) found that virtual laboratory package made positive effects on students' achievements and attitudes when compared to conventional laboratory method. Karamustafaoglu, Aydin and Ozmen (2005) found that the teaching by the virtual laboratory package with an applied dynamic system is more successful than the teaching implemented by traditional laboratory method. Alkazemi (2003) also found that students in treatment group completed the virtual laboratory activities in electrochemistry before those in actual physical laboratory. Van-LeJeune (2002) found that the use of computer-simulated experiments and interactive videodisc simulation in science education classrooms improve students problem solving ability and other higher-order thinking skills when compared to traditional science laboratory activities.

However, Hall (2000); Jimoyiannis and Komis (2000); Bayrak, Kanlı & Kandilİngeç (2007) did not find any difference between the performance of students taught with virtual laboratory and those taught with traditional laboratory method. Similarly, Moslehpour (1993) reported no significant difference between the students taught using computer simulation in an electronics class laboratory and those taught using conventional class laboratory method.

Gender issues have been linked with performance of students in academic tasks in several studies but without any definite conclusion. Some studies revealed that male students performed better than the female in science courses. For instance, Kost, Pollock and Finkelstein (2009) found that male students performed better than female in interactive physics, while Anagbogu and Ezeliora (2007) found that girls performed better than boys using science process skills method of teaching. However, Adeyemi (2008), Gambari (2010) and Orabi (2007) reported that gender had no influence on academic performance of students. Therefore, part of this study examined the influence of female and male students exposed to the same amount and types of experiences in physics practical using virtual lab package in order to determine whether gender have any influence on students' performance.

Retention is a crucial issue in learning science concepts. In some review of empirical studies on retention in science concepts, Lux (2002) found that there was 80% increase in retention rate when students were exposed to virtual laboratory during microbiology class. Similarly, Kara (2008) reported that using computer assisted instructional package improved the achievement and retention of students in science education. Also, they did not find any gender difference in achievement and retention of students taught in virtual laboratory package and computer assisted instructional package with microbiology and science.

Attitude is one of the factors that influence students' performance in learning. Attitude can be viewed as a predisposition to respond in a favorale or unfavourable manner with respect to a given subject (Okobia & Ogumogu, 2012). Several researches in developed nations reported that students liked to work with simulation program. For instance, Josephsen and Kristensen (2006) investigated undergraduate chemistry students' response to the SimLab computer-based learning environment, the results revealed that students enjoyed working with it, they found it motivating, and realised that it created a lot of experience, which they believed could be remembered more easily. Pyatt and Sims (2012) reported that students showed preference towards the chemistry virtual laboratory than physical laboratory.

From foregoing, most of the earlier studies from developed countries indicate that virtual laboratory could be an effective instructional tool for enhancing students' performance in sciences. However, there is very little research on the effectiveness of virtual laboratory for conducting physics practical at the senior secondary school level in Nigeria. Virtual laboratory is a new innovation in Nigerian education system particularly at secondary school level, therefore, this study examined the effect of researcher developed virtual laboratory on the performance of secondary school students in physics practical in Minna, Niger State, Nigeria.

Purpose of the Study

The purpose of this study was to determine the efficacy of virtual laboratory package on the achievement and attitude of secondary school students in physics practical. Specifically, the study examined the:

(i) effect of virtual laboratory package on the achievement and retention of students taught physics practical.

(ii) influence of gender on the achievement and retention of students taught practical physics with virtual laboratory package.

(iii) students' attitude towards physics practical before and after virtual laboratory package and physical laboratory method.

Research Hypotheses

The following null hypotheses were formulated:

Ho_1 There is no significant difference between the mean achievement scores of students who had physics practical with virtual laboratory package and those with physical laboratory method.

Ho_2 There is no significant difference between the mean achievement scores of male and female students taught physics practical using virtual laboratory package.

Ho_3: There is no significant difference in the mean retention scores of students exposed to virtual laboratory package and those exposed to physical laboratory method.

Ho_4: There is no significant difference in the mean retention scores of male and female students exposed to virtual laboratory.

Ho_5: There is no significant difference in the pre-test and posttest mean attitude scores of students exposed to virtual laboratory (VL) and those exposed to physical laboratory method (PLM).

Methodology

Research Design: The research design adopted was a pretest, posttest, experimental and control group design. Two levels of independent variable (one treatment and a control), two levels of gender (male and female) were investigated on students' performance in physics practical. The two groups were first pretested. After four weeks treatment, posttest was administered and four weeks later retention test was administered using Physics Practical Achievement Test (PPAT).

Population and Sample: The target population for the study was all the year II Senior Secondary (SS II) physics students in Minna, Niger State, Nigeria. The sample for the study was made up of 32 SS II students, 16 male and 16 female students from two public co-educational secondary schools. Three stages of sampling technique were adopted. Firstly, two senior secondary schools in Minna, Niger State were purposively sampled based on: equivalent (manpower and physics facilities); composition (mixed schools); facilities (SchoolNet programme); exposure (availability and usage of computer); years of experience (presenting candidates for SSCE physics examination for a minimum of ten years). Secondly, the schools were randomly assigned to each of the experimental group (VL) and control group (PLM). Thirdly, a stratified random sample of 28 students (14 males and 14 females) from each school was employed.

Research Instruments: Three research instruments developed for this study were: (i) Treatment Instrument, (ii) Physics Practical Achievement Test, and (iii) Physics Attitude Scale. Virtual Laboratory Package (VLP) for senior secondary school physics practical, developed by the researchers is a treatment. The necessity for researcher-made VLP was based on the fact that the commercially produced VLP are not common in Nigeria. Even, if they are available they may not be directly relevant to the topic or objectives of the study and may not culturally relevant to Nigeria environment. As a result of this, developing a VLP was inevitable. The VLP package was written in html format using “Macromedia Dreamweaver 8” as the overall platform. Other computer programmes and applications that were also utilized during the development process are Microsoft Word, Macromedia Fireworks 8, and Macromedia Flash 8. Macromedia Fireworks was used for specific texts, graphics and buttons, while Macromedia Flash was used for simulation.

(i) The video demonstration of physics practical embedded in the VLP was recorded using digital camcorder camera. The package was validated by computer programmers and educational technology experts; subject content (physics) specialists; and finally field tested on sample representative similar to the students used for the final study. The VLP contained four SSCE physics topics, namely: Simple pendulum (lesson 1), Mass on spring (lesson 2); Change in momentum (lesson 3); and Image on a convex lens (lesson 4). The main menu of the package consisted of introduction, students’ registration, list of practical lessons as in lesson 1, 2, 3, & 4 and exit. The VL is divided into three sections, namely: Lesson Note section, where students read the experimental procedures; Video section, where the students watch a practical demonstration of the experiment; and virtual laboratory section, where the students perform the experiment. VLP adopted the simulation modes of Computer-Assisted Instruction (CAI). The production of the package was effected through a team of professionals and specialists including the system programmer, computer operator, cameraman, video editor and the instructional designers (the researchers). Dick and Carey (2005) instructional development model was adapted to develop the package.

(ii) Physics Practical Achievement Test (PPAT) is researcher-adopted test in student used for data collection. The PPAT consist of 40-multiple choice objective items with five options adopted from past examination of West African Examinations Council (WAEC, May/June, 1988-2010) and National Examination Council (NECO, June/July, 2000-2010). The PPAT was based on the contents of the VLP package. Students were required to indicate their correct answers by ticking one of the letters (A - E) that corresponded to the correct option in each item. This instrument (PPAT) was administered to the experimental and control groups as pre-test, posttest and again for the retention test after the options had been reshuffled. ‘1’ mark was awarded for each correct answer. Thus, maximum score was 40 marks. The items were validated by experts in physics education and computer science department, and tested for reliability using 20 randomly selected SSII students. The test was administered once on the pilot samples. A reliability coefficient of 0.92 was obtained using the Kuder Richardson (KR-21).

(iii) Physics Attitude Scale (PAS) was developed for measuring the attitude of students toward physics. It has 20-item using four point Likert type. PAS reliability of 0.89 was obtained using Kuder-Richardson (KR-21) formula.

The objectives and the modalities of the experiments were specified and operational guide was produced before the commencement of the treatment. The physics teachers in the experimental group were trained as research assistants in the use of the VLP for one week. The control group teachers were informed to prepare the lab for usual PLM.

The researcher administered the PPAT as a pre-test to ascertain the equivalence of the students before treatment. Treatment was followed immediately. Each group was given a pre-lab instruction for ten minutes followed by laboratory activities specifically designed for each group. For treatment group, VLP was installed on stand-alone computer systems. The physics practical contents were presented through the computer and the students interacted and responded to the computer prompts. The VLP presents information in textual, video and simulation formats and students studied the topics in such order. In the simulation section of the package, an interactive animation platform was displayed, students selected some parameters required and started the virtual experiment. Thereafter, PPAT was administered as posttest to measure the achievement of the sampled students in each school. Four weeks later, PPAT was reshuffled and re-administered as retention. PAS was administered as a pretest before the experiment, after the treatment, it was administered as a posttest to determine the students' attitude towards the course. The scores obtained were subjected to data analysis. The data were analyzed based on the stated hypotheses, using mean, standard deviation and t-test. The significance of the various statistical analyses was ascertained at 0.05 alpha level.

Results

To test for the hypotheses, the data were analysed using t-test statistics with Statistical Package for Social Sciences (SPSS) version 15 at 0.05 alpha level. To analyse the pretest data, the mean scores of the experimental and control groups were computed and compared using t-test.

Hypothesis One: There is no significant difference between the mean achievement scores of students who had physics practical with virtual laboratory package and those with physical laboratory method.

In testing the hypothesis, Pre-tests of all CG and EG, and post-tests of all CG and EG were compared separately to see whether methods used in this study affected students' achievement levels. The results of the analysis are presented in Table 1.

Table 1: t-test comparison of pretest and posttest mean scores of the experimental and control groups

Type of Tests	Variable	No. of samples	df	Mean	SD	t-value	Sig.(2-tailed)
Pretest	CG	28	54	20.00	4.683	0.782^{ns}	0.438
	EG	28		19.07	4.189		
Posttest	CG	28	54	62.86	3.669	6.302*	0.000
	EG	28		77.50	11.736		

ns: Not Significant at 0.05 level.
*Significant at 0.05 level

Table 1 presents the t-test results of the experimental and control groups in the pretest and posttest. Table 1 shows that there was no significant difference between the experimental (EG) and control group (CG) students' pre-test results (t_{cal} = 0782, df = 54, p = 0.438). In other words, students in control and experimental groups had similar knowledge entry level before the study.

Table 1 also shows that posttest results was significantly different depending on the instructional methods used (t_{cal} = 6.302, df = 54, p = 0.000).

The experimental group with a mean of 77.50 outperformed the control group (62.86). Also the mean gain of the CG was 42.00 (from 20.00 to 62.00) while that of EG was 58.43 (from 19.07 to 77.50). These results indicate that students who used VLP for physics practical were more successful than those students who used physical laboratory method. On the basis, hypothesis one is rejected.

Hypothesis Two: There is no significant difference between the mean achievement scores of male and female students exposed to physics practical using virtual laboratory package.

Posttest scores of male and female in the EG were compared to see whether virtual laboratory package used in this study affected students' gender. The results of the analysis are presented in Table 2.

Table 2: t-test comparison of posttest mean scores of male and female students taught physics practical using virtual laboratory package

Group	Gender	No. of Samples	df	Mean	SD	t-value	p-value
	Male	14	26	75.86	12.184	0.734^{ns}	
EG	Female	14		79.14	11.481		0.469

ns: Not Significant at 0.05 level

Table 2 presents the results of male and female students who did physics practical using virtual laboratory package. From the table, the calculated t-value (t_{cal} = 0.734, *df* = 26, *p* = 0.469) was not significant at 0.05 alpha level. On this basis, hypothesis two was not rejected. Therefore, there is no significant difference between the mean achievement scores of male and female students taught physics practical with the virtual laboratory package.

Hypothesis Three: There is no significant difference in the mean retention scores of students exposed to virtual laboratory package and those exposed to physical laboratory method.

Retention scores of all CG and EG were compared to see whether methods used in this study affected students' retention levels. The results of the analysis are presented in Table 3.

Table 3: t-test comparison of retention mean achievement scores of the experimental and control groups

Variable	No. of Samples	df	Mean	SD	t-value	Sig.(2-tailed)
CG	28	54	60.29	3.430		
EG	28		73.71	11.165	6.084*	0.000

*: Significant at 0.05 level

Table 3 shows the t-test comparison of the retention mean scores of the experimental and control groups. From the Table, the calculated t-value (t_{cal} = 6.084, *df* = 54, *p* = 0.000) was significant at 0.05 alpha level. On this basis, the null hypothesis was rejected, therefore, there is significant difference between the experimental and control group result favouring the experimental group which used virtual laboratory package.

Hypothesis Four: There is no significant difference in the mean retention scores of male and female students exposed to virtual laboratory. The result is presented in Table 4.

Retention of male and female in EG were compared to see whether virtual laboratory package used in this study affected students' gender. The results of the analysis are presented in Table 4.

Table 4: t-test comparison of retention mean achievement scores for male and female students exposed to physics practical using virtual laboratory package

Group	Gender	No. of Samples	df	Mean	SD	t-value	Sig(2-tailed)
	Male	14	26	75.00	11.246	0.602^{ns}	
EG	Female	14		72.43	11.352		0.552

ns: Not Significant level 0.05

Table 4 presents the result of the retention scores of male and female students that were taught physics practical using virtual laboratory package. From the Table, the calculated t-value (t_{cal} = 0.602, *df* = 26, *p* = 0.552) was not significant at 0.05 alpha level. On this basis, hypothesis 4 was not rejected, therefore, there is no significant difference between the mean retention scores of male and female students taught physics practical with the virtual laboratory package.

Hypothesis Five: There is no significant difference in the pre-test and posttest mean attitude scores of students exposed to virtual laboratory (VL) and those exposed to physical laboratory method (PLM).

Pre-tests of all CG and EG, and post-tests of all CG and EG compared separately to see whether instructional methods used in this study were affected students' attitudes toward to physics. The results of the analysis are presented in Table 5.

Table 5: t-test comparison of pretest and posttest mean attitude scores of students exposed to physics practical using VLP and PLM

Types of Test	Group	No. of Samples	df	Mean	SD	t-value	Sig(2-tailed)
Pretest	CG	28	54	32.271	7.627	0.102^{ns}	
	EG	28		32.493	8.525		0.919
Posttest	CG	28	54	49.150	8.294	6.134^{*}	
	EG	28		60.093	4.505		0.000

ns: Not Significant level 0.05

Table 5 shows that pre-test of Physics Attitude Scale (PAS) scores of CG and EG are not significantly different from each other (CG = 32.271; EG = 32.493), (t_{cal} = 0.102, df = 54, p = 0.919), on the other hand, the post-test mean scores are significantly different (CG = 49.150; EG = 60.093), (t_{cal} = 6.134, df = 54, p = 0.000). On this basis, the null hypothesis was rejected. This implies that students developed positive towards physics after exposed to virtual laboratory method, therefore, change in attitude to the subject was based on the instructional method used in this study.

Discussion of Findings

The results of hypothesis one reveals that students exposed to physics practical using virtual laboratory package performed better than those with conventional laboratory method. This finding agrees with the earlier findings of Van-LeJeune (2002), Alkazemi (2003), Karamustafaoglu, Aydin and Ozmen (2005), Tuysuz (2010), Tatli and Ayas (2012) and Shegog; Lazarus; Murray; Diamond; Sessions and Zsigmond (2012), who established that virtual laboratory than conventional laboratory method.

However, the findings disagree with the findings of Hall (2000); Jimoyiannis and Komis (2000); Bayrak, Kanlı & Kandilİngeç (2007) which did not find any difference between the performance of students taught with virtual laboratory and those taught with traditional laboratory method. Similarly, it contradicts the findings of Moslehpour (1993) which reported no significant difference between the students taught using computer simulation in an electronics class laboratory and those taught using conventional class laboratory method.

The superiority of virtual laboratory package over the conventional laboratory method stems from the fact that they are task structured (i.e. reading the pre-laboratory instruction; watching the video demonstration; and practice as many times as possible by varying the parameters in a simulated platform). Virtual laboratory package is activity based which arouses students' interest; it is stress free because virtual materials, facilities, and equipment are readily available. These could be part of factors that are responsible for students' better performance.

The results of hypothesis two shows that there is no gender effect on the achievement of male and female students taught physics practical with VLP. This finding agrees with the earlier findings of Adeyemi (2008), Gambari (2010) and Orabi (2007) who reported that gender had no effect on academic performance of students in chemistry, physics and biology respectively. However, the findings disagree with the findings of Kost, Pollock, and Finkelstein (2009) who found that male students performed better than female in interactive physics. Also, it contradicts the findings of Anagbogu and Ezeliora (2007) who reported that girls performed better than boys using science process skills method of teaching. The finding is not supported by the findings of ChanLin and LihJuan (2001) who found that gender effect was significant among girls and insignificant among boys while using computer assisted learning with different presentation formats (animation, still graphics, and text).

The results of hypothesis three shows that students exposed to physics practical with VLP had better retention of the contents than those taught with PLM. This finding agree with earlier findings of Lux (2002) who found that students retention was increased by 80% after exposed to virtual laboratory in microbiology course. Similarly, it agree with the findings of Kara (2008) who reported that using computer assisted instructional package improved the achievement and retention of students in science education.

The results of hypothesis four shows that there was no gender effect on the retention of male and female students exposed to physics practical with VLP. This finding agrees with earlier findings of Adeyemi (2008), Gambari (2010) and Orabi (2007). However, it disagree with the earlier findings of Kost, Pollock, and Finkelstein (2009), Anagbogu and Ezeliora (2007) and ChanLin and LihJuan (2001) which reported gender bias.

The results of hypothesis five shows that students taught physics practical with VLP developed positive attitudes towards the course than those taught with PLM. This finding agrees with the earlier findings of Josephsen and Kristensen (2006), and Pyatt and Sims (2012) who reported that students enjoyed working with virtual laboratory, showed preference towards the virtual medium in their lab experiences, found it motivating, and gained a lot of experience, which they believed could be remembered more easily.

The findings in this study have strong implications for teaching and learning of physics practical in senior secondary schools in Nigeria using virtual laboratory package. Major implication of these findings is that virtual laboratory package is better than conventional laboratory method. Furthermore, the findings provide sound empirical basis which indicate that performance of students in physics practical would be improved if students are exposed to varieties of virtual laboratory strategies in all aspect of physics curriculum in particular and science in general.

Conclusion

From the above findings, it can be deduced that virtual laboratory package produced more positive effect on students learning outcomes. It is gender friendly and improves students' retention in physics practical. This package is therefore better approach for teaching practical physics at senior secondary schools in Nigeria. Through the use of virtual laboratory package, practical content can be delivered in simplest, motivating and interactive manners. This would put into rest the age long poor performance in physics practical in Nigeria.

Recommendations

Based on the major findings of this study, the following recommendations are proffered.

(i) Teachers should expose physics students to virtual laboratory package so as to promote active learning, discovery learning, motivation, learning by doing and learning by experience among students.

(ii) In addition, Federal and State ministries of education and other educational agencies (NERDC, NTI, NUC, etc.), NGOs, UNICEF, UNESCO, and other education and stakeholders should organize workshops on the use of virtual laboratory package to enhance better performance of secondary school students.

(iii) Teacher education programme in Nigerian tertiary institutions should be improved upon to prepare teachers who can apply innovative approached (virtual laboratory instructional package), which will promote effective teaching and learning.

(iv) The instructional designers, computer programmers, instructional developers should develop relevant virtual laboratory package packages for use within the Nigerian school systems.

References

Adejoh, M. J. & Ityokyaa, F. M. (2009). Availability and adequacy of laboratory and workshop resources in secondary schools in Benue State, Nigeria. *Journal of Research in Curriculum and Teaching, 4(1),304-311*

Adeyemi, B. A. (2008). Effects of cooperative learning and problem-solving strategies on junior secondary school students' achievement in social studies. *Electronic Journal of Research in educational Psychology, 6*(3), 691–708. Retrieved February 13, from http://www.springerlink.com/content/c19u25816754q5j5/

Alkazemi, E. (2003). *The effect of the instructional sequence of a computer simulation and a traditional laboratory on middle-grade students' conceptual understanding of electrochemistry.* Unpublished doctoral dissertation, University of Florida.

Anagbogu, M. A. and Ezeliora, B. (2007).Sex differences and scientific performance. *Women Journal of Science and Technology, 4, 10-20.*

Bayrak, B., Kanlı, U. & Kandilİngeç, Ş. (2007). To compare the effects of computer based learning and the laboratory based learning on students' achievement regarding electric circuits. *The Turkish Online Journal of Educational Technology,* 6(1), 15-24.

Budhu, M. (2000). *Interactive multimedia web-based courseware with virtual laboratories.* In Proceedings of the CATE Computers and Advanced Technology in Education 2000 Conference. Cancun, Mexico, 19-25.

Dick, W. & Carey, L. (2005). *The systematic design of instruction (4th edition).* New York: Harper Collins College Publishers.

Federal Republic of Nigeria, (2004). *National policy on education.* Lagos: Federal Government Press.

Flint, S, & Stewart, T. (2010). Food microbiology-design and testing of a virtual laboratory exercise. *Journal of Food Science Education, 9(4), 84-89*

Gambari, I. A. (2010). *Effect of computer-supported cooperative learning strategies on the performance of senior secondary students in physics, in Minna, Nigeria.* Unpublished Ph.D thesis, University of Ilorin, Ilorin, Nigeria.

Hall, T. (2000). Quantitative analysis of the effectiveness of simulated electronics laboratory experiments, *Journal of Engineering Technology*, 17(2), 60-66.

Jimoyiannis, A. &Komis, V. (2000). Computer simulations in physics teaching and learning: A case study on students' understanding of trajectory motion. *Computers & Education, 36, 183-204.*

Josephsen, L. & Kristensen, A. (2006), Simulation of laboratory assignments to support students' learning of introductory inorganic chemistry. *Chemistry Education Research and Practice*, 7(4), 266-279.

Kara, İ. (2008). The effect on retention of computer assisted instruction in science education. *Journal of Instructional Psychology,* 35(4), 357-364.

Karamustafaoğlu, O., Aydın, M. & Özmen, H. (2005). Bilgisayar destekli fizik etkinliklerinin oğrenci kazanımlarına etkisi: BasitHarmonik hareketorneği. *The Turkish Online Journal of Educational Technology, 4(4), 67-81.*

Kerr, M. S., Rynearson, K. & Kerr, M. C. (2004).Innovative educational practice: using virtual labs in the secondary classroom, *The Journal of Educators Online*, 1(1), 1-9

Kost, L. E., Pollock, S. J. & Finkelstein, N. D. (2009). Characterizing the gender gap in introductory physics. *Physics Education Research, 5(1) 1-14.*

Lux, M. F. (2002). An activity-based format increased student retention in a community college microbiology course. *Journal of microbiology and biology education, 3(1).* Retrieved on the 2nd Feb., 2012 from http://jmbe.asm.org/index.php/jmbe/article/view/64/html_34

Michael, P. (2006). *The importance of physics: Breakthroughs drive economy, quality of life, world leaders, public increasingly take scientific advances for granted.* Retrieved April 29 2007, from http://www.physics2005.org.

Moslehpour, S. (1993). *A comparison of achievement resulting from learning electronics concepts by computer simulation versus traditional laboratory instruction.* Unpublished doctoral dissertation, Iowa State University.

Okobia, E. O. & Ogumogu, E. A. (2012. Attitude of secondary school students towards the teaching profession. *Journal of Research in Curriculum and Teaching, 6(1)493-499.*

Orabi, I. I. (2007). Gender differences in student academic performance and attitudes in an introductory engineering course. *American Society for Engineering Education Journal, 9(3), 68-75.*

Pyatt, K. & Sims, R. (2012). Virtual and physical experimentation in inquiry-based science labs: Attitudes, performance and access. *Journal of Science Education and Technology, 21(1), 133-147.*

Tatli, Z. & Ayas, A. (2012). Virtual chemistry laboratory: Effect of constructivist learning environment. *Turkish Online Journal of Distance Education, 13(1), 183-199.*

Tuysuz, C. (2010). The effect of the virtual laboratory on students' achievement and attitude in chemistry. *International Online Journal of Educational Sciences, 2010, 2 (1), 37-53.*

Van-LeJeune, J. (2002). *A meta-analysis of outcomes from the use of computer simulated experiments in science education.* Unpublished Ph.D dissertation, Texas A&M University.

West African Examination Council, (2007, 2008, 2009, 2010 & 2011). May/June. *Chief Examiner's Report*. Lagos: WAEC.