Web-based interactive problem-solving tutorial as a tool for conceptual change among physics students

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Abstract

This study investigated the effect of web-based interactive problem-solving tutorial as a tool for conceptual understanding among physics students. A pre-test, post-test, control group quasi-experimental design was adopted for the study. Multistage sampling technique was used to select four public secondary schools comprising of 169 Senior Secondary School Il physics students from Mbaitolu Local Government Area ofImo State. Schools were assigned to treatment groups of web-based interactive problem-tutorial (YVET) and conventional lecture method (CLM). The instrument for data collection were work and energy achievement test (r— 85) and physics interest questionnaire (r— 0.84). Three research questions guided this study and mere null hypotheses were tested at 0.05 level of significance. Data was analyzed using MANCOVA Treatment had significant effect on achievement R 0.79, F (2,162) 21.87; P<0.05, partial? — 0.213 with effect size of 21.39% and interest F (1.163) 4.12; P<0.025, partial 0.025 with effect size of 2.5%. Also, there was significant effect of gender on dependent variable (achievement and interest) X 0.87, F (2,162) = 11.73; P <0.01, partial? 0.126 with effect size of 12.6%. web-based interactive problem-solving tutorial should be introduced into Nigerian educational system for optimal performance of students. Keywords: web-based, problem- solving, interactive, tutorial, conceptual change

Introduction

Research has shown that students' conceptions in physics often differ from acceptable scientific view or established facts. Cataloglu and Ates (2013) stated that these conceptions commonly referred to as misconceptions or alternative conceptions usually emanate from different sources which could be the learner, the teacher or the textbook.

The teacher is a major player in teaching and learning process, therefore, needs to be adequately equipped to facilitate learning. However, many teachers are either not versatile enough in the subject matter or deficient in the pedagogical skill. These factors constitute sources of misconception or alternate conception without the teacher being aware of it (Bayraktar, S. 2009).

Textbooks are also sources of alternate conception. This could emanate from inadequate explanations, illustrations, abstract analogies or inadequate examples. When facts are not explained explicitly either by a teacher or in a textual material, it could generate disequilibrium in the learner which leads to misconception. The 2012 revised edition of the physics curriculum document places emphasis on structure and special features which are basic science and technological component of curriculum (Igbokwe 2015). Emphasis was laid on the need to use textbook which promotes innovative instructional strategy. It is therefore expedient to revise textbooks to match the innovative approach to teaching of science for good conceptual understanding. The type of illustration that is used in textbooks may not be able to confront alternate conception mainly because these illustrations could only be represented in one dimension. Therefore, there is need to ascertain if the web-based interactive problem-solving tutorial with the "physics classroom" as a teaching tool could promote learning better than the conventional method.

Conceptual understanding involves the ability of the learner to recognize the relationship among bits of facts, concepts or procedures in order to be able to demonstrate good understanding of the subject matter. Conceptual understanding enables the learner to apply the understanding of a concept or phenomenon to a completely different or new situation which will result to a conceptual change (McDermott 2004). Conceptual understanding in learning is the ability to facilitate or re-construct knowledge in the learner by the building of more coherent network of knowledge from a less coherent one instead of replacing old knowledge system (Ozmen 2008; Kola 2017).

Sahin (2006) reported after research that many learners lack a coherent understanding of physics. Also, learners encounter some difficulties when trying to apply what is being taught to different situations. Learners are faced with the difficulty of applying the principles of physics to real life situations. This difficulty according to Chukwunenye (2018) is believed to have emanated from the altemate conception which according to Cataloglu and Ates (2014) is a well-established system of common-sense belief about how the physical world works. This system of belief is deep-seated. It is also an established fact that the conventional way of teaching physics today cannot challenge this system of belief (Duit & Treagust, 2012). Unfortunately, many classroom instructors are not conscious of the nature of these belief systems or alternate conception that is deep seated and strongly opposed to change.

Learners' cognition is domain specific; also, the learner is a universal novice at least in the area this learner intends to acquire knowledge. The major difference between the novice and an expert which the teacher represents is the level of knowledge that each of them possesses. Therefore, conceptual change in learning is to facilitate the learners' knowledge reconstruction through building a more coherent knowledge network from a less coherent network instead of replacing the old knowledge system which is difficult and could result to more incoherence in the long run (McDermott 2004). Research has shown that the learning experiences presented in the classroom may not enhance conceptual understanding. This is because the usual quantitative approach to problem-solving

alone is viewed by the learner as exercises where figures are manipulated to get results. The learner has little or no understanding of the physics concept behind the mathematical operations. Secondly, the abstract nature of physics has also made the qualitative presentation of physics concepts result in rote learning (Chukwunenye, Ihekwaba & Adegoke 2019; Singh 2009; Catalogiu &Ates 2013). It could therefore be deduced that many classrooms teaching or instructions are totally ineffective. This is because students' cognition and background in physics varies significantly and this makes it impossible even for a conscientious teacher to adequately meet the instructional need of the learner without a level of individualized instruction which is provided by web-based instruction (Duit & Treagust, 2012).
Web-based interactive problem-solving tutorials is a model developed by Chandralelåa Singh, a professor in the department of physics and astronomy at the University of Pittsburgh in the United States of America. This model is a combination of problem-solving method of teaching and tutorial method of teaching to develop an online instructional strategy with teaching materials which are self-paced study tools.

The tutorial did not only provide a model to problem-solving but also provided help and feedback that exemplify a systematic approach to problem-solving (Singh 2008; Singh 2009). Each tutorial problem is matched with another problem which the developer referred to as paired problems. These sets of paired problems are presented to the learner sequentially. The first one at the beginning of the lesson, and the other one at the end of the lesson. The second paired problems play an important role at the weaning stage of the learning model. This is because it is used to verify if the learner has developed self-reliance and is also able to solve problems based on related principle without any assistance. These paired problems could also serve as homework. The work is supported by National Science Foundation (NSF) while the tutorial is developed and evaluated by From on Education of American Physical Society (APS).

The web-based interactive problem-solving tutorial is a teaching model that uses 'the physics classroom' as one of the online teaching tools. The physics classroom is a website programme written and developed in 1989 by Tom Henderson, a physics and chemistry teacher. It was originally developed and used by Glenbrook High School before it was fill there developed and now rated as online teaching tools of American Physical Society (APS). Similar package was also developed for mathematics and chemistry. There are online homework system already being exploited in introductory physics lessons which are web Assign, LON CAPPA and Mastering physics.

Web-based interactive tutorial combines both quantitative and qualitative approach to problem-solving in learning physics. It focuses on helping learners to develop functional understanding of physics while learning useful skills. This is because research has shown that using only the usual quantitative approach to problem-solving alone could be viewed as an exercise where figures are manipulated to get a result with very little understanding of the physics concept behind the mathematical operations or exercises in focus. Also, qualitative approach or conceptual problems alone are often viewed as guess tasks (APS 2008; Singh 2013). Web-based interactive problem-solving tutorial therefore create ample opportunity for the learner to tackle mathematical physics problem as a learning opportunity instead of mere mathematical exercises. It also provides structural approach to problem-solving and promotes active engagement while helping students develop self-reliance. In this kind of instructional strategy, the computer acts as a tutor as it presents the information and extends to chill and practice, simulations or games for proper explanation of the concepts involved. This is because the design of web-based problem-solving tutorial as a full package is guided by cognitive apprenticeship learning paradigm. It also provides responses to every learning activity and option explaining why the response is either wrong or correct. An effective web-based interactive problem-solving tutorial is a combination of tutorial and problem-solving method which uses 'the physics classroom' as a teaching tool. Tutorial includes three stages which are; modeling -+ coaching -Y weaning. Modeling involves demonstrations or exemplifying of skills for the naive learner by the teacher as a way of exposing the learner to the required task or learning experience. Coaching provides the learner opportunity, guidance and practice so as to become actively engaged and improves consistently towards mastery. From coaching to weaning stage, support and feedback gradually reduces so as to enable the learner develop a level of self-reliance (DeVore, Marshman & Singh 2017). In problem-solving, the teacher is actually aimed at developing in the learner critical thinking approach to learning by exposing them to learning experiences that will elicit the related skills which aids the development of critical thinking. The following steps are therefore essential components of problem-solving approach (i) quantitative analysis (ii) planning/making decisions (iii) implementation (iv) reflection and assessment (APS 2008).

Adegoke & Chukwunenye (2013) stated that interest is a very important factor to learning. This is because without interest, learning cannot take place. It is imperative for the teacher to find ways to capture or arrest the interest of the learner in order to facilitate learning. Nwachukwu (2012) provided evidence of lack of interest of learners in physics, he identified the abstract nature of physics as a factor that generates lack of interest to the learner hence, web-based interactive problem-solving tutorial appears to have the potentials of amassing the interest of the learner for learning to take place.

Statement of Problem

Learners encounter difficulty in applying classroom instruction or knowledge to a real life situation. This is because many students lack the basic skills required to solve problems in physics. The application of the usual quantitative approach to problem-solving alone sometimes tums out as an exercise where figures are manipulated to get result with very little understanding of the physics concept behind the mathematical operations or exercises in focus. Also, qualitative approach or conceptual problems alone are often viewed as guess tasks.

Hence, many students learn by rote in order to pass their examinations. There is therefore need to find ways or method that could challenge the learner to critical thinking and at the same actively engage the learner towards mastery. It is against this background that the research investigated web-based interactive problem-solving tutorial as a tool for conceptual change in physics students.

The following research questions and hypothesis guided the study;

Research Questions

l. What is the mean achievement score of physics students taught using web-based interactive problem-solving tutorial and those taught using the conventional method?
2. What is the mean interest score of physics students taught using interactive web-based problem-solving tutorial and those taught using the conventional method?

Research Hypothesis

1. There is no significant main effect of treatment (WIT and CLM) on dependent variable (Achievement and Interest)
2. There is no significant main effect of gender on dependent variable (Achievement and Interest)
3. There is no interaction effect of treatment (WIT and CLM) and gender on dependent variable (achievement and interest)

Framework

Wolfgang Kohler Cognitive theory

This study is hinged on the theory proposed by a German psychologist by the name Wolfgang

Kohler in 1920. It is a cognitive theory referred to as insightful learning. Wolfgang Kohler proposed that insightful learning is the abrupt realization of a problem's solution. It is not learning that occurs as a result of trial and error, observing someone else attempt the problem or responding to environmental stimuli, rather it is learning that occurs as a result of cognitive experience emanating from the ability of the learner to visualize problem and proffer the solution internally (Kohler 2015). Insightful learning is considered a type of learning because it results in a long lasting-change following the occurrence of insight. The realization of how to solve the problem can be repeated in a future similar situation. Insightful learning happens regularly all around us. Inventions and innovations alike are often times as a result of insightful learning. It is often the root of creativity (Wittmann & Thompson 2008).

The implication of this theory to this work is that learning occurs when what is learnt in a situation is applied to solve problems in real situation. Problem-solving techniques would be said to have been implored by the learner when withdrawn for a while to analyze and reflect on the existing problems. This theory is greatly related to this study because when a problem is presented to the learner in the form of tutorial, the learner would have to cany out mental reflection and other cognitive exercises in sequence to discover how to unravel or solve the problem.

iii. Methodology

A pre-test, post-test, control group quasi-experimental design was used for the study Web-based interactive problem-solving tutorial (WPT) was used for the experimental group with a control group as conventional lecture teaching method (CLM). The dependent variables are interest and achievement, while gender is the moderator variable. Preliminary investigation showed there are twenty-two public secondary schools in Mbaitoli Local Government Area. Purposive sampling was used to select the ten secondary schools that have; (i) regular physics teachers and (ii) computer laboratory. The ten schools were further stratified into two groups; (schools with computers and schools without computers). Random sampling was used to select two schools each from the two groups to constitute the experimental group and control group respectively. A total of 169 senior secondary school two students of intact classes in Mbaitoli Local Govern ment Area ofImo state took part in the study. WPT group = 94, CLM group 75,

schools were randomly assigned to treatment groups. The instructors and research assistants were trained within the first two weeks before the treatment commenced. The treatment lasted for about six weeks.

Research Instruments

The instruments used for data collection were;

1. Work and energy test (WET)
2. Physics students' interest questionnaire (PSIQ)
3. Online Physics Classroom (OPC)

Work and Energy Diagnostic Test (WET): This is a multiple-choice test adapted by the researcher from an online teaching tool called 'The Physics Classroom'. The items were based on the concept of work and energy. WET is divided into four sections; each section contains questions based on different levels of conceptual understanding on the concept of work and energy. Twenty questions representing five from each section or level were teased out to constitute the work and energy diagnostic test OWET). These objective test items were prepared by experts, validated and introduced for use in high schools especially in America as part of 'the physics classroom'. Each test item was modified by the researcher into four options (A, B, C,D) from the original five-option format.

Validity of Instruments

The questions were selected from a standard international online physics classroom tutorial designed for high schools by expert to showcase different levels of conceptual understanding. However, the researcher revalidated this instrument by administering the modified form to some senior secondary school Il physics students who were not part of the study. The item difficulty index of 4.0 was obtained using Ruder Richardson 20 (KR20) the validity was established as 0.90. The internal consistency was determined and the reliability index of0.92 was obtained.

Physics Students' Interest Questionnaire (PSIQ): This instrument was designed by the researcher to ascertain the level of interest physics students have in learning physics. It is a 20-item, four-point Likert type scale instrument with Strongly Agree (SA), Agree (A), Disagree (D) and Strongly Disagree (SD). The researcher validated the instrument by administering it to a population 80 students that was not part of the study and the reliability index of 0.88 was obtained.
The Physics Classroom: This is a web-site to which schools or individuals pay, to gain access. It serves as a teaching tool for the problem-solving tutorial instruction. It contains every facility needed by the learner for a self-paced individualized instruction. It contains questions that are concept builders. Following the tutorial questions in steps using the problem-solving model in (Singh 2008), implies building up conceptual understanding of a particular concept or topic. 'The physics classroom' is an online teaching tool and hence cannot be used offline except for the tutorial questions which could be downloaded and printed.

Administration of Instrument and Data Collection

Pre-test and Posttest: The teacher described the activities about to be engaged in and entertained questions from the students. This was followed by pre-test administered to the students. This pre-test includes (i) work and energy test obtained from online physics classroom (ii) physics students' interest questionnaire (PSIQ). These two instruments were compiled into a booklet which consisted of
two pairs of each test in a single booklet; the first session for pre-test and the second session for post- test. Each student was given identification number on the booklet. The students were instructed to attempt the achievement test and the questionnaire within a stipulated time. The pre-test was administered before any treatment commenced. At the end of the treatment, the posttest was administered to the two groups in the various locations.

Experimental Group: In administering the instrument, the experimental group adopted the three stages of tutorial which are modelling, coaching and weaning. Then steps for problem-solving technique was adopted as described by Singh (2008). The following problem- solving steps were taken;

Step I : Analyze quantitatively

1. Redraw or add further information to the diagram provided to help in solving the problem

11. List all known and unknown quantities

111. Try to make predictions about the solutions

Step 2: Plan/Make decisions

1. Divide a problem into sub-problems if necessary

11. Which physics principle apply to the problem?

111. Choose the system that may be helpful

IV. Write down relevant equations for solving this problem based on your planning

Step 3: Implementation

1. Solve the system of equations (based on the relevant physics principles and concepts you decide on)

Step 4: Reflection and assessment

i. Does the solution make sense?
ii. Does the solution have the right dimension?
iii. Does the solution agree with quantitative prediction?

Presentation of Content for Experimental Group (WPT)

Step l: Administration of pre-test and physics interest questionnaire

Step 2: Presentation of lesson using online physics classroom teaching tool

Step 3: Use of pre-worksheet (with first analytical problem)

Step 4: Use of web-based interactive problem-solving tutorial (solving different analytical problems based on the presented concepts)

Step 5: Use of post-worksheet (to repeat the first analytical problem)

Step 6: Administration of post-test and post physics interest questionnaire

Presentation of Content for Control Group

Step l: Administration of pre-test and physics interest questionnaire

Step 2: Presentation of lessons using conventional lecture method

Step 3: Solving problems on the chalk board

Step 4: Presenting exercises to be solved by the students

Step 5: Making corrections on the chalk board

Step 6: Giving assignments to the students

step 7: Administration of post-test and post physics interest questionnaire

iv. Results

The table presents a test of significance descriptive statistics (mean and standard deviation) to present the results in tables.

Research Question 2:

What is the mean interest score of physics students taught using web-based interactive problem-solving tutorial and those taught using the conventional method?

Table I shows that students taught physics using web-based interactive problem-solving tutorial (WPT) had higher mean achievement score

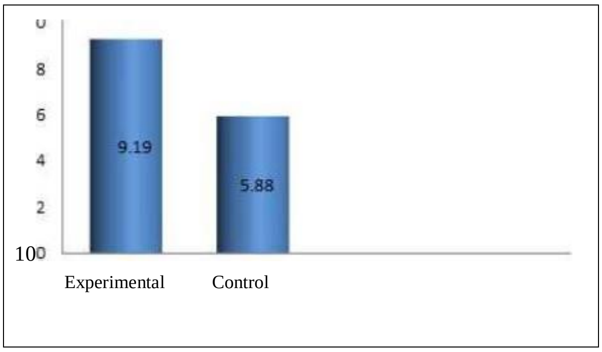

Figure 1: Mean Achievement Score for Experimental and

(9.19) than students taught using conventional lecture method (5.88). Also, table I shows that students taught physics

Table l: Descriptive statistics of Mean and Standard Deviation of Treatment and Control Group

Dependent Variables	Treatment	Mean	Std Error	95% confidence level	
				Lower bound	Upper bound
Post achievement score	Experimental	9.191a	.465	8.273	10.110
	Control	5.879a	.532	4.829	6.930
Post interest score	Experimental	37.870	1.921	34.076	41.664
	Control	32.549a	1.681	29.231	35.868

a. Covariates appearing in the model are evaluated at the following values pre-score 5.7219

Research Question I:

What is the mean achievement score of physics students taught using web-based interactive problem-solving tutorial and those taught using the conventional method?

(CLM)

using web-based interactive problem-solving

tutorial (WPT) had higher mean interest score (37.87) than students taught using conventional lecture method (32.55)
Figures I and 2 represent the table in form of a bar chart

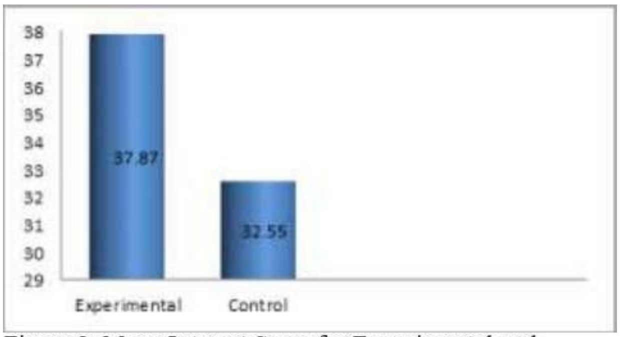

Figure 2: Mean Interest Score for Experimental and Control Group

Figure 3: Mean Interest Score for Experimental and Control Group

Table 2: Multivariate Analysis of covariate (MANCOVA)

Effect		Value	F	Hypothesis	Error	Sig	Partial Eta Squared
Intercept	Wilk's Lambda	.922	6.884	2.000	162,000	.001	.078
Pre-score	Wilk's Lambda	.978	I .829b	2.000	162.000	164	.022
Vmt pre	Wilk's Lambda	.978	2.156b	2.000	162,000	.119	.026
Treatment	Wilk's Lambda	.787	21.868b	2.000	162,000	.ooo	.213
Sex	Wilk's Lambda	.874	11.725b	2.000	162,000	.ooo	.126
Treatment. Sex	Wilk's Lambda	.898	9.242b	2.000	162,000	.000	.102

a. R squared 287 (adjusted R squared__ 265)
b. R squared 208 (adjusted R squared__ 184)

Research Hypothesis 1 :
There is no significant main effect of treatment (WIT and CLM) on dependent variable

From table 2, there is a significant effect of treatment (YWT and CLM) on dependent variable (students achievement and interest) Wilks Lambda 0.79, F (2,162) =21.87, P <0.01, partial? —0.213. The effect size (21.3%) of treatment on dependable variable is good. Since treatment has effect on the dependent variable. Each of these variables were fill there

(Achievement and Interest)

Table 3: Multivariate analysis of covariate (MANCOVA) Test of Between-Subject effect

Source	Dependent variable	Type 111 sum of square	Df	Mean score	F	Sig	P artial Eta square
Corrected model	Post-score	1257.730b	5	251.546	13.123	.ooo	287
	Vint-score	10696.844b	5	2139.369	8.553	.ooo	208
Intercept	Post-score	207.087	1	207.087	10804	.001	.062
	Vint-score	2418407	1	2418407	9.668	.002	.058
Pre-score	Post-score	64.901	1	64.901	3.386	.068	.020
	Vint-score	462.341	1	463.341	1.848	.178	.011
Vint-pre	Post-score	.781	1	781	O. 41	.840	.000
	Vint-score	741.555	1	741.555	2.965	.087	.018
Treatment	Post-score	399.582	1	399.582	20.846	.ooo	.113
	Vint-score	1031.468	1	1031.468	4.124	.044	.025
Sex	Post-score	420.802	1	420.802	15.771	.ooo	.119
	Vint-score	2859.598	1	2859.598	11.432	.001	.065
Treatment.Sex	Post-score	302.297	1	302.297	15.771	.ooo	.088
	Vint-score	2859.598	1	2859.598	11.432	.001	.066
Error	Post-score	3124.401	163	19.168			
	Vint-score	40773.179	163	250.142			
Total	Post-score	13821.000	169				
	Vint-score	248811.000	169				
Conected total	Post-score	4382.130	168				
	Vint-score	51470.024	168				

examined using univariate ANCOVA after Bonfenonni adjusted alpha level of 0.025. The analysis of individual dependent variable showed that there is significant effect of treatment on achievement in physics F, (1.163) = 20.85, P <0.025, paltial 0.113. The effect size (11.3%) of treatment on physics achievement is good. The table also showed that there is significant effect of treatment on students' interest in physics. F (1.163) = 4.12, P<0.0025, partial ? — 0.025, with the effect size of2.5%.

Research Hypothesis 2:

There is no significant main effect of gender on dependent variable (Achievement and Interest) From table 2, there was a significant main effect of gender on dependent variable (achievement and interest) Wilks Lambda 0.87, F (2,162) =11.73, P <0.01, partial? 0.126.The effect size (12.6%) of gender on achievement and interest is good. Each of these variables were examined using multivariate ANCOVA after Bonferroni adjusted alpha level of 0.025. The analysis of individual dependent variable showed that there was a significant effect of gender on achievement. F (1,163) =15.77, P <0.001, partial? 0.119. The effect size (Il .9%) is good. The table also showed that there was a significant difference between gender and interest. F (1,63) =11.4, P <001, partial? 0.065. The effect size (6.5(6.5%) is good.

Research Hypothesis 3:

There is no interaction effect of treatment (WIT and CLM) and gender on dependent variable (achievement and interest)

Table 2 showed that there was a significant effect of interaction between treatment and gender on dependent (achievement and interest). Wilks Lambda 0.90, F (2,162) =9.24, P <0.01, partial? — 0.102. The effect size (10.2 (10.2%) is good. Each of the variables were examined using univariate ANCOVA univariate ANCOVA after Bonfenoni adjusted alpha level of 0.025. The analysis showed that there was significant was significant interaction effect of treatment and gender on students student's achievement. achievement. F (1,163) =15.77, P <0.01, partial — 0.088. The effect size (8.8%) is good. Analysis also showed that there was significant effect of interaction of treatment and gender of students' student's interest. F (1,163) =11.43, P <0.om, partial? 0.66. The effect size (6.6%) is good.

V. Discussion of Findings

Findings revealed there was a significant effect of treatment (WIT and CLM) on dependent variable (achievement and interest). Further steps taken to examine the effect of this variable revealed that the significant effect of treatment on achievement is more (l I .3%) than the effect of treatment on interest (2.5%). Also, findings revealed that students taught physics using web-based interactive problem-solving tutorial (WIT) performed better than students taught using conventional method (CLM). This is in agreement with Singh & Haileselassie (2010). They posited that physics teaching can be made more engaging and effective through developing problem- solving skills for learner via web-based tutorials. These findings are is also in agreement with Igwe (2012) that physics students who were taught using combined effect of computer tutorial and drill, performed better than those taught using the conventional method.

The study also revealed that gender has a significant effect (21.6%) on dependent variable (achievement and interest) when the effect of this variable is further examined. It was revealed that significant effect of gender on achievement was more (Il .9%) than the significant effect of interest (6.5%). However, there was regular interruption of electric power supply in these sessions which interrupted the instructional procedure and left some of the students frustrated. This may have negative impact on their interest in the subject.

Conclusion

It is quite interesting to note that the mean score of students in the experimental group is much higher than the mean score of students in the control group. Female students exposed to web-based interactive problem- solving tutorial performed better than their male counter-part. Web- based interactive problem- solving tutorial can attest the interest of the learner to bring about learning if the lessons are properly arranged.

Recommendations

From the findings of this study, the following recommendations were made;

(1) There is need for online version of a well-structured and innovative textbook which could also be accompanied with a CD or online copies for proper illustrations that could be presented in

three dimensions accompanied with adequately- worked examples.

(2) In learning physics, every attempt must be made to ensure that the interest of the learner is not only captured but sustained throughout the class so that learning would be optimal. Interruption must be minimal or completely eliminated where necessary.

(3) In physics teaching learning activities, enough time must be given for lessons because the web-based interactive problem- solving tutorial requires more time to be effective. Teachers must avoid rushing lessons for real learning to take place. The teacher must not move to the next topic unless the previous topic is first understood by the learner. The teacher must create a situation where the learner is a master of his own understanding/subject.

(4) During classes, activity and exercises must be channeled towards training the reasoning skill of the learner and not just reproducing information, equations or facts for students to memorize.

(5) There is urgent need to develop local online text books or textual materials and learning environment which provide illustrations in three dimensional format, motion pictures, simulations, worked examples as well as self- paced physics classroom where the teacher functions only as a facilitator.

References

Adegoke, B. A & Chukwunenye J.N. (2013). Improving students learning outcomes in practical physics which is better? Computer Simulated Experiment or Hands-On Experiment. Journal of Research and Methods in Education (IOSR-JRME)2 (6) 18-26

American physical society (APS) https://www.aps.org/programs/education /highschool/teachers retrieved 13th April 2020

Bayraktar, S. (2009). Misconceptions of Turkish pre-service teachers about force and motion. International Journal of Science and Mathematics Education, 7(2), 273291.

Cataloglu, E & Ates, S. (2013). The effect of students' cognitive style on conceptual understanding of problem-solving skills in introductory mechanics. Research in Science and Technological Education 2 5, 167-178

Cataloglu, E., & Ates, S. (2014). The effects of cognitive styles on naive impetus theory application degrees of pre-service science teachers. Internationa I Journal of Science and Mathematics Education, 12(4), 699-719.

Chrandra, V &Watter, J (2012). Re-thinking physics teaching with web-based learning. Computer Education 58 (l), 63

Chukwunenye, J. N. (2018). Computer simulated experiment as teaching strategy in Nigeria secondary school. Lambert Academic Publishing 2018.

Chidcwunenye, J. N., Adegoke, B. &lhekwaba, C. N (2019). Effect of naive impetus application theory on misconceptions of newtonian motion among Nigerian secondary school students. RAJournal of Applied Research 5 (3) 2340 - 2346

Devore, S., Marshman, E., & Singh, C. (2017). Challenge of engaging all students via self-paced interactive electronic learning tutorials for introductory physics. Physical Review Physics Education Research, 13(1), 010127.

Duit, R, &Treagust, D. F. (2012). How can conceptual change contribute to theolY and practice in science education? In Second international handbook of science education (pp. 107-118). Springer, Dordrecht.

Igbokwe, C. (2015). Recent curriculum refonn at the basic education level in Nigeria, Education Research 3 (l) 31- 371 aimed at catching them young to create change department of early childhood education, American Journal of

Igweh, A. U. (2012). Combined effect of computer tutorial and drill on senior secondary school students' achievement, interest, and retention in basic electronics in Lagos state. APh. D thesis submitted to the Department of NOcational Teacher Education, Faculty of Education, University of Nigeria, Nsukka.

Kohler, W. (2015). Insight and mediation. Thinking About Thinking: Studies in the Background of some Psychological Approaches, 269.

Kola, A. J. (2017). Investigating the Conceptual Understanding of Physics through an Interactive Lecture-Engagement. Cumhuriyet International Journal of Education, 6(1), 82.

Kun-yuan, Y. & Jia-Sheng, H. (2007). The impact of internet virtual Physics laboratory instruction on achievement in Physics: Science process skills and computer attitude of I (P Grade Students, American Journal of Science Education and Technology 16 (5) 451-461

McDermott, L. C. (2004). Physics Education Research: the key to student learning. Physics world, 17(1), 40.

Nwachukwu, C. O (2012). Revisiting science and education and national development Nigerian situation and the way forward. Journal of Business and Management Review 10 (l)

Özmen, H. (2004). Some student misconceptions in chemistry: A literature review of chemical bonding. Journal of Science Education and Technology, 13(2), 147-159.

Sahin, S. (2006). Perception and numerical ability and computer based simulation in Turkish online. Journal of Distance Education TOJDE. Retrieved June 24 2012 from https://tojdeanadolu.edu.tr/tojde24/pdf/ article.7:4.

Singh, C. (2004). Interactive video tutorials for enhancing problem solving, reasoning, and meta cognitive skills of introductory physics students. In AIP conference proceedings (Vol. 720, No. 1, pp. 177180). American Institute ofPhysics.

Singh, C. (2008). Computer-based tutorials to develop expertise in introductory physics students. In Forum on Education (p. 13).

Singh, C. (2009, July). Problem-solving and learning. In Al P Conference Proceedings (Vol. 1140, No. l, pp. 183197). American Institute ofPhysics.

Singh, C., & Haileselassie, D. (2010). Developing problem-solving skills of students taking introductory physics via Web-based tutorials. Journal of College Science Teaching, 39(4), 42.

Wlthnam, M. C., & Thompson, J. R. (2008). Integrated approaches in physics education: A graduate level course in physics, pedagogy, and education research. American Journal of Physics, 76(7), 677-683.