International Journal of Innovative Mathematics, Statistics & Energy Policies
13(1):12-17, Jan.-Mar., 2025

 www.seahipublications.org **ISSN: 2467-852X**

doi:10.5281/zenodo.14714665

Assessment of the Impact of Physics Education Technology (PhET) Interactive Simulation-Based Learning on Academic Achievement of NCE Physics Students on Abstract Concepts

Dr. Anastasia O. Udoh*

Department of Physics
Nwafor Orizu College of Education, Nsugbe, Anambra State, Nigeria
***Email: udohanastasia@gmail.com**

ABSTRACT
The study assessed the impact of simulation-based teaching method, i.e. Physics Education Technology (PhET) interactive simulation-based learning, on academic achievement of NCE physics students on abstract concepts. Two research questions and two hypotheses guided the study. Experimental design was used. Sample comprised of 91 NCE physics students. Instrument for data collection was Physics Achievement Test on Abstract Concepts which has reliability of 0.84. Data were analyzed using mean, standard deviation and t-test. Findings indicated that the Physics Education Technology interactive simulation-based learning significantly enhanced students' academic achievement on abstract concepts in physics irrespective of gender. Implication of this is that PhET is effective in teaching abstract concepts in physics. Recommendations were made which include that curriculum planners should include in subsequent review of NCE physics curriculum the use of Physics Education Technology interactive simulation-based learning in teaching abstract concepts in physics.
Key Words: Assessment, Impact, Physics Education Technology (PhET) Interactive Simulation-Based Learning, Academic Achievement, NCE Physics Students, Abstract Concepts.

INTRODUCTION

Physics deals with the study of matter and its motion through space and time, along with related concepts such as energy and force. Physics is a subject that is difficult due to its abstract nature (Adeyemo, 2010), yet it plays very important role in scientific and technological advancement which affects the lives of mankind (Sciencing, 2021). Hence, concepts in the physics curriculum identified as abstract cannot be expunged from the curriculum on the basis of their abstract nature, rather effort should be made to simplify them through the use of appropriate instructional method (Author, 2021). These concepts need to be concretized through the use of Information and Communication Technology (ICT) resources in order to enhance students' understanding of such concepts.

Application of ICT in physics learning, such as Physics Education Technology (PhET) Interactive Simulation-Based learning, can help students to understand the abstract concepts, its laws and theories and to retain what they have learnt in their memory for a very long period (Kola, 2013). Physics education technology (PhET) are online tools for teaching and learning introductory physics at the high school and college levels. It can be in the form of simulation-based learning which is training in virtual environment

that mimics real-world activities and scenarios. Simulation of abstract concepts can reduce the level of abstraction in them, thus concretizing the concepts for easy grasp and understanding by the students. As revealed by Wellington (2004), computer simulation is one of the effective teaching methods and has positive impacts in teaching science students. According to Mahdi, Laafou and Mohamed (2018), computer simulation can activate multiple skills in science learners such as observing, measuring, predicting, controlling variables, formulating hypotheses and interpreting results. Ozofor (2001) also revealed that with computer simulation, students are motivated because the simulation on the computer screen excites the students and motivates them to further study the subject.

Students can use simulators to study complex phenomena such as atomic and electronic structure, digital and analog circuit, optimal and acoustical design, and chaotic system. Computer simulation an also be used to teach concepts like optical phenomena, wave-particle duality, magnetic and mechanic phenomena, models of atom, solar system, movement of air, its interactions and collision, which the teachers cannot easily teach in traditional classroom setting. Researchers have indicated that appropriate use of computer simulation for teaching these abstract concepts facilitates teaching and learning (Mohammed, 2015; Gambari & Yusuf, 2014; Yusuf, Gambari & Olomorin, 2012). From Kola (2013) point of view, benefits of simulated visual materials include promoting hard work for both physics teachers and students, improving physics students' participation in classroom activities, helping both physics students and teachers to exchange ideas, learning materials and teaching strategies quickly, helping both physics teachers and students sustain and update their knowledge in physics education and helping physics students to understand abstract and very difficult concepts in physics.

However, one of the challenges students often have in understanding abstract concepts in physics arises due to gender disparity on students' understanding (Grainne, 2018; Camarao & Navia, 2017). Ugwu (2011) observed that there is gender difference in attainment in physics in favour of boys. Similar results were obtained by Mkpanang (2016) and Anih and Egbo (2015). However, Afolabi and Olajuyigbe (2018) found in their study, that female students had higher achievement mean score in physics than their male counterparts. Thus, physics teachers should take this into consideration when teaching physics, by using teaching methods that would involve active participation of both genders (Okoye, 2011).

Hence, abstract concepts can be difficult to discuss effectively without creating pictorial representations of such concepts. Students can be frustrated trying to assimilate information on abstract concepts in some courses if they are missing a purpose for learning or the concrete real-world reference to the abstract concept being explored. Such frustration can lead to students' inattentiveness in the concepts being taught. Lack of interest by students in such concepts makes them to be weak academically and affects their performance in the courses. Thus, there is need to use instruction media that can portray real life representation of the abstract concepts in order to concretize them. This can best be achieved through the use of computer simulation. On this premise, this research work assessed impact of physics education technology (PhET) interactive simulation-based learning on academic achievement of National Certificate in Education (NCE) physics students on abstract concept. The researcher went further to determine if gender has any influence on the academic achievement of the students when exposed to physics education technology (PhET) interactive simulation-based learning.

Research Questions

The following research questions were posed for the study.

1. What is the impact of physics education technology (PhET) interactive simulation-based learning and conventional lecture method (CLM) on academic achievement of NCE physics students on abstract concepts?
2. What is the influence of gender on mean achievement scores of students on the abstract concepts in physics when exposed to physics education technology (PhET) interactive simulation-based learning?

Hypotheses

The following null hypotheses were tested at 0.05 level of significance.

H_{01}: There is no significant difference between the post-test mean achievement scores of students exposed to abstract concepts in physics using physics education technology (PhET) interactive simulation-based learning and those taught using conventional lecture method (CLM).

H_{02}: There is no significant influence of gender on mean achievement scores of students on the abstract concepts when exposed to physics education technology (PhET) interactive simulation-based learning.

METHOD

The design of the study was experimental design which involved pre-test, post-test non-equivalent group. The population of the study comprised of ninety-one (91) NCE II and III physics students from four government-owned Colleges of Education (two state and two federal) in Anambra and Delta states of Nigeria. The sample of the study was made up of all the students in the population of the study since the population was small. Hence, no sampling technique was adopted. Two Colleges of Education (one state and one federal) comprising of 44 NCE physics students were assigned to treatment with PhET and were the experimental group. The other two Colleges of Education (one state and one federal) consisting of 47 NCE physics students were assigned to treatment with CLM and were the control group.

The instrument used for data collection was validated Physics Achievement Test on Abstract Concepts (PATAC) The questions in the PATAC were multiple choice question items drawn from Models of Atom, Solar System and Wave-Particle Duality concepts in physics. Kinder-Richardson formular 20 (K-R20) was used to compute the reliability of PATAC which gave a coefficient of 0.84. The instrument was used for both pre-test and post-test. The PATAC was developed by the researcher using the lesson notes prepared on the topics contents of models of atom, solar system and wave particle duality concepts. The notes were also used to develop and download simulated material which were packaged in a Compact Disc Read Only Memory (CD-ROM) by a computer technical designer.

A day before the students were exposed to physics education technology (PhET) interactive simulation-based learning and conventional lecture method of instruction (CLM), the pre-test of PATAC was administered to the sample students to ascertain their present status with regards to understanding of the abstract concepts before the treatments. After the pre-test, the experimental group was exposed to Physics education technology (PhET) interactive simulation-based learning while the control group was taught using conventional lecture method (CLM). The period of instruction lasted for two weeks, i.e., two days for each college. The same test (but reshuffled) was administered to the sample students the next week after instruction, as post-test, in order to ascertain the impact of the treatments on the students' academic achievement on the abstract concepts. The scores of the two groups from pre-test and post-test were compared by finding the means and standard deviations which were used to answer the research questions. T-test was used to test the hypotheses at 0.05 level of significance

RESULTS

The results of the study are presented below.

Research Question One*:* *What is the impact of physics education technology (PhET) interactive simulation-based learning and conventional lecture method (CLM) on academic achievement of NCE physics students on abstract concepts?*

Table 1*:* Mean and Standard Deviation of Students' Academic Achievement on Abstract Concepts when exposed to Physics Education Technology (PhET) Interactive Simulation-Based Learning and Conventional Lecture Method (CLM) of Instruction.

Instructional Method	N	Pre-test		Post-test		Mean Gain Score	Mean Gain Difference
		Mean	SD	Mean	SD		
PhET	44	22.41	3.61	45.35	3.05	22.94	8.94
CLM	47	24.92	3.74	38.92	3.74	14.00	

Result in Table 1 shows that in the pre-test, the students taught the abstract concepts (models of atom, motion of planets, and wave-particle duality) using PhET had mean achievement of 22.41 with standard deviation of 3.61 while those taught using CLM had mean score of 24.92 and standard deviation of 3.74. At post-test, students exposed to PhET had mean achievement score of 45.35 and standard deviation of 3.05 while their counterparts taught using CLM had mean achievement of 38.92 and standard deviation of 3.74. Mean gain difference of 8.94 was obtained in favour of students exposed to PhET.

Research Question Two: *What is the influence of gender on mean achievement scores of students on the abstract concepts in physics when exposed to physics education technology (PhET) interactive simulation-based learning?*

Table 2: Mean and Standard Deviation of Students' Academic Achievement on Abstract Concepts, by Gender, when exposed to Physics Education Technology (PhET) Interactive Simulation-Based Learning.

Gender	N	Pre-test		Post-test		Mean Gain Score	Mean Gain Difference
		Mean	SD	Mean	SD		
Male	18	22.89	2.83	45.50	3.13	22.61	0.10
Female	26	22.52	4.05	45.23	3.23	22.71	

Result in Table 2 indicated that male students exposed to PhET had mean achievement score and standard deviation of 22.89 and 2.83 respectively in the pre-test while their female counterparts got mean achievement score of 22.52 with standard deviation of 4.05 in the pre-test. For the post-test, the mean achievement score and standard deviation for the males were 45.50 and 3.13 respectively, while those of the females were 45.23 and 3.23 respectively. The slight mean gain difference of 0.10 recorded in favour of females simply indicates no significant influence of gender on students' mean achievement scores on the abstract concepts in physics when exposed to PhET.

***Hypothesis One*:** There is no significant difference between the post-test mean achievement scores of students exposed to abstract concepts in physics using physics education technology (PhET) interactive simulation-based learning and those taught using conventional lecture method (CLM).

Table 3: T-Test of Students' Mean Achievement Scores when exposed to Abstract Concepts in Physics using PhET Interactive Simulation-Based Learning and Conventional Lecture Method (CLM).

Instruction Method	N	$\bar{X}$	SD	df	S.E.	$t-cal$	t-$crit$	Decision
PhET	44	45.35	3.05	89	0.71	9.056	1.980	Significant
CLM	47	38.92	3.74					

The result in Table 3 showed that $t-cal$, 9.056, of students' mean achievement scores when exposed to abstract concepts in physics using PhET and CLM is more than the $t-crit$, 1.980, at 0.05 level of significance. This implies that the null hypothesis one is rejected indicating that there is significant difference between the post-test mean achievement scores of students exposed to abstract concepts in physics using PhET and those taught using CLM.

***Hypothesis Two*:** There is no significant influence of gender on mean achievement scores of students on the abstract concepts when exposed to physics education technology (PhET) interactive simulation-based learning.

Table 4: T-Test of Students' Mean Achievement Scores on the Abstract Concepts, by Gender, when exposed to Physics Education Technology (PhET) Interactive Simulation-Based Learning.

Gender	N	$\bar{X}$	SD	df	S.E.	$t-cal$	t-$crit$	Decision
Male	18	45.50	3.13	42	0.97	0.278	2.021	Not Significant
Female	26	45.23	3.23					

In table 4, the result indicated that the $t-cal$, 0.278, is less than $t-crit$, 2.021, at 0.05 level of significance. Thus, the null hypothesis two is accepted implying that gender has no significant influence on mean achievement scores of students on the abstract concepts when exposed to Physics Education Technology (PhET) interactive simulation-based learning.

Hence, based on the analysis of result, findings indicated that:

1. Physics education technology, (PhET) interactive simulation-based learning significantly enhanced students' academic achievement on abstract concepts in physics compared to conventional lecture method (CLM).
2. Gender has no significant influence on mean achievement scores of students on abstract concepts in physics.

DISCUSSION

The findings revealed that physics education technology (PhET) interactive simulation-based learning significantly enhanced students' academic achievement on abstract concepts compared to the use of conventional lecture method (CLM). This is in line with the findings of Herbert and Joseph (2023) that the use of computer simulation-based learning in teaching provides visualization and teaching aids that help easily to understand content knowledge, hence, improving students' achievement and motivation level.

Also, the findings of the study revealed that gender has no significant influence on mean achievement scores of students on the abstract concepts when exposed to physics education technology (PhET) interactive simulation-based learning. This agrees with the finding of Mhamed, Mohamed, Abdesselam, Taoufik and El Mehdi (2021) who examined influence of gender on performance of students taught physics using computer simulation and found that students' gender has no significant influence on their performance.

Thus, it can be concluded that the use of PhET interactive simulation-based learning for instruction enhances students' academic achievement on abstract concepts in physics. Hence, this implies that physics lecturers could strive to adopt the use of physics education technology (PhET) interactive simulation-based learning in teaching their courses, especially abstract concepts in the courses. Effective use of physics education technology (PhET) interactive simulation-based learning in teaching students the abstract concepts in physics can enhance students' understanding of the concepts, thus, leading to better academic achievement in physics.

On the basis of the conclusion, the following recommendations were made:

1. Stakeholders in education should provide ICT facilities to colleges of education to enable the lecturers use simulation-based learning in teaching.
2. Curriculum planners should include in subsequent review of NCE physics curriculum the use of physics education technology (PhET) interactive simulation-based learning in teaching abstract and complex physics concepts.
3. Physics lecturers should strive to discourage gender stereotyping of physics as male subject and seek out available PhET interactive simulation-based learning packages in their different courses and use them to teach their students.
4. Colleges of education management should strive to ensure that there is adequate and efficient electricity power supply in the colleges to enhance effective use PhET interactive simulation-based learning in teaching physics, especially the abstract concepts in physics.

REFERENCES

Adeyemo, S. A. (2010). Teaching/learning of physics in Nigerian secondary schools. The curriculum transformation, issues, problems, and prospects. *International Journal of Educational Research and Technology, 1*(1), 99-111.

Afolabi, F. & Olajuyigbe, O. A. (2018). Bridging gender gap in physics achievement: Do teaching approaches matter? *Journal of Social Sciences, 4*(2), 69-80.

Anih, C.A., & Egbo, J. I. (2015). The influence of gender on science students' achievement using practical activities in senior secondary schools in Enugu Education zone of Enugu State, Nigeria. *Conference 2704890. International Institute of Social and Economic Sciences. RePEC: Sek: Lac Pro: 2704890*.

Author (2021).

Camarao, M. K., & Nava, F.J. (2017). High school students' difficulties in physics. *https://www.researchgate.net*.

Gambari, I. A., & Yusuf, M. O. (2014). Development and validation of computer instructional package on physics for secondary schools in Nigeria. *Educational Research International, 3*(1), 112-130.

Grainne, K. (2018). Gender difference in cognitive development and school readiness, *https://www.childrenresearchnetwork.org*.

Herbert, J. B., & Joseph, N. (2023). The impact of physics education technology (PhET) interactive simulation-based learning on motivation-based learning on motivation and academic achievement among Malawian physics students. *Journal of Science Education and Technology, 32*,127-141.

Kola, J. K. (2013). Effective teaching and learning in science education through Information and Communication Technology (ICT). *IOSR Journal of Research and Method in Education (IOSR-JRME), 2*(5), 43-47.

Mahdi, K., Laafou, J. I., & Mohamed, R. (2018). The impact of continuous distance training on teachers of physics in computer simulation software. *Journal of Educators, Teachers and Trainers, 9*(1), 27-41.

Mhamed, B.O., Mohamed, A. H., Abdesselam, B., Taoufik, H., & El Mehdi, A. I. (2021). The effect of using computer simulation on students' performance in teaching and learning physics: Are there any gender and area gaps? Education Research International. *https://doi.org/10.155/2021/6646017*

Mkpanang, J. T. (2016). Influence of creature style and gender on the students' achievement in physics. *Journal of Education and Practice, 7*(12), 47-46.

Mohammed, F. N. A. (2015). The impact of integrating computer simulation on the achievement of grade II Emirati students in uniform circular motion. (M. Ed (Curriculum and Instruction) Thesis). United Arab Emirates University.

Ozofor, O. (2021). *Introduction of educational technology*. John led publishers.

Okoye, P. N. (2011). Factors obstructing students' understanding and achievement in physics. *Journal of Science Education, 11*(1), 84-87.

Sciencing (2021). The roles of physics in our modern society. *https://www.sciencing.com*

Ugwu, D. U. (2011). Gender and achievements in senior secondary school physics. *The Nigerian Journal of Research and Production, 18*(1), 1-9.

Wellington, J. (2004). *Using ICT in teaching and learning in and learning in science.* In R. Holliman & E. Scanion (Eds). Mediating science learning through information and communication technology. Routledge Falmer.

Yusuf, M. O., Gambari, I. A. & Olomorin, O. (2012). Effectiveness of computer supported co-operative learning in physics. *International Journal of Social Science and Education, 2*(2), 25-32.