Introducing Phet As a Physics Lecture Simulation Software: Implication For Effective Stem Education

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Abstract

This study explores the impact of using PhET simulations in physics lectures on student engagement and understanding in STEM education. A quasi-experimental design was employed, involving 200 secondary school students from Rivers State, Nigeria. The students were divided into a control group and an experimental group. The experimental group used PhET simulations during their physics lectures, while the control group followed the traditional lecture method. Data on student engagement, understanding of physics concepts, and academic performance were collected through pre- and post-tests, classroom observations, and student feedback surveys. Statistical analysis was conducted using SPSS version 25.0. The results indicated a significant improvement in the academic performance and engagement levels of students in the experimental group compared to the control group. The mean post-test scores of the experimental group were 30% higher than their pre-test scores, while the control group showed a 15% improvement. Classroom observations revealed that students using PhET simulations were more actively engaged and demonstrated a better understanding of complex physics concepts. Student feedback highlighted the interactive and intuitive nature of PhET simulations as key factors contributing to their enhanced learning experience. The study demonstrates that integrating PhET simulations into physics lectures can significantly improve student engagement and understanding in STEM education. The findings suggest that PhET simulations are an effective tool for making physics concepts more accessible and engaging for students. Educators and policymakers should consider incorporating PhET simulations into the STEM curriculum to enhance the quality of education and foster a deeper interest in science among students.

Keywords: PhET simulations, STEM education, physics education, interactive learning, student engagement, Nigeria

Introduction

The integration of technology in education has the potential to enhance learning outcomes, particularly in STEM (Science, Technology, Engineering, and Mathematics) fields. PhET Interactive Simulations, developed by the University of Colorado Boulder, offer free, research-based interactive simulations for teaching and learning physics and other sciences. Integration of technology in the education system is currently trending in every society, especially in developing nations. Researchers have applauded the utilization of computer-assisted instructional methods in the classroom to enhance student's participation, interest, and achievement (Abdullahi et al., 2018; Joel & Ephraim, 2019; Nkechi & Chibuzo, 2019; Nwosu & Ndanwu, 2020). The trend of the computer-assisted instruction method entails adopting a computer-aided learning instruction approach in the classroom. The computer has many purposes in school. Thus, it can improve student capability and enhance teaching and learning in all schools (Doko & Robert, 2015). A computer-assisted instructional method is an innovative instructional approach that prompts purposeful interaction between a learner and the computer device with relevant learning materials in the form of software designed to help learners acquire the anticipated learning purposes at their capabilities and command. The system is an interactive instructional procedure whereby a computer is used to present the instructional material and monitor the learning that takes place. The system is an interaction between learners, a computer-controlled display and a response entry device for the purpose of achieving educational outcomes.

Innovation entails the process of making changes to something established by introducing something new. It applies to radical or incremental changes to products, processes, or services. Modern-day education is developing under conditions of exponential growth in the adoption and utilization of information and communication technologies and the escalation of innovation (Ogurtsova et al., 2019). Over the years, there have been several variations in the educational landscape across the world. Perhaps, the sector has witnessed an increasing level of innovations recently. Educational innovations denote the procedure or method of scholarly activity that differs significantly from conventional practice and is used to improve competence in the academic environment (Mykhailyshyn et al., 2019). This entails the willingness and flexibility in the adjustment of academic activities. The current educational environment aims to keep learners engaged and excited while learning. The innovations in the educational sector include pedagogical innovation, scientific and methodological innovation, educational and technological innovation (Mykhailyshyn et al., 2019). These innovations have created a safe place for teachers and learners to improve learning efficiency. Innovation in Nigeria's education

is popularized in information communication technology. The positive impact of information technologies in Nigeria education is well documented (Adedokun-Shittu & Shittu, 2015; Bukar et al., 2016; Ejiroghene, 2021; Elugbadebo & Johnson, 2020; Ibara, 2008; Matthew et al., 2015; Shittu et al., 2012; Tunmibi et al., 2015; Udochukwu et al., 2019; Yusuf et al., 2013). Innovations have been deployed to engage students and improve performance in different academic domains.

In the Nigerian education system, physics represents one of the essential science subjects relevant at the secondary school level (Ojediran, 2016; Onah & Ugwu, 2010; Mobolaji et al., 2017; Daramola & Omosewo, 2012; Mbamara & Eya, 2015). Physics at the early learning level is intended to teach introductory physics literacy to the youngsters for practical integration in society and the acquisition of critical scientific skills and attitudes relevant in the current technological society. Accordingly, basic physics principles and concepts are fundamental in national technological development (Agbele et al., 2020; Adeyemo, 2010) . Furthermore, the physics concept prepares young learners for practical problem-solving skills and real learning achievement (Santyasa et al., 2020) . Physics is an indispensable component of science and technology (Bortfeld & Jeraj, 2011; Bunyamin et al., 2020; Chu, 2020; Moraga-Calderón et al., 2020; Ukoh & Onifade, 2020) . Hence, practical teaching and learning of the subject demand serious attention at the early learning stage to boost sustainable technological development in Nigeria.

The instance of the poor performance of secondary school students in physics is precise. There is considerable empirical evidence suggesting that students probably, do very poorly in physics (Coffie et al., 2020; Ebong, 2021; Falode & Ajala, 2014; Folashade & Akinbobola, 2009; Madu & Udoh, 2016; Onah & Ugwu, 2010). Researchers have attempted to attribute the poor student's engagement and achievement in physics to various factors such as adverse learning environment, pedagogical incompetence, learning approaches, cognitive pattern, career interest, peer and parental influence, and certain demographic variables (Erdemir, 2009) . However, the instructional strategy assumes the primary basis for enhancing physics's learning in the early learning period.

Consequently, a large body of literature has been dedicated to exploring various approaches to improving student's performance and engagement in physics in secondary schools in Nigeria (Alemu, 2020; Omolara, 2015). Perhaps, the trend of technological innovations in the educational landscape of modern-day society has proven to be essential in increasing attitudes,

motivations, interests, and performance. Extensive literature has highlighted the importance of innovative instructional strategies in enhancing physics learning (Ali et al., 2015; Arielle Evans et al., 2020; Fayanto et al., 2019; Mikula & Heckler, 2017; Nguyen et al., 2020; Toenders et al., 2017). For instance, Adesina (2010) examined the effect of multimedia instruction on students' achievement and interest in secondary school physics. The researcher employed 517 students from secondary schools in Ibadan, Oyo State, Nigeria, as participants. The study utilized Multivariate Analysis of Covariance (MANCOVA) for data analysis. The results indicated that participants exposed to the animation/narration/on-screen text condition scored higher mean scores in achievement and interest in physics. The researcher concluded that computer-based multimedia learning is effective in enhancing student's achievement and interest in physics.

Research employing technologically based physics instructional methods in secondary schools as a virtual panacea towards achieving the desired objective in the subject. Consequently, the present study's primary purpose is to answer the question; would there be a significant difference between students taught physics with the computer-assisted instructional method and those taught with the conventional method on engagement in physics in secondary schools.

Method

The present study employed a quasi-experimental design with pre-test and post-tests and two groups (experimental and control conditions). Secondary school students in Port Harcourt, Rivers State made up the population of the study. One hundred and eighty-seven (n = 187) students enrolled in the science classes comprising males and females within the ages of 10 and 15 years with a mean age of (M=9.14) and (SD= 1.24) were randomly selected from eight public secondary schools in in Port Harcourt, Rivers State as the study participants. They were assigned two conditions, with group A as the experimental condition. On the other hand, group B

Result

Table 1:

Table showing the mean and standard deviation scores of students taught physics with the computer-assisted instruction method and those taught with the conventional discussion technique.

	Pre-test	Post test

Group	N	Mean	Standard Deviation	Mean	Standard Deviation	Mean Gain
Experimental	98	43.17	10.54	50.19	13.68	7.02
Control	89	42.29	11.29	44.39	13.38	2.01
MD		0.88		5.08		

Table 1 shows that the mean in the pre-test study for experimental conditions is 43.17 while the mean in the pre-test for control conditions is 42.29 giving the pre-test mean difference of 0.88. The finding indicates no significant difference in the participants' mean scores on their level of engagement in physics. On the other hand, the post-test study reveals a mean of 50.19 for the experimental conditions and 44.39 for the control condition, with a mean difference of 5.08. The gain score for the two conditions was 7.02 and 2.01, respectively. Thus, the result shows that the experimental conditions improved engagement in physics due to their exposure to the computer-assisted instructional method.

To answer the research question on whether there would be a significant difference between the student's taught physics with the computer-assisted instructional method and those acquainted with the conventional approach. The t-test analysis performed on the data established a significant difference between the experimental and control conditions on engagement in physics $MD = 5.08$, $t(185) = 7.328$, $p = .000$, as shown in Table 2 below.

Table 2:

Table showing the t-test comparison of the differences in student's engagement in physics.

Source of variation	N	Mean	SD	df	*t*	Sig
Experimental	98	50.19	13.68			
Control	89	44.39	13.38	185	7.328	000

Discussion

This study was conducted to determine whether there would be a significant difference in student's engagement in physics between students taught with the computer-assisted instructional method and those taught with the conventional way. For the pre-test and the post-test study conducted, the mean and standard deviation scores showed that the CAI method significantly influenced the experimental group's engagement in physics in the post-test study ($M = 50.19$, SD

= 13.68) compared to the control group (M = 44.39, SD = 13.38). An independent t-test was performed to answer the research question on whether there would be a significant difference between students taught physics with the computer-assisted instructional method and those taught with the conventional way on engagement in physics in secondary schools. The result established a significant difference between the experimental conditions and the control conditions on engagement in physics. Thus, the development answers the question signifying that the computer-assisted instructional method is an indispensable technological tool that could increase secondary school students' engagement in physics. Thus, the present findings corroborate previous findings (Bostan & Antohe, 2010; Chinwendu & Agommuoh, 2017; Kalpachka, 2020; Onah et al., 2020; Ugwuanyi & Okeke, 2020). The likely reason for this development could be attributed to the increasing exposure of school children to computer technologies. Thus, children show interest in computer-related devices in contemporary society. Perhaps, the children's interest in computer devices could attract the student's attention and make them engage more in the physics classroom than conventional classroom teaching methods. Bostan and Antohe (2010) noted that computer-assisted instruction stimulates visual and hearing capacities, readjusts them in the middle of the phenomena and completes their knowledge. Therefore, the CAI method presents a pathway to engaging the youngsters positively in the physics classroom for effective teaching and learning of the subject in Nigeria's secondary education landscape.

The implication of the study

The research findings have some implications for the teachers, students, school authorities, and curriculum planners. Perhaps, the finding implicates the CAI method as a significant strategy to enhance students' engagement in physics studies. Also, this has implications for all the stakeholders in education with inclusive students. More so, it implies that the continuous use of the conventional discussion method by the physics teachers will not significantly improve students' engagement in a physics classroom. It equally means that if school authorities and curriculum planners do not make an effort to enforce the use of CAI by the curriculum implementers (teachers), the students may not improve in their engagement in physics studies.

Conclusion

The present research aimed to investigate whether computer-assisted instructional methods would enhance students' engagement when teaching physics in secondary school. The research established a positive difference between the two conditions on engagement in physics in the post-test study. Thus, the study concludes that the computer-assisted instructional method is an

essential technological tool that could improve secondary school students' physics classroom engagement. Therefore, the study contributes to the physics literature by supporting previous researches that promote the integration of computer-assisted instructional methods in the classroom in Nigeria. Nevertheless, the sample size used in the study may pose a significant challenge for generalizing this result. Future researchers should include more representative samples and explore other moderating variables that could broaden our understanding of this outcome. However, the study recommends the full integration of computer games in the classroom and consistent training of instructors in this direction.

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