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ENHANCING PHYSICS EDUCATION USING PHET FOR SUSTAINABLE STEM EDUCATION IN NIGERIA

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Abstract
This research delves into the effects of integrating PhET simulations into physics lectures on student engagement and comprehension in STEM education. A quasi-experimental methodology encompassed 200 secondary school students from Edo State, Nigeria. The students were segregated into a control group and an experimental group. The experimental group utilized PhET simulations during their physics lectures, while the control group adhered to the conventional lecture approach. Data pertaining to student engagement, grasp of physics concepts, and academic achievement were gathered through pre-and post-tests, classroom observations, and student feedback surveys. Statistical analysis was carried out utilizing SPSS version 25.0. The outcomes revealed a substantial enhancement in the academic performance and engagement levels of students in the experimental group in comparison to the control group. The average post-test scores of the experimental group exhibited a 30% escalation from their pre-test scores, whereas the control group displayed a 15% advancement. Classroom observations unveiled that students engaging with PhET simulations were more actively involved and exhibited a superior comprehension of intricate physics concepts. Student feedback underscored the interactive and intuitive attributes of PhET simulations as pivotal elements contributing to their enriched learning encounter. The study illustrates that incorporating PhET simulations into physics lectures can markedly elevate student engagement and comprehension in STEM education. The findings intimate that PhET simulations are potent in rendering physics concepts more accessible and captivating for students. Educators and policymakers should consider integrating PhET simulations into the STEM curriculum to elevate the educational standard and instill a more profound passion for science among students.

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

Introduction

Incorporating technology into education can enrich learning outcomes, particularly within STEM (Science, Technology, Engineering, and Mathematics) disciplines. PhET Interactive Simulations, a product of the University of Colorado Boulder, provides complimentary, research-grounded interactive simulations for the teaching and learning physics and other scientific subjects. The integration of technology within the educational framework is currently a prevalent trend across societies, especially in developing nations. Scholars have commended the use of computer-assisted instructional methodologies in classrooms to elevate student engagement, interest, and academic performance (Abdullahi et al., 2018; Joel & Ephraim, 2019; Nkechi & Chibuzo, 2019; Nwosu & Ndanwu, 2020). The evolution of the computer-assisted instruction method involves adopting a computer-facilitated educational approach in educational settings. The computer serves many functions within schools, enhancing students' capabilities and refining the teaching and learning process (Doko & Robert, 2015). A computer-assisted instructional method represents an innovative educational strategy that fosters purposeful interaction between a learner and the computer device through pertinent educational materials in software format designed to facilitate learners in achieving their educational objectives at their own pace and proficiency. This system embodies an interactive instructional process where a computer presents instructional content and oversees the learning progress. It facilitates interaction among learners, a computer-managed display, and a response input device to attain educational goals.

Innovation entails making changes to something established by introducing something new. It applies to radical or incremental product, process, or service changes. 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 worldwide. Perhaps the sector has witnessed an increasing level of innovation recently.

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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 to adjust to 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, and 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 youngsters for practical integration into society and the acquisition of critical scientific skills and attitudes relevant to the current technological society. Accordingly, basic physics principles and concepts are fundamental to 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 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). 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 effectively enhances student achievement and interest in physics.

The interplay between PhET simulations and sustainable STEM education in Nigeria is a promising avenue for enhancing the quality and accessibility of STEM education. Studies have indicated that using interactive simulations, such as those offered by PhET, can markedly enhance educational outcomes in STEM fields. Within the Nigerian context, this translates to students being better equipped to confront the complexities of a swiftly evolving global labor market, thereby bolstering the nation's overall progress. The research employs technologically based physics instructional methods in secondary schools as a virtual panacea toward achieving the desired objective. 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?

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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 Igueben and Benin City, Edo 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 between 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 the study parameter 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:

The table shows the mean and standard deviation scores of students taught physics using the Phet simulation-based instructional method and those taught using the conventional discussion technique.

		Pre-test		Post-test		
Group	N	Mean	SD	Mean	SD	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 of whether there would be a significant difference between the students taught physics with the Phet simulation-based 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 Phet 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

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was performed to answer the research question of whether there would be a significant difference between students taught physics with the Phet and those taught with the conventional way of engagement in physics in secondary schools. The result established a significant difference between the experimental and control conditions on engagement in physics. Thus, the development answers the question signifying that the Phet simulation-based-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 youngsters to computer technologies. Thus, youths show interest in computer-related devices in contemporary society. The student's interest in computer devices could attract their attention and engage them more in the physics classroom than in conventional classroom teaching methods. Bostan and Antohe (2010) noted that computer-assisted instruction stimulates visual and hearing capacities, readjusts them during the phenomena, and completes their knowledge. Therefore, the Phet simulation-based-instructional method presents a pathway to engaging 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 Phet simulation-based-instructional-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 physics teachers' continuous use of the conventional discussion method will not significantly improve students' engagement in a physics classroom. It equally means that if school authorities and curriculum planners do not try to enforce the use of the Phet simulation-based-instructional-method by the curriculum implementers (teachers), the students may not improve their engagement in physics studies.

Conclusion

The present research investigated 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 research that promotes 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 integration of PhET simulations into STEM education in Nigeria, which represents a significant step towards creating a more engaging, accessible, and sustainable educational system. By leveraging these innovative tools, educators can enhance the quality of STEM education and better prepare students for future success.

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