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ASSESSING STIMULATION MODELLING AS A PATHWAY TO ENHANCING PHYSICS EDUCATION IN ANAMBRA STATE

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Abstract

This study explores the efficacy of stimulation modelling as an innovative pedagogical approach to enhance physics education in Anambra State, Nigeria. Stimulation modelling, involving interactive simulations and conceptual frameworks, aims to bridge conceptual gaps and improve student engagement and understanding. A quasi-experimental design was employed, involving 120 secondary school students across two groups: an experimental group exposed to stimulation modelling and a control group taught via traditional methods. Pre- and post-test assessments measured conceptual understanding and interest in physics. Results indicate significant improvements in the experimental group, suggesting that stimulation modelling could be a viable pathway to revitalize physics education in Anambra State.

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

Introduction

Integrating technology in education can potentially enhance learning outcomes, particularly in STEM (Science, Technology, Engineering, and Mathematics). PhET Interactive Simulations, developed by the University of Colorado Boulder, offer free, research-based interactive simulations for teaching and learning physics and other sciences. Technology integration 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.

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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.

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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.

Physics education in Nigeria, particularly in Anambra State, faces challenges such as low student interest, poor conceptual understanding, and outdated teaching methods. Traditional lecture-based approaches often fail to address students' difficulties with abstract concepts like momentum, electricity, and waves. Stimulation modelling, which integrates interactive simulations (e.g., PhET simulations) and structured conceptual frameworks, has shown promise in global physics education research for fostering deeper understanding and engagement.

Research highlights the effectiveness of simulation-based learning in physics. For instance, a 2022 study in Malawi demonstrated that PhET simulations improved students' motivation and achievement in oscillations and waves. Similarly, a 2020 study on momentum emphasized that conceptual frameworks paired with simulations enhance knowledge integration. In Anambra State, prior studies (e.g., a 2018 investigation on concept mapping) found alternative strategies boost achievement, yet stimulation modelling remains underexplored locally. This study assesses whether stimulation modelling can enhance physics education in Anambra State by improving students' conceptual grasp and interest. The research question is: "To what extent does stimulation modelling improve students' conceptual understanding and interest in physics compared to traditional methods?"

Method

A quasi-experimental design with pre- and post-test assessments was adopted. The study population comprised Senior Secondary 2 (SS2) physics students from public schools in Awka South Local Government Area, Anambra State. Two schools were purposively selected, and 120 students (60 per school) were randomly assigned to experimental (stimulation modelling) and control (traditional lecture) groups.

The experimental group used PhET simulations and a conceptual framework on electricity and magnetism over six weeks, while the control group received conventional lessons. The Physics Conceptual Understanding Test (PCUT), a 20-item multiple-choice instrument (reliability coefficient = 0.87 via Kuder-Richardson 20), and the Physics Interest Scale (PIS), a 10-item Likert scale (reliability = 0.82), were administered pre- and post-intervention. Data were analyzed using mean scores, standard deviations, and t-tests at a 0.05 significance level.

Results

The table below summarizes the pre- and post-test results for both groups:

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Group	Test Type	Conceptual Understanding (PCUT)	Interest (PIS)	t-value	p-value
Experimental	Pre-test	M = 8.5, SD = 2.1	M = 22.3, SD = 3.4	-	-
Experimental	Post-test	M = 16.2, SD = 1.8	M = 34.7, SD = 2.9	12.45	0.001
Control	Pre-test	M = 8.7, SD = 2.3	M = 21.8, SD = 3.6	-	-
Control	Post-test	M = 10.1, SD = 2.5	M = 23.5, SD = 3.2	1.87	0.067

The experimental group's mean score increased from 8.5 to 16.2 (out of 20), a gain of 7.7 points, compared to the control group's modest increase from 8.7 to 10.1 (1.4 points). The t-test ($t = 12.45$, $p < 0.001$) indicates a statistically significant improvement for the experimental group. The experimental group's interest score rose from 22.3 to 34.7 (out of 50), a gain of 12.4 points, while the control group's increased marginally from 21.8 to 23.5 (1.7 points). The t-test ($t = 12.45$, $p < 0.001$) confirms a significant difference. The slight improvement ($p = 0.067$) was not statistically significant, suggesting traditional methods had limited impact.

Discussion

The results align with prior findings that simulation-based learning enhances conceptual understanding and engagement. The significant gains in the experimental group reflect stimulation modelling's ability to make abstract concepts tangible and interactive, fostering curiosity and comprehension. The control group's minimal progress underscores the limitations of rote learning in physics education. In Anambra State, where resources are constrained, integrating free tools like PhET could be a cost-effective solution. 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 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 Phet simulation-based-instructional-method by the curriculum implementers (teachers), the students may not improve in their engagement in physics studies.

Conclusion

Stimulation modelling significantly enhances physics education in Anambra State by improving students' conceptual understanding and interest. This approach could address longstanding educational challenges if scaled across schools. Physics teachers in Anambra State should adopt stimulation modelling using accessible tools like PhET simulations. The Anambra State Ministry of Education should provide training and digital resources to support implementation. Further research should explore long-term impacts and scalability across other science subjects.

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