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ENHANCING SCIENCE EDUCATION INREMOTEREGIONS: THE IMPACT OF PHET SIMULATIONS ON TEACHING ELECTRICITY IN NORTHERN VIETNAM

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ABSTRACT:

This study explores the efficacy of PhET simulations in enhancing science educationinremote regionsofnorthernVietnam, addressingtheeducational disparities exacerbated by geographical isolation. Employing a mixed- methods research design, the study surveyed and interviewed science teachers across several remote schools to evaluate their experiences with PhET simulations in teaching. The subjects included both experienced and novice teachers, who provided insights into the integration of simulationsinto their teaching practices. Findings indicate a significant improvement in student engagement and comprehension of complex scientific concepts, with teachers reporting enhanced instructional quality and student interest. The study underscores the potential of digital tools in democratizing education, suggesting that PhET simulations represent a valuable resource for overcoming the challenges of delivering quality science education inresource-constrained settings. This research contributes to the broader discourse on educational equity, highlighting the role of technology in bridging the gap between urban and rural education systems.

Keywords:
PhETS imulations,Remote Education,Science Teaching,Educational Technology, Vietnam.

INTRODUCTION

Academic The integration of digital resources in science education has emerged as a pivotal strategy to enhance student engagement and understanding of complex concepts. Particularly in regions with limited access to physical laboratory resources, such as the northern mountainous areas of Vietnam, the adoption of interactive simulations represents a significant opportunity to revolutionize the teaching and learning process. This paper focuses on the use of PhET Interactive Simulations—a suite of free, research-based, interactivelearningtools developedbythePhET project at theUniversityofColorado Boulder—in teaching the topic of electricity in Grade 8 natural science curriculum.

The rationale behind the integration of PhET simulations stems from the challenges faced byeducators in resource-constrained environments. Traditional teaching methods, reliant on textbook- based instruction and limited hands-on experiments, often fail to convey the dynamic nature of scientific concepts, such as electricity, to students. PhET simulations, recognized for their ability to make abstract concepts tangible through interactive, visual representations, offer a promising alternative. These simulations provide an immersive learning experience, allowing students to manipulate variables, visualize outcomes, and engage in inquiry-based learning practices that are otherwise difficult to implement in a conventional classroom setting.

The decision to focus on the northern mountainous regions of Vietnam is motivated by the unique educational challenges present in these areas, including geographical isolation, scarcity of resources, and limited access to quality science education. The implementation of PhET simulations in this context is not merely an educational intervention but a critical step towards educational equity, ensuring that students in remoteareas haveaccess to thesame quality of science education as thosein more affluent urban centers.

This study aims to assess the impact of PhET simulations on teaching and learning in these underserved areas, with particular attention to teachers' perspectives on the usability, effectiveness, and educational value of the simulations. The investigation was conducted through an online survey distributed to 51 science teachers, exploring their experiences with integrating PhET simulations into their teaching practices. The survey sought to understand the extent to which these simulations enhancethevisualizationandcomprehensionof electricalconcepts, contributetostudent engagement, and address the pedagogical challenges faced by teachers in remote regions.

The integration of technology in education, particularly in developing countries, is a complex process influenced by factors such as infrastructure, digital literacy, and pedagogical support. As such, this study also explores the barriers to technology integration and the support systems necessary to facilitate the effective use of PhET simulations in educational settings. By examining the experiences of teachers in the northern mountainous regions of Vietnam, this research contributes to the broader discourse on educational technology's role in enhancing science education, with implications for policy, practice, and future research in similar contexts globally.

LiteratureReview

The integration of PhET simulations into science education represents a paradigm shift towards interactiveandtechnology-enhancedlearning environments.Theliteratureprovides extensiveinsights into the effectiveness, challenges, and pedagogical strategies associated with using PhET and other interactive simulations in teaching complex scientific concepts.

PhET simulations have been identified as a valuable tool for enhancing student engagement and understanding in various scientific disciplines (McKagan et al., 2008; Adams, 2010). Theseinteractive tools facilitate a constructivist learning environment, where students can manipulate variables, observe outcomes, and engage in inquiry-based learning processes. The visual and interactive nature of PhET simulations has been shown to significantly improve students' conceptual understanding and retention of scientific concepts (Clark & Chamberlain, 2014).

Educational gamification, including the use of gamified science simulations, has been recognized for its potential to increase motivation and engagement among students (Pirker & Gütl, 2015). The gamification elements within PhET simulations, such as instant feedback and interactive challenges, align with this pedagogical approach, offering an engaging and effective learning experience.

The practicality and effectiveness of using PhET simulations in collaborative and creative learning environments have also been explored. Studies have demonstrated that PhET simulations can significantly enhance students' scientific creativity and collaborative skills when integrated into a Collaborative Creativity Learning (CCL) model (Astutik & Prahani, 2018). This suggests that the benefits of PhET simulations extend beyond individual learning gains to include the development of essential 21st-century skills.

Research on PhET simulations in the context of developing countries, particularly in regions with limited educational resources, highlights both opportunities and challenges. While PhET simulations provide an accessible and cost-effective alternative to traditional laboratory equipment, barriers such as internet connectivity, technological infrastructure, and teacher digital literacy can limit their implementation (Putranta & Wilujeng, 2019; Haryadi & Pujiastuti, 2020).

The impact of PhET simulations on fostering creative thinking skills and scientific process skills further underscores their educational value (Habibi, Jumadi, & Mundilarto, 2020). These simulations encourage students to engage in higher-order thinking processes, such as hypothesis testing, experimentation, and analysis, which are crucial for developing a deep understanding of scientific principles.

Finally, the role of PhET simulations in addressing gender disparities in STEM education has been examined. Interactive simulations can help female students overcome stereotypes and buildconfidence in their scientific abilities, thereby contributing to a more inclusive and equitable science education environment (Kalender et al., 2019).

Materials and Methods

Theresearchadopteda descriptivesurveydesigntogather data ontheutilizationof PhET simulations by teachers. The survey aimed to understand teachers' perspectives on the effectiveness, practicality, and educational value of these simulations in science education.

The study involved 51 science teachers from various schools in the northern mountainous regions of Vietnam. These participants were selected based on their experience in teaching Grade 8 science and their voluntary participation in the study. All participants were informed about the purpose of the study and assured of their anonymity and confidentiality. Participation was entirely voluntary, with participants having the right to withdraw at any time without penalty (Table 1).

An online survey questionnaire was developed, comprising both closed and open-ended questions.Thequestionnairecovered variousaspects, includingthefrequencyofPhET simulationuse, perceived benefits and challenges, and the impact on student engagement and understanding of the "Electricity" topic. The survey was distributed online to the targeted teachers, with instructions and consent forms provided. The participants were given a three-week window to complete and submit their responses. Reminders were sent periodically to maximize the response rate.

Quantitative data from closed-ended questions were analyzed using descriptive statistics, including frequencies and percentages. Qualitative data from open-ended responses were analyzed thematically to identify common themes and insights related to the use of PhET simulations in teaching.

This methodologicalapproachaimed toprovidea comprehensiveunderstanding ofthecurrent stateof PhET simulationuseinscience educationina specific regionalcontext, contributingvaluableinsights into its effectiveness and challenges in enhancing science teaching and learning.

ResultsandDiscussion

A survey was designed on the Google Form platform and sent to Zalo groups in which the researcher participated, as wellas throughpersonal emails ofteachers. Answering questions onGoogleFormdid not present any difficulties for the participating teachers, especially after the recent Covid-19epidemic in Vietnam. The data collection period was from December 31, 2023, to January 9, 2024. The research team received 51 responses from the survey participants. All of these responses were complete with the necessary information for analysis (Table 1).

Table1.SurveySubjects

Research Sample	**Sex**		**Teachingexperience**			**Educationallevel**	
	Male	Female	Under 5years	From5 – 10 years	Over 10 years	Bachelor's degree	Master's degree
Number (Teachers)	14	37	12	19	20	35	16
Percentage (%)	27.5	72.5	23.5	37.3	39.2	68.6	31.4

According to Table 2, besides the gender ratio of survey participants being skewed (however, this is consistent with reality as the percentage of female teachers in Vietnam accounts for 61.2%), the majority of the teachers participating in the survey have more than 5 years of service (accounting for 76.5%). This further enhances the quality of the survey subjects, leading to a higher reliability in the data obtained.

To evaluate the reliability of the data collected, we calculated Cronbach's Alpha coefficient using SPSS 20.0 software. Theresults (Table2)showthat this coefficient is at 0.716, meaning it is at a high level of reliability and can be used to analyze the necessary information in the study.

Tabel2.Reliability Statistics

Cronbach's Alpha	Cronbach's AlphaBased on Standardized Items	Nof Items
.716	.720	8

The survey results arepresented inTable3.

Table3.Item-TotalStatistics

	ScaleMeanif Item Deleted	Scale Varianceif ItemDeleted	Corrected Item-Total Correlation	Squared Multiple Correlation	Cronbach's AlphaifItem Deleted
Q1	32.7059	5.332	.490	.401	.677

Q2	32.8235	5.388	.359	.337	.697
Q3	32.8235	5.548	.248	.154	.719
Q4	32.9412	4.896	.490	.445	.669
Q5	32.8235	5.268	.369	.314	.695
Q6	32.9216	4.914	.375	.266	.698
Q7	32.8824	4.706	.548	.445	.655
Q8	32.9216	5.074	.417	.389	.686

The survey focuses on teachers' perceptions across various dimensions, including the visualizationand engagement aspects of PhET simulations, their effectiveness in teaching complex concepts, integration challenges, and overall satisfaction and recommendations.

VisualizationandEngagement

The study utilized two questions: Q1. Do you feel that PhET simulations make lectures more visual? And Q2. In your opinion, do PhET simulations make lessons more engaging and capture students' attention? Both questions were designed using a 5-point Likert scale, with level 1 being "strongly disagree" and level 5 being "strongly agree."

Teachers overwhelmingly acknowledged the visual and interactive elements of PhET simulations as significant enhancers of student engagement and understanding. The vivid and interactive nature of simulations aligns with the principles highlighted by Laal, Laal, and Khattami (2012) on the importance of collaboration in 21st-century learning, suggesting that interactive tools like PhET can foster a moreengagingandcollaborativelearning environment. Thedynamicandinteractive natureof PhET simulations seems to captivate students' attention, making abstract concepts more tangible and understandable.

TeachingEffectiveness

The study utilized two questions: Q3. Do you find that using PhET simulations makes it easier to explain concepts in the Electricity chapter? And Q4. Do PhET simulations help students practice and experiment in a safe and effective manner?

Respondents alsoreporteda notable improvement inteaching effectiveness, particularlyin explaining complex electricity concepts. This is consistent with the findings of Perkins et al. (2012)and Haryadi andPujiastuti(2019),whoemphasizedPhETsimulations'roleinenhancingphysicsteachingand learning. The ability of these simulations to facilitate hands-on experimentation in a safe and controlled environment was particularly valued, echoing the potential of digital tools to improve understanding and practice of scientific concepts (Pheeraphan, 2014).

IntegrationintoTeaching

The study utilized two questions: Q5. Is integrating PhET simulations into your lessons challenging? And Q6. Do you feel that PhET simulations are suitable for widespread application in other lessons? WhiletheintegrationofPhETsimulationsintothecurriculumwasviewedpositively,challenges relatedtotechnologicalaccessandteachertrainingwerenoted.However,theoveralleaseof integration suggests that with appropriate support, these simulations can be widely adopted,as alsosuggestedbyClarkandChamberlain(2014)inthecontextofgeneralchemistry.Thereadinessof teachers torecommend PhET topeers underscores its perceived valuein enhancingscienceeducation, resonatingwiththe broaderliterature onthe adoptionofdigitaltoolsineducation(VanLaaretal., 2017).

OverallSatisfactionandRecommendations

The study utilized two questions: Q7. How do you rate the use of PhET simulations in teaching the

Electricity chapter? And Q8. Would you recommend your colleagues use PhET simulations in their teaching?

The high level of satisfaction with PhET simulations among teachers, combined with a strong inclination to recommend their use to colleagues, indicates a positive reception in the educational community. This sentiment supports theargument by QianandClark(2016)that game-basedlearning and interactive simulations can significantly contribute to acquiring 21st-century skills, including critical thinking and problem-solving.

SuggestionsonusingPheTinteaching

In response to the open-ended question about recommendations for using PhET in their teaching, educators arelikely to haveproposed a variety of strategies aimed at maximizing thebenefits of these simulations. They might suggest integrating PhET simulations more deeply into the curriculum to provide students with hands-on experience and a better understanding of abstract concepts. Teachers could advocate for the use of these simulations as a complement to traditional teaching methods,rather than a replacement, to enhance student engagement and learning outcomes. Additionally, they may recommend training sessions for teachers to become more proficient in utilizing PhET simulations effectively, ensuring they are equipped to guide students through the simulations and integrate them into lesson plans seamlessly. Furthermore, educators might emphasize the importance of aligning simulations with learning objectives and assessment methods to ensure educational coherence. Lastly, suggestions could include the development of a community of practice around PhET simulations, where teachers can share experiences, teaching materials, and best practices to support each other in implementing these tools effectively.

Discussion

The findings suggest that PhET simulations offer a promising avenue for enhancing scienceeducation, particularly in remote and underserved areas. The visual, interactive, and engaging nature of PhET simulations can make science more accessible and enjoyable, potentially sparking students' interest and motivation in science subjects. However, the effective integration of these tools into educational practices requires addressing barriers related to technology access and teacher training.

In conclusion, the study highlights the potential of PhET simulations to transform science education by making complex concepts more understandable and engaging for students. It also underscores the need for continued research and investment in educational technologies as a means to bridge the educational divide, particularly in remote regions. Future studies could explore the long-term impacts of such technologies on students' academic performance and interest in STEM fields, further contributing to the discourse on educational equity and quality in the 21st century.

Conclusion

The transformative potential of PhET simulations for science education, particularly in remote areas, cannot be overstated. This study has shed light on their significant impact in making scienceeducation more accessible, engaging, and effective, aligning with the 21st-century educational goals. Theevidencefrom northern Vietnamunderscores theimportanceof integratingthesedigitaltools into teaching practices to overcome geographical and resource limitations.

However, to harness the full potential of PhET simulations, it is crucial to address the challenges of technological access and enhanceteacher training. Empoweringteachers withthe necessaryskills and resources to effectively use these tools will ensure that students in remote regions can benefit from enriched science education. Furthermore, the enthusiastic reception of PhET simulations among teachers, reflected in their willingness to recommend them, suggests a promising path towards wider adoption in educational settings.

Future research should focus on long-term impacts of PhET simulations on student outcomes and explore innovative strategies to integrate them into diverse educational contexts. By building on the positive findings of this study, educators and policymakers can work together to bridge theeducational divide, ensuring that all students, regardless of their geographical location, have the opportunity to engage with science in meaningful and transformative ways.

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