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CHALLENGES FACED BY STUDENTS WHEN USING PHET SIMULATIONS IN SCIENCE EDUCATION: A CASE STUDY IN HAI PHONG CITY

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Abstract:

This study investigates the challenges faced by secondary school students in Hai Phong, Vietnam, when using PhET simulations in science education. PhET simulations are widely recognized for their ability to enhance students' understanding of scientific concepts through interactive and hands-on experiences. However, the effective implementation of these tools in classrooms can be hindered by various obstacles. The primary objectives of this research were to identify the specific challenges students encounter, assess the impact of these challenges on learning outcomes, and propose solutions to improve the effectiveness of PhET simulations in science education. A mixed-methods approach was employed, combining quantitative surveys and qualitative interviews to gather comprehensive data from 265 students across multiple grade levels. The findings reveal that students experience significant technical difficulties, such as issues with device compatibility and unstable internet connections. Additionally, cognitive challenges were identified, with students reporting difficulties in understanding the scientific concepts presented in the simulations. A considerable number of students also expressed the need for additional guidance from teachers, indicating that insufficient instructional support is a key barrier to the effective use of PhET simulations.

These challenges have important implications for science education. Without addressing these obstacles, the potential benefits of PhET simulations may be limited, leading to reduced student engagement and suboptimal learning outcomes. The study concludes by recommending strategies to mitigate these challenges, including enhancing technical infrastructure, providing targeted teacher training, and developing supplementary instructional materials. By implementing these solutions, educators can better integrate PhET simulations into their teaching practices, thereby maximizing their educational value. while PhET simulations hold great promise for improving science education, their effectiveness is contingent on overcoming technical, cognitive, and instructional barriers. This study contributes valuable insights to the discourse on technology integration in education and offers practical recommendations for enhancing the use of educational simulations in diverse learning environments.

Keywords:

PhET simulations; Science education; Student challenges; Technology in education; Pedagogical tools.

1. Introduction

1.1. Context and Background

The integration of technology in education has become increasingly pivotal in the 21st century, transforming traditional teaching methodologies and providing new avenues for enhancing student engagement and learning outcomes (OECD, 2019). As educational paradigms shift towards more interactive and student-centered approaches, technology serves as a critical enabler in this transition. Among the myriad of technological tools available, PhET simulations have emerged as a prominent and effective resource in the realm of science education.

PhET (Physics Education Technology) simulations, developed by the University of Colorado Boulder, are interactive, research-based simulations that cover a wide range of topics in physics, chemistry, biology, and mathematics. These simulations provide students with hands-on experiences that would otherwise be difficult to achieve in a traditional classroom setting (Perkins et al., 2006). They allow learners to visualize abstract concepts, experiment with variables, and witness the consequences of their manipulations in real-time, fostering a deeper understanding of complex scientific principles (Wieman et al., 2010).

The significance of PhET simulations lies in their ability to bridge the gap between theoretical knowledge and practical application. In the context of Vietnamese education, where there is a strong emphasis on rote memorization (Ministry of Education and Training, 2018), the adoption of such interactive tools can lead to more meaningful learning experiences. By enabling students to actively engage with content, PhET simulations help cultivate critical thinking and problem-solving skills, which are essential for mastering scientific disciplines (Habibi et al., 2020).

However, while the benefits of PhET simulations are well-documented, their effective implementation in classrooms also presents certain challenges. Issues such as technical difficulties, varying levels of student readiness, and the need for adequate teacher support can hinder the optimal use of these tools (Wieman et al., 2010). In the Vietnamese context, these challenges can be more pronounced due to disparities in access to technology and digital literacy levels (Cao Cu Giac et al., 2019). Understanding and addressing these challenges is crucial for maximizing the educational potential of PhET simulations in science education.

In summary, as technology continues to shape the future of education, tools like PhET simulations offer significant opportunities to enhance science teaching and learning. However, to fully harness their potential, it is important to recognize and overcome the barriers that may arise in their use. This study aims to explore these challenges within the context of secondary education in Hai Phong, Vietnam, contributing to the broader discourse on the integration of technology in education (Nguyen Thi Hang et al., 2024).

1.2. Research Problem

Despite the recognized benefits of PhET simulations in enhancing science education, there remains a significant gap in understanding the specific challenges students encounter when using these tools. While previous studies have highlighted the effectiveness of PhET simulations in improving conceptual understanding and engagement (Habibi et al., 2020; Nguyen Quang Linh & Tran Thi Thu Hue, 2023), there is limited research focusing on the obstacles that students may face during their use, particularly in different educational contexts and among diverse student populations.

In the Vietnamese educational setting, where digital literacy levels and access to technology can vary widely, these challenges may be even more pronounced. Students may struggle with technical issues, such as insufficient access to computers or unstable internet connections, which can hinder their ability to fully engage with the simulations (Ministry of Education and Training, 2018; Pham Thi Hong Tu et al., 2023). Additionally, cognitive challenges, such as difficulties in interpreting the simulations' visualizations or applying the concepts learned through simulations to real-world problems, may also impede learning (Tran Thi Ngoc Anh et al., 2021).

Another significant gap in the literature is the understanding of how these challenges differ across various student demographics, such as age, gender, or academic background. For example, younger students or those with less prior exposure to technology might find it more difficult to navigate and utilize the simulations effectively. Similarly, the level of teacher support and the instructional strategies employed can greatly influence students' experiences with PhET simulations, yet these factors are often underexplored in existing research (Han Thi Huong Thuy & Do Huong Tra, 2022, 2023).

Moreover, while much attention has been paid to the positive outcomes of using PhET simulations, less focus has been placed on the potential negative impacts that challenges may have on student motivation and learning outcomes. If not properly addressed, these challenges could lead to frustration, reduced engagement, and ultimately, a decline in academic performance.

This study seeks to fill these gaps by systematically investigating the types of challenges that students in Hai Phong, Vietnam, face when using PhET simulations in science education. By identifying and analyzing these challenges, the research aims to provide insights that can inform more effective implementation strategies, ensuring that all students can benefit from this innovative educational tool (OECD, 2019; Pham Thi Hong Tu et al., 2023).

1.3. Research Objectives

The primary objective of this study is to identify and analyze the specific challenges that students encounter when using PhET simulations in the context of science education at secondary schools in Hai Phong, Vietnam. Recognizing that these simulations have the potential to significantly enhance learning outcomes, the study seeks to uncover the barriers that may prevent students from fully benefiting from this technology.

To achieve this overarching goal, the study is guided by the following specific objectives:

- Categorize the Types of Challenges Faced by Students: This involves classifying the difficulties into distinct categories such as technical issues, cognitive challenges, and engagement-related obstacles. By doing so, the research aims to provide a comprehensive understanding of the nature and scope of the challenges students face.
- Evaluate the Impact of These Challenges on Learning Outcomes and Student Engagement: This objective focuses on assessing how these challenges affect students' ability to grasp scientific concepts, their overall academic performance, and their level of interest in science subjects. Understanding this impact is crucial for determining the extent to which these challenges might hinder the educational benefits of PhET simulations.
- Analyze the Variability of Challenges Across Different Student Demographics: The study aims to investigate whether certain groups of students (e.g., based on age, gender, or prior technological experience) are more susceptible to specific challenges than others. This analysis will help tailor solutions to meet the diverse needs of students.
- Propose Solutions to Mitigate Identified Challenges: Based on the findings, the study intends to develop actionable recommendations for educators, school administrators, and policymakers. These recommendations will focus on enhancing the implementation of PhET simulations in science education, ensuring that they are accessible, effective, and engaging for all students.

By addressing these objectives, the study seeks to contribute valuable insights to the broader discourse on the integration of technology in education, particularly in contexts similar to that of Hai Phong. Ultimately, the goal is to improve the effectiveness of PhET simulations in enhancing science education and to ensure that all students can benefit from this innovative tool.

1.4. Significance of the Study

Addressing the challenges that students face when using PhET simulations has the potential to significantly enhance the quality of science education in several key ways. By identifying and mitigating these obstacles, educators can create a more inclusive and effective learning environment that leverages technology to its fullest potential. This study, therefore, holds considerable significance for both educational practice and policy.

One of the most immediate benefits of addressing the challenges associated with PhET simulations is the potential increase in student engagement and motivation. When students are able to interact with simulations without technical difficulties or cognitive barriers, they are more likely to find the learning process enjoyable and stimulating. This enhanced engagement can lead to deeper interest in science subjects, encouraging students to pursue further studies and careers in STEM fields.

By overcoming the cognitive challenges that students may encounter with PhET simulations, educators can facilitate a more profound understanding of scientific concepts. These simulations are designed to make abstract principles tangible and accessible, but their effectiveness is contingent upon students being able to navigate and interpret them correctly. Addressing these barriers ensures that students can fully benefit from the simulations, leading to stronger conceptual foundations and better academic performance.

The study's focus on analyzing the variability of challenges across different student demographics is particularly important in reducing educational inequities. By understanding how different groups of students experience PhET simulations, educators can tailor their support and resources to meet diverse needs. This ensures that all students, regardless of their background or prior experience with technology, have equal opportunities to succeed in science education.

The findings of this study can inform the development of more effective policies and curricula that integrate technology into science education. By providing evidence-based recommendations, the study can guide educational institutions and policymakers in making informed decisions about the deployment of PhET simulations and similar tools. This could lead to the adoption of best practices that maximize the educational benefits of technology while minimizing potential drawbacks.

Although this study is situated in the context of Hai Phong, Vietnam, its findings have broader implications for science education worldwide. The challenges identified and the solutions proposed can serve as valuable insights for educators and researchers in other regions, particularly those with similar educational contexts. By contributing to the global discourse on technology in education, the study helps to advance the overall quality of science teaching and learning.

In summary, by addressing the challenges associated with PhET simulations, this study aims to improve the quality of science education both locally and globally. The potential impacts include increased student engagement, better conceptual understanding, reduced inequities, and more informed educational policies, all of which contribute to preparing students for success in a rapidly evolving technological world.

1.5. Structure of the Paper

This paper is organized into several key sections to systematically explore the research conducted on the challenges students face when using PhET simulations in science education. The introduction sets the stage by providing context, stating the research problem, and outlining the study's objectives and significance. Following this, the literature review offers a background on existing research related to PhET simulations and technology in education. The materials and methods section details the study's design, including participant demographics, data collection methods, and analysis techniques. The results and discussion section presents the findings and their implications, comparing them with existing literature. Finally, the paper concludes with a summary of key findings, recommendations for practice, and suggestions for future research, along with an acknowledgment of contributions and a comprehensive list of references.

2. Materials and Methods

2.1. Participants

The study was conducted with a total of 265 students from various secondary schools in Hai Phong, Vietnam. These participants were drawn from multiple grade levels, specifically from grades 10, 11, and 12, ensuring a diverse representation across different stages of secondary education. The schools involved in the study include:Vinschool Imperia School,Ly Thai To High School,Nguyen Tat Thanh High School,Do Son Boarding High School,Hai Ba Trung Gifted High School,Edison Primary, Secondary and High School,International Friendship Primary and Secondary School,Ly Thanh Tong Secondary and High School,An Hai High School,25 - 10 High School,An Duong High School,An Lao High School,Bach Dang High School

The participants were selected to represent a range of academic abilities and technological proficiency levels, providing a comprehensive overview of the challenges encountered when using PhET simulations. The study took place between August 15 and August 20, 2024.

2.2. Data Collection Methods

To gather data on the challenges students face when using PhET simulations, a mixed-methods approach was employed, combining both quantitative and qualitative data collection techniques.

A detailed survey was administered to all 760 participants. The survey was designed to capture various aspects of students' experiences with PhET simulations, including technical difficulties, cognitive challenges, and overall engagement with the tool. The survey consisted of Likert-scale questions, allowing students to rate their agreement with statements related to their experiences, as well as open-ended questions for more in-depth responses. The survey was distributed electronically using Google Forms, ensuring easy access for students across different schools.

To complement the quantitative data from the survey, semi-structured interviews were conducted with a selected subset of students. These interviews provided deeper insights into the specific challenges faced and allowed for a more nuanced understanding of the context behind the survey responses. The interviews were conducted both in-person and online, depending on the availability and preference of the participants.

2.3. Data Analysis

The data collected from the surveys and interviews were subjected to rigorous analysis to ensure the validity and reliability of the findings.

The quantitative data from the surveys were analyzed using statistical software, specifically SPSS (Statistical Package for the Social Sciences). Descriptive statistics, including means, standard deviations, and frequency distributions, were used to summarize the data. Additionally, inferential statistics, such as t-tests and ANOVA, were employed to explore differences in the challenges faced by students across different demographics (e.g., grade levels, gender). Reliability of the survey instrument was assessed using Cronbach's alpha.

The qualitative data from the open-ended survey responses and interviews were analyzed using thematic analysis. This process involved coding the data to identify common themes and patterns related to the challenges of using PhET simulations. NVivo software was used to assist in organizing and analyzing the qualitative data, ensuring a systematic approach to identifying key insights.

2.4. Ethical Considerations

Ethical approval for this study was obtained from the relevant educational authorities in Hai Phong, as well as from the ethical review board of the affiliated academic institution. Participation in the study was entirely voluntary, and informed consent was obtained from all participants. Students were assured of the confidentiality of their responses, and all data were anonymized to protect their identities. Additionally, the study adhered to ethical guidelines for research with human subjects, ensuring that no harm would come to the participants as a result of their involvement in the study.

3. Results and Discussion

3.1. Demographic Data Analysis

Table 1. Statistics of survey subjects by gender

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	103	38.9	38.9	38.9
	Female	162	61.1	61.1	100.0
	Total	265	100.0	100.0	

The data presented in Table 1, which outlines the statistics of survey subjects by gender, shows that out of the total 265 participants, 103 (38.9%) are male, and 162 (61.1%) are female. This gender distribution indicates a higher representation of female students in the study, which could have implications for the analysis of challenges faced when using PhET simulations in science education. The overrepresentation of female students may reflect the gender composition of the schools involved or could suggest differing levels of interest or accessibility between genders. This disparity in participation could potentially influence the study's findings, particularly in understanding gender-specific challenges or preferences in using technology-based educational tools like PhET simulations. Understanding these nuances is crucial for developing targeted interventions and ensuring that the benefits of such tools are equitably distributed across different student demographics.

Table 2. Survey subjects by grade level

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Level_10	65	24.5	24.5	24.5
	Level_11	119	44.9	44.9	69.4
	Level_12	81	30.6	30.6	100.0
	Total	265	100.0	100.0	

The data presented in Table 2, which details the survey subjects by grade level, reveals that among the 265 participants, 65 students (24.5%) are in Grade 10, 119 students (44.9%) are in Grade 11, and 81 students (30.6%) are in Grade 12. This distribution shows a higher participation rate from Grade 11 students, with nearly half of the respondents belonging to this grade, while Grade 10 and Grade 12 students are less represented. The predominance of Grade 11 students in the sample could influence the study's findings, as their experiences and challenges with PhET simulations may differ from those of younger or older students due to their intermediate stage in the secondary education curriculum. This distribution highlights the need to consider how grade level might impact students' familiarity with and responses to PhET simulations, potentially affecting the overall analysis of educational challenges and the development of tailored strategies for different academic stages.

3.2. Reliability Analysis

Table 3. Reliability Statistics

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.818	.818	13

The data in Table 3, which presents the reliability statistics of the survey instrument, indicates a Cronbach's Alpha of 0.818, suggesting a high level of internal consistency among the 13 items included in the survey. A Cronbach's Alpha value above 0.8 is generally considered to reflect good reliability, meaning that the survey questions are likely measuring the same underlying construct consistently. This high reliability is crucial for the validity of the study, as it ensures that the results derived from the survey are dependable and can be confidently used to analyze the challenges students face when using PhET simulations in science education. The strong internal consistency supports the robustness of the findings, allowing for more accurate identification of the specific difficulties students encounter and facilitating the development of effective educational interventions.

3.3 Analysis of main results obtained

Table 4. Item Statistics

	Mean	Std. Deviation	N
Q1	4.8377	.41753	265
Q2	4.6906	.50237	265
Q3	4.7019	.53460	265
Q4	4.5774	.57952	265
Q5	4.6755	.55079	265
Q6	4.6038	.66114	265
Q7	4.8151	.43493	265
Q8	4.7170	.49149	265
Q9	4.7057	.53315	265
Q10	4.5547	.58211	265
Q11	4.6906	.54574	265
Q12	4.5887	.66334	265
Q13	4.6453	.59243	265

Table 4 presents the item statistics, showing the mean and standard deviation for each of the 13 survey questions related to students' experiences with PhET simulations. The analysis of these statistics provides valuable insights into the specific challenges and benefits perceived by students when using PhET simulations in science education.

Starting with the mean scores, all items have mean values above 4, indicating a general trend towards agreement or strong agreement with the statements presented in the survey. For instance, the highest mean score is observed for Q1 (Mean = 4.8377), which suggests that a significant portion of students feel that they encounter difficulties in using computers or devices to run PhET simulations. This high score underscores the importance of addressing technical issues as a primary barrier to the effective use of simulations in science education. It also highlights the necessity for schools to ensure that students have access to reliable technology and the necessary technical skills to use these tools effectively.

On the other hand, items such as Q10 (Mean = 4.5547) and Q13 (Mean = 4.6453) also show relatively high mean scores, which indicate that students generally recognize the usefulness of PhET simulations as a learning tool and express a desire for additional support from teachers during the process. These findings suggest that while students see value in PhET simulations, they still require more guidance and resources to maximize their learning outcomes. This could imply that the integration of such tools into the curriculum needs to be accompanied by adequate teacher training and the provision of supplementary instructional materials.

The standard deviation values, which are generally below 0.7 for most items, indicate a relatively low level of dispersion in students' responses. This suggests that there is a consistent perception of the challenges and benefits of PhET simulations across the student population surveyed. The lower standard deviation for Q1 (Std. Deviation = 0.41753) further emphasizes the widespread nature of the technical difficulties encountered by students, making it a critical area for intervention.

Interestingly, the relatively lower mean scores for items like Q3 (Mean = 4.7019) and Q6 (Mean = 4.6038), which address issues related to internet stability and the need for additional guidance from teachers, suggest that while these are important factors, they may not be as pressing as the direct technical challenges or the perceived usefulness of the tool. However, the consistent agreement across these items still points to the necessity of ensuring robust internet infrastructure and effective teacher involvement to facilitate the optimal use of PhET simulations.

In summary, the analysis of the item statistics reveals that students generally face technical challenges when using PhET simulations and recognize the tool's educational value. There is a clear demand for enhanced teacher support and resources to help students navigate these challenges. These insights underscore the importance of a holistic approach to integrating technology in education, one that considers both the technical and pedagogical support needed to fully realize the potential of tools like PhET simulations.

Table 5. Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Q1	55.9660	14.366	.485	.806
Q2	56.1132	14.661	.302	.817
Q3	56.1019	14.509	.314	.817
Q4	56.2264	13.312	.574	.796
Q5	56.1283	13.877	.462	.806
Q6	56.2000	13.062	.539	.799
Q7	55.9887	14.239	.502	.804
Q8	56.0868	14.504	.355	.813
Q9	56.0981	14.498	.318	.816
Q10	56.2491	13.407	.546	.799
Q11	56.1132	13.881	.466	.805
Q12	56.2151	13.041	.542	.799
Q13	56.1585	13.399	.536	.799

Table 5 presents the item-total statistics, which include the scale mean if an item is deleted, the scale variance if an item is deleted, the corrected item-total correlation, and Cronbach's Alpha if an item is deleted. These statistics are critical for assessing the contribution of each survey item to the overall reliability and consistency of the survey instrument.

Starting with the "Scale Mean if Item Deleted", the values range from approximately 55.97 to 56.25. The relatively small variation in scale mean if any item is deleted suggests that each item contributes similarly to the overall scale. However, the slight increase or decrease in the mean when certain items, such as Q4 (56.23) and Q10 (56.25), are deleted indicates that these items have a significant influence on the average score. Q4, which addresses difficulties in understanding scientific concepts presented in PhET simulations, and Q10, which evaluates the perceived usefulness of PhET simulations, are particularly critical in shaping the overall perception of PhET’s impact on learning.

The "Scale Variance if Item Deleted" provides insights into how the removal of an item affects the variability of the overall scale. Items such as Q4 (Scale Variance = 13.31) and Q6 (Scale Variance = 13.06) show lower variance compared to others, indicating that these items contribute less to variability and more to the consistency of the scale. Q6, which assesses the need for additional guidance from teachers when using PhET simulations, seems to be a consistent concern among students, reflecting a widespread recognition of the importance of teacher support in the effective use of these tools.

The "Corrected Item-Total Correlation" values, which measure the correlation between each item and the total score, are all positive, ranging from 0.302 (Q2) to 0.574 (Q4). Higher correlations indicate that the item is more closely related to the overall survey content. Q4 again stands out with the highest corrected item-total correlation (0.574), signifying that students' difficulty in understanding scientific concepts in PhET simulations is strongly aligned with their overall experience of challenges. Conversely, Q2 (0.302), which deals with software errors in PhET simulations, shows a relatively lower correlation, suggesting that while software errors are a concern, they may not be as central to the overall challenge experienced by students as cognitive or instructional issues.

Finally, the "Cronbach's Alpha if Item Deleted" values are all close to the overall Cronbach’s Alpha of 0.818, with slight variations. The removal of any item results in a small decrease in Cronbach's Alpha, except for Q4 and Q6, which slightly increases reliability (0.796 and 0.799, respectively). This suggests that while these items are important, the overall consistency of the survey would slightly improve if they were excluded. However, their inclusion is justified given their relevance to the study's focus on cognitive and instructional challenges in using PhET simulations.

In summary, the item-total statistics reveal that each survey item contributes meaningfully to the overall scale, with particular emphasis on cognitive difficulties (Q4) and the need for teacher support (Q6). These insights highlight the critical areas where students face challenges with PhET simulations, particularly in understanding scientific concepts and needing additional instructional guidance. The analysis underscores the importance of addressing these issues to improve the effectiveness of PhET simulations in science education, ensuring that students receive the necessary support to overcome these challenges and fully benefit from the educational tool.

Table 6. Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
									Lower	Upper
Q1	Equal variances assumed	2.020	.156	-.690	263	.491	-.03632	.05267	-.14003	.06739
	Equal variances not assumed			-.665	191.405	.507	-.03632	.05462	-.14405	.07141
Q2	Equal variances assumed	.307	.580	-.533	263	.594	-.03380	.06340	-.15863	.09103
	Equal variances not assumed			-.537	222.564	.592	-.03380	.06293	-.15781	.09021
Q3	Equal variances assumed	4.420	.036	-1.012	263	.312	-.06820	.06737	-.20085	.06445
	Equal variances not assumed			-.977	191.642	.330	-.06820	.06984	-.20595	.06955
Q4	Equal variances assumed	4.517	.034	-1.190	263	.235	-.08684	.07298	-.23053	.05685
	Equal variances not assumed			-1.157	196.903	.249	-.08684	.07508	-.23491	.06123
Q5	Equal variances assumed	3.287	.071	.783	263	.434	.05442	.06946	-.08236	.19119
	Equal variances not assumed			.811	241.179	.418	.05442	.06708	-.07772	.18655
Q6	Equal variances assumed	.510	.476	-.226	263	.821	-.01888	.08347	-.18323	.14547
	Equal variances not assumed			-.222	205.365	.824	-.01888	.08486	-.18619	.14844
Q7	Equal variances assumed	.450	.503	-.276	263	.783	-.01516	.05491	-.12328	.09295
	Equal variances not assumed			-.269	199.125	.788	-.01516	.05631	-.12621	.09589
Q8	Equal variances assumed	.285	.594	-.473	263	.636	-.02937	.06203	-.15151	.09277
	Equal variances not assumed			-.477	222.838	.634	-.02937	.06155	-.15066	.09193
Q9	Equal variances assumed	5.047	.025	-1.107	263	.269	-.07437	.06716	-.20661	.05787
	Equal variances not assumed			-1.067	190.767	.287	-.07437	.06971	-.21187	.06313
Q10	Equal variances assumed	2.315	.129	-.462	263	.645	-.03392	.07347	-.17858	.11074
	Equal variances not assumed			-.450	199.003	.653	-.03392	.07536	-.18254	.11469
Q11	Equal variances assumed	5.554	.019	1.126	263	.261	.07737	.06874	-.05798	.21272

	Equal variances not assumed			1.172	244.399	.242	.07737	.06603	-.05269	.20743
Q12	Equal variances assumed	.393	.531	-.120	263	.904	-.01007	.08375	-.17498	.15484
	Equal variances not assumed			-.118	205.810	.906	-.01007	.08510	-.17784	.15771
Q13	Equal variances assumed	8.697	.003	-2.025	263	.044	-.15031	.07422	-.29646	-.00416
	Equal variances not assumed			-1.964	195.547	.051	-.15031	.07651	-.30121	.00059

The results in Table 6, which present the Independent Samples Test, provide insights into whether there are significant differences in the responses between different groups of students regarding the challenges faced when using PhET simulations. The p-values across most items are above the significance threshold of 0.05, indicating no statistically significant differences between groups for the majority of the survey items. This suggests that the challenges related to technical issues, cognitive understanding, and the need for teacher support are consistently experienced across the student population, regardless of the group differences. However, item Q13, which assesses the need for additional teacher support, has a p-value close to the significance level (p = 0.044), suggesting a potential difference in perceptions between groups on this particular issue. This finding implies that while most challenges are uniformly experienced, there might be variations in how different groups of students perceive the adequacy of teacher support when using PhET simulations, highlighting the need for tailored instructional approaches to better address diverse student needs.

Table 7. ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Q1	Between Groups	.298	2	.149	.855	.427
	Within Groups	45.724	262	.175		
	Total	46.023	264			
Q2	Between Groups	.277	2	.139	.547	.579
	Within Groups	66.349	262	.253		
	Total	66.626	264			
Q3	Between Groups	.864	2	.432	1.517	.221
	Within Groups	74.585	262	.285		
	Total	75.449	264			
Q4	Between Groups	.210	2	.105	.311	.733
	Within Groups	88.454	262	.338		
	Total	88.664	264			
Q5	Between Groups	.239	2	.120	.393	.676
	Within Groups	79.851	262	.305		
	Total	80.091	264			
Q6	Between Groups	.918	2	.459	1.051	.351
	Within Groups	114.478	262	.437		
	Total	115.396	264			
Q7	Between Groups	.746	2	.373	1.985	.139
	Within Groups	49.194	262	.188		
	Total	49.940	264			
Q8	Between Groups	.271	2	.135	.558	.573
	Within Groups	63.503	262	.242		

	Total	63.774	264			
	Between Groups	.410	2	.205	.719	.488
Q9	Within Groups	74.632	262	.285		
	Total	75.042	264			
	Between Groups	.190	2	.095	.279	.757
Q10	Within Groups	89.267	262	.341		
	Total	89.457	264			
	Between Groups	.017	2	.008	.028	.973
Q11	Within Groups	78.610	262	.300		
	Total	78.626	264			
	Between Groups	.396	2	.198	.448	.639
Q12	Within Groups	115.770	262	.442		
	Total	116.166	264			
	Between Groups	.209	2	.105	.297	.744
Q13	Within Groups	92.447	262	.353		
	Total	92.657	264			

The ANOVA results in Table 7 show the analysis of variance across different groups for each survey item, focusing on whether there are statistically significant differences in how students from various groups experience challenges with PhET simulations. The p-values for all items are well above the 0.05 significance threshold, indicating no significant differences between groups for any of the survey items. This uniformity suggests that the challenges related to technical issues, cognitive understanding, and the impact on learning and engagement are consistent across the different student groups, regardless of their grade level or other demographic factors. The lack of significant variability across groups reinforces the notion that the difficulties students face when using PhET simulations are widespread and not confined to specific subgroups. This consistency across the board underscores the importance of addressing these challenges at a broad level, ensuring that interventions are designed to be inclusive and effective for the entire student population.

In comparing the results of this study with existing literature on the use of technology in education, several key similarities and differences emerge. Previous studies have consistently highlighted the benefits of technology, particularly tools like PhET simulations, in enhancing student engagement and understanding of scientific concepts. For instance, research by Perkins et al. (2006) and Wieman et al. (2010) emphasizes the role of PhET simulations in providing interactive, hands-on learning experiences that can make abstract scientific concepts more accessible to students. This aligns with the findings of the current study, where students generally recognize the usefulness of PhET simulations, as reflected in the high mean scores for items related to understanding and interest in science.

However, this study also reveals persistent challenges, such as technical difficulties and the need for additional teacher support, which are consistent with issues identified in other research. For example, studies like those by Habibi et al. (2020) and Hán Thị Hương Thủy & Đỗ Hương Trà (2022) have noted that while technology can enhance learning, its effectiveness is often hindered by factors such as inadequate infrastructure, insufficient teacher training, and varying levels of student digital literacy. The technical challenges and the need for more instructional guidance highlighted in this study echo these concerns, suggesting that while PhET simulations are a valuable educational tool, their successful implementation requires addressing these underlying issues.

Additionally, the current study's findings on the uniformity of challenges across different student groups align with observations from the broader literature, which suggests that technology-related difficulties in education are often pervasive, affecting diverse student populations regardless of their specific demographics. This reinforces the importance of comprehensive strategies that address both technical and pedagogical aspects to maximize the benefits of technology in education, as advocated by educational researchers globally.

In summary, the results of this study corroborate existing literature on the dual nature of technology in education—offering significant benefits while also presenting challenges that need to be carefully managed. This study contributes to the ongoing discourse by providing specific insights into the Vietnamese educational context, particularly in secondary schools in Hai Phong, and highlights the importance of holistic approaches to integrating tools like PhET simulations into science education effectively.

7. Conclusion

This study identified several significant challenges that students face when using PhET simulations in science education, particularly in secondary schools in Hai Phong. The most prominent challenges include technical difficulties, such as issues with device compatibility and unstable internet connections, and cognitive challenges, such as difficulties in understanding scientific concepts presented through the simulations. Additionally, there is a notable need for increased teacher support, as many students reported requiring additional guidance to effectively use the simulations. These challenges have important implications for teaching practices, as they suggest that without proper technical support and instructional guidance, the educational benefits of PhET simulations may not be fully realized, potentially leading to reduced student engagement and learning outcomes.

To mitigate these challenges and improve the effectiveness of PhET simulations, educators should consider the following strategies:

(1) Enhance Technical Infrastructure: Schools should ensure that students have access to reliable devices and stable internet connections to minimize technical barriers. This might include investing in better hardware and providing technical support to both students and teachers.

(2). Provide Targeted Teacher Training: Educators should receive comprehensive training on how to effectively integrate PhET simulations into their teaching practices. This training should include not only the technical aspects of using the simulations but also strategies for guiding students in their learning and addressing common cognitive challenges.

(3). Develop Supplementary Materials: Schools and educational institutions should create and distribute instructional materials that can help students better understand how to use PhET simulations and apply the concepts they learn to real-world scenarios. These materials could include step-by-step guides, example exercises, and video tutorials.

Given the limitations of this study, several areas warrant further investigation. Future

By addressing these research gaps, future studies can contribute to a more comprehensive understanding of how to optimize the use of PhET simulations and similar educational technologies, ultimately enhancing the quality of science education for all students.

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9. Appendix: Survey Content

EXPLORING CHALLENGES IN USING PHET SIMULATIONS IN SCHOOL SCIENCE SUBJECTS

Dear students,

We are conducting a study aimed at exploring the challenges you may encounter when using PhET simulations in your Science studies. PhET simulations are an online learning tool that offers many benefits, but they can also present some challenges during usage. We would like to hear your opinions to better understand these difficulties and, in turn, propose improvements for teaching and learning.

This survey will help us collect valuable information from you, contributing to the enhancement of educational quality at secondary schools in Hai Phong. Specifically, your feedback will assist us in developing appropriate support solutions to make learning Science easier and more enjoyable.

We greatly appreciate your enthusiastic participation in this survey. Participation is entirely voluntary, and all your personal information will be kept strictly confidential.

Thank you very much for taking the time to participate and contribute to our research!

Sincerely,

Please mark (X) the box that best reflects your opinion according to a scale from 1 to 5, where:

1. Strongly disagree
2. Disagree
3. Neutral
4. Agree
5. Strongly agree

I. General Information

1. Grade: 10/11/12
2. Gender: Male/Female

II. Survey Questions

1. Technical Issues

- Q1. I find it difficult to use computers or devices to run PhET simulations.
  [ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5
- Q2. PhET simulations often encounter errors when I use them.
  [ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5
- Q3. Unstable internet speed makes it difficult to use PhET simulations.
  [ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5

2. Cognitive Understanding

- Q4. I find it difficult to understand the scientific concepts presented in PhET simulations.
  [ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5
- Q5. I struggle to apply knowledge from PhET simulations to real-life lessons.
  [ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5
- Q6. I need additional guidance from my teacher when using PhET simulations.
  [ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5

3. Impact on Learning and Interest

- Q7. PhET simulations help me better understand Science subjects.
  [ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5
- Q8. I feel more interested in learning Science with PhET simulations.
  [ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5
- Q9. The difficulties in using PhET simulations reduce my learning efficiency.
  [ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5

4. General Evaluation

- Q10. I think PhET simulations are a useful tool for learning Science.

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5

- Q11. I would like to continue using PhET simulations in Science lessons.

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5

5. Suggestions for Improvement

- Q12. I think there should be more instructional materials to use PhET simulations more effectively.

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5

- Q13. I need more support from my teacher while using PhET simulations.

[ ] 1 [ ] 2 [ ] 3 [ ] 4 [ ] 5

III. Additional Comments (Optional)

- Q14. Please provide any additional comments on the use of PhET simulations in Science learning:

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Thank you for participating in the survey!