American Journal of Education and Technology (AJET)

ISSN: 2832-9481 (ONLINE)

VOLUME 4 ISSUE 3 (2025)

PUBLISHED BY
E-PALLI PUBLISHERS, DELAWARE, USA

American Journal of Education and Technology (AJET)

Volume 4 Issue 3, Year 2025
ISSN: 2832-9481 (Online)
DOI: https://doi.org/10.54536/ajet.v4i3.4512
https://journals.e-palli.com/home/index.php/ajet

Physics Education Technology (PhET) Interactive Simulations in Learning Selected Topics in Physics among College Students

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Article Information

Received: February 07, 2025
Accepted: March 11, 2025
Published: June 23, 2025

Keywords

Effectiveness, Perception, PhET, Projectile Motion, Vector Addition

ABSTRACT

Physics is often perceived as a challenging subject, with students struggling to grasp fundamental concepts like kinematics—a crucial foundation of classical physics and a prerequisite for advanced studies. This study investigates the effectiveness of PhET Interactive Simulations as a learning intervention for college students. A total of 54 students enrolled in a Biophysics course participated in the study, focusing on Kinematics in Two Dimensions, specifically Vector Addition and Projectile Motion. A quantitative research design was employed, integrating pre-test, post-test, and Likert scale questionnaires. An independent sample t-test confirmed the comparability of the control and experimental groups before the intervention ($t(52) = 1.523$, $p = 0.134$). The related-samples Wilcoxon Singed-Rank test revealed a significant improvement in pre- and post-test scores within the groups ($n = 54$, $Z = -6.222$, $p < 0.001$), attributing the improvement of respondents' performance; also underscores the higher gain of the experimental group. Additionally, using Mann-Whitney U test, a significant difference was observed in post-test scores between the two groups ($U = 103.5$, $Z = -4.528$, $p < 0.001$), confirming the effectiveness of PhET Interactive Simulations. Likert scale analysis showed that students' perceptions of the intervention were highly favorable across four parameters: (1) ease of access, (2) physical features and display, (3) ease of manipulation, and (4) relevance to the topic, with an overall weighted mean of 4.731 ($SD = 0.449$). These findings suggest that PhET Interactive Simulations serve as an effective tool for enhancing student learning in physics. Based on these findings, it is recommended that educators integrate PhET Interactive Simulations into physics instruction to improve conceptual understanding and student engagement.

INTRODUCTION

Physics, much like mathematics, is often perceived as difficult due to its abstract concepts and reliance on complex formulas and calculations. Many students struggle to see its relevance to real-world applications, leading to disengagement and poor performance (Guido, 2018; Tekwani, 2020). Common difficulties include memorizing formulas without understanding, solving problems without being able to explain the reasoning, and actively participating in class yet failing simple quizzes (Retnawati *et al.,* 2018). Despite teachers' efforts, a majority of students find physics unapproachable, and conventional teaching methods have not effectively addressed this challenge (Lopez, 2017).

Moreover, only a small fraction of students show genuine interest in physics, posing a persistent challenge for educators. Kinematics, as a fundamental branch of physics, is crucial for understanding more advanced topics like dynamics. However, its abstract nature and the complex relationship between motion and forces make it difficult for students to grasp, leading to significant learning gaps that hinder their ability to fully comprehend subsequent concepts (PhysicsForums, 2018; Putri *et al.,* 2024; Shodiqin & Taqwa, 2021). Not just students, pre-service teachers are also having difficulty in dealing with physics concepts (Sutarno *et al.,* 2017). Given the highly abstract nature of kinematics and dynamics, and the well-documented difficulty students face in mastering these concepts, there is a pressing need for effective alternative teaching-learning strategies that can simplify and enhance their understanding (Tazitabong, 2024). While technology offers new ways to enhance learning, many physics teachers still rely on traditional lectures, which students often find boring and irrelevant (Uwizeyimana *et al.,* 2018). The gap between the evolving role of technology and outdated teaching methods highlights the need for a shift in pedagogical approaches to improve student engagement and understanding.

Physics Education Technology (PhET) Interactive Simulations present a promising tool to bridge these gaps (Almadrones & Tadifa, 2024). PhET Interactive Simulations was a project of the University of Colorado Boulder and it provides over 130 free interactive math and science simulations. It was founded on 2002 by Nobel Laureate Carl Wieman. PhET simulations are based on extensive education research and engage students through an intuitive, game-like environment where students learn through exploration and discovery (PhET-iO, 2016). While these simulations have been used for years, their potential to transform physics education became even more apparent during the pandemic, when traditional teaching methods proved insufficient (Bahasoan *et al.,* 2020). However, further exploration is needed to assess the impact of PhET simulations on students' conceptual

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understanding and engagement, particularly in post-pandemic blended learning environments.

The limited local studies, the need for effective learning tools in physics education due to its difficulty, and the potential of PhET Interactive Simulations as an alternative strategy motivated this research. This study aims to evaluate the effectiveness of PhET Interactive Simulations in enhancing college students' performance in learning selected physics topics. Specifically, this research aims to answer the following questions:

1. What are the pre-test and post-test scores of students before and after the utilization of
   a. conventional teaching strategies; and
   b. conventional teaching strategies with PhET Interactive Simulations?
2. Is there a significant difference in the pre-test and post-test scores of Control and Experimental groups?
3. Is there a significant difference in the post-test scores of Control and Experimental groups?
4. What are the perceptions of students on the use of PhET Interactive Simulations in learning selected Physics topics in terms of:
   a. ease of access;
   b. physical features and display;
   c. ease of manipulation; and
   d. significance to the topic?

LITERATURE REVIEW

Teaching and Learning Physics

It is common knowledge, especially for learners, that physics is such a difficult subject. One cannot separate physics from mathematics, for both discipline shares a common language—numbers. Aside from complicated formulas and long, confusing computations, physics is full of abstract concepts. The very reason why many secondary and tertiary learners have a hard time understanding it (Guido, 2018; Tekwani, 2020; Wangchuk *et al.,* 2023). Students have prejudices about schools, learning, and the field of physics itself, in addition to preconceptions about physical phenomena. Some students could find it particularly challenging because they have general misconceptions about what physics is and how to approach it. A study conducted by Reddy and Panacharoensawad (2017) revealed that poor mathematical skills and a lack of understanding of the problem are major obstacles in developing problem-solving skills in physics. Likewise, there is often a severe problem of lack of communication between teachers and students. Based on the study of Sartika and Humairah (2017), college students struggled to understand problems and found it difficult to devise a solution plan. On the other hand, findings of Bustami *et al.* (2020) revealed that college student factors, teaching-learning factors, and learning facility factors did not cause college students to experience difficulties in understanding physics subjects.

Alternative Learning Strategies

In recent years, the integration of technology has expanded the possibilities for learning exercises in physics. Interactive simulations and virtual experiments enable students to explore phenomena that may be challenging to observe directly in a traditional classroom setting. These simulations provide a hands-on experience that allows students to manipulate variables, observe the effects in real-time, and develop an intuitive understanding of the concepts being taught (Laws *et al.,* 2015).

Using analogies to scaffold understanding in "Electromagnetic Waves" and "Sound Waves" topics are found to be effective in enhancing learners' metacognitive abilities compared to the abstract presentation (Distrik *et al.,* 2018; Mahmudah *et al.,* 2024; Maulidah & Prima, 2018). Beyond what is being mentioned, Bantuyong and Antonio (2018) developed PhET-based activities that are found to be effective in learning "Electromagnetism". The learning experiences of the students are synthesized into three themes: (1) Physics is fun; (2) Physics is real; and (3) Physics is simple and easy. Because of these findings, despite the abstractness of physics, it could still be taught through an effective learning tool. High school and college students can grasp complicated physics topics once they find the way of teachings interesting. Additionally, the research conducted by Kibirige and Lehong in 2016 proved that the utilization of cooperative learning techniques in learning projectile motion resulted in a greater improvement in learners' performance compared to the traditional teaching approach. Pineda (2020) even recommended, based on the learning improvement of students, that the developed Teaching-Learning Package should be used in teaching projectile motion compared to the traditional textbook. Syuhendri (2021) further proved that conceptual change-based instruction led to significantly greater acquisition of conceptual change in kinematics compared to traditional instruction.

Conceptual questions, on the other hand, focus on assessing students' comprehension of key concepts and their ability to apply them in different contexts. These questions may require students to explain phenomena, predict outcomes, or analyze the consequences of changing variables (Docktor *et al.,* 2015). Furthermore, Laws *et al.* (2015) explored collaborative learning exercises in physics. These exercises such as group problem-solving sessions or laboratory experiments, foster teamwork and communication skills. These exercises encourage students to engage in discussions, share ideas, and collectively arrive at solutions. Similarly, Akinbobola (2015) said that the most effective way in facilitating student's transfer of knowledge in physics is through guided discovery followed by demonstration. It is advised that guided discovery and other student-centered teaching methodologies be used to actively include the students in learning scientific knowledge processes and ethics.

ICT, online simulations, and virtual labs have gained significant attention in recent years as effective tools for enhancing science education (Bahasoan *et al.,* 2020; Selmi, 2023). These innovative approaches leverage computer-based technologies and create interactive environments where students can explore and experiment with physics concepts. By manipulating variables, observing outcomes, and analyzing data in a simulated setting, students engage in a dynamic and immersive learning experience (Calderón & Ruíz, 2019). Virtual environments, including simulations and virtual worlds, provide valuable opportunities for active learning, enabling students to take a more hands-on role in the learning process (Bogusevschi *et al.,* 2020). Research by Alnagrat *et al.* (2023) and Lamb *et al.* (2019) has shown that simulation software and virtual reality (VR) significantly improve student achievement. Furthermore, teachers are increasingly integrating technology-based tools like PhET into their instruction, as Lagon (2023) highlighted, demonstrating a shift toward more interactive and technology-enhanced teaching strategies.

Simulations are valuable tools for interactive and engaging learning experiences, but they cannot replace the essential role of teachers (Kaufman & Ireland, 2019). Teachers provide subject expertise, guidance, individualized instruction, and emotional support that simulations alone cannot offer. Teachers foster critical thinking, adapt instruction to students' needs, and create a supportive classroom environment. While simulations enhance learning, their integration with skilled teaching practices maximizes student engagement and comprehension, creating a holistic educational experience.

Integration of PhET Interactive Simulations in Philippine Classrooms

The adaptability of PhET Interactive Simulations across different classroom settings provides educators with flexibility in their instructional approaches. Their availability online makes them accessible anytime, allowing students to review concepts, conduct virtual experiments, and deepen their understanding of physics. PhET also has a database of teacher-created lessons to which the teachers use the simulations in a variety of ways—from embedding simulations to lectures, to small-group projects, to homework assignments (PhET-iO, 2016). The findings of Mallari and Lumanog (2020) showed that Filipino high school students were highly engaged, motivated, and challenged during interactive classroom activities. It can be concluded and recommended that incorporating PhET interactive simulation-based activities positively influences students' academic performance in Science.

Maulidah and Prima (2018) conducted research aimed at exploring students' utilization of simulations to develop a conceptual framework and investigate the impact of different levels of guidance on their usage of simulations. Through detailed analysis, it was discovered that the incorporation of visualizations and analogies aided secondary students in constructing their understanding. Almadrones and Tadifa (2024) and Batuyong and Antonio (2018) also showcased the effectiveness of PhET Interactive Simulations in teaching physics. They further recommended PhET to be used for classroom instruction for understanding Physics concepts for diverse learners. Furthermore, the use of PhET simulations led to a notable improvement in test scores for students, outperforming those who used only printed modules. The engaging learning environment and the tool's reliable, effective instructional features contributed to these positive outcomes (Blacer-Bacolod, 2022).

On the contrary, the results of Yunzal and Casinillo's (2020) study indicated that there was no significant difference in the mean scores between the control and experimental groups, despite the students' expressed interest in playing the simulation. Students may be more drawn to simulations that align with the content covered in their lectures. Additionally, the study revealed that the students' performance before and after being exposed to the PhET simulation did not exhibit a substantial variation, but it did show a slight improvement in their overall performance.

MATERIALS AND METHODS

Research Design

This study utilized PhET Interactive Simulations as a learning intervention. It intends to examine the level of performance of third-year college students undertaking Bachelor of Science in Biology major in Medical Biology (BSB MedBio) of Palawan State University who are enrolled in Biophysics course before and after the intervention. The researcher used a quasi-experimental quantitative research design with the integration of pre-test and post-test (Cook, 2015). In this design, all the respondents are subjected to conventional teaching strategies (multimedia aided lecture-discussion); however, only the experimental group used PhET Interactive Simulations as a learning intervention. The pre-test and post-test scores of the control and experimental groups were recorded and compared to assess the distribution of data. For pre-test mean scores, an independent samples t-test was used to ensure that the groupings were not statistically different and are therefore comparable. The pre-test and post-test mean scores of each group was also compared using non-parametric test (related samples Wilcoxon Signed-Rank test) to see if the improvement in the respondents' scores is significantly different. Likewise, the post-test mean scores of the two groups was further compared using an independent samples Mann-Whitney U test. The tests answer if PhET Interactive Simulation is effective or not as a learning intervention. Moreover, to collect relevant data on students' perceptions in terms of the use of intervention, the researcher employed a Likert-scale questionnaire where responses vary from Strongly Agree (SA) to Strongly Disagree (SD) for each statement.

Research Instrument

To collect relevant quantitative data, the researcher used (1) a validated and reliable (Cronbach's alpha coefficient $\alpha=0.83$) pre-test and post-test, that measured the improvement in student's performance before and after the intervention, (2) a validated and reliable (Cronbach's alpha coefficient $\alpha=0.97$) Likert scale, that measured students' perception of the use of teaching intervention. As indicated in the course syllabus, the focus of the questionnaires is the Classical Mechanics: Motion in Two Dimensions; specifically, Vector Addition and Projectile Motion.

Before the instruction begins, a paper-and-pen pre-test in the form of a multiple-choice was administered to the respondents. Parallel post-test, together with the Likert scale questionnaire (only in experimental group), followed shortly after teaching the intended topics. The pre- and post-tests are backed-up with prepared Table of Specifications (TOS). The five-point Likert scale have varying responses of Strongly Agree (SA), Agree (A), Neutral (N), Disagree (D), and Strongly Disagree (SD).

Statistical Treatment

All statistical treatments were carried out using Statistical Package for Social Science (SPSS). The researcher computed and compared the mean scores, mean percentage scores and standard deviation (SD) of the pre-test and post-test scores of both groups. To describe the level of performance of the respondents through frequency distribution from the 30-item multiple choice test, the following descriptors was adapted, with modifications, from the study of Bantuyong and Antonio (2017) for interpretation.

Table 1: Pre-test – Post-test Scores Descriptor

Respondents' Score Interval	Descriptor
25 – 30	Outstanding
19 – 24	Very Satisfactory
13 – 18	Satisfactory
7 – 12	Fair
0 – 6	Needs Improvement

To prove that both groups are comparable, the researcher administered an independent sample t-test after the pre-test data passed the test for normality using Kolmogorov-Smirnov test (Lilliefors, 2012) and homogeneity of variance using Levene's test (Schultz, 1985). The data gathered from post-test scores was found out to be not normally distributed using the same normality test (Kolmogorov-Smirnov); thus, the researcher opted to administer the non-parametric Wilcoxon Signed Rank test to determine if there is a significant difference in the pre-test – post-test scores (related samples test) and a Mann-Whitney U test for the post-test scores of both groups (independent samples test). Furthermore, to determine the practical significance of the difference between groups, the researcher computed the effect size. In this study, rank-biserial correlation (r) was employed as a measure of the effect size of the variables (DATAtab Team, 2025). Effect size r helps to quantify the strength of the observed difference, allowing for a better understanding of the practical implications of the study findings. Below is the corresponding descriptor to effect size r values computed.

Table 2: Effect size r Descriptor

r value	Descriptor
0.00 < 0.30	Small effect
0.30 < 0.50	Medium effect
0.50 or more	Large effect

To describe the perception of the respondents on the use of intervention in terms of the following parameters: (1) ease of access; (2) physical features and display; (3) ease of manipulation; and (4) significance to the topic, the researcher calculated the mean weight and standard deviation of Likert scale data. The following scale was adapted and modified from the study of Bacolod *et al.,* (2022) for the interpretation of results.

Table 3: Students' Perception Mean Score Descriptor

Weighted Mean Interval	Description	Characteristics
1.2 – 5.0	Highly Favorable	Respondents perceive the intervention as very effective and user-friendly.
3.4 – 4.19	Favorable	Respondents recognize the intervention as effective with some minor limitations.
2.6 – 3.39	Neutral	Respondents are undecided about the effectiveness or usability of the intervention.
1.8 – 2.59	Unfavorable	Respondents perceive the intervention as having noticeable usability or effectiveness issues.
1.0 – 1.79	Highly Unfavorable	Respondents see major usability and effectiveness problems in the intervention.

RESULTS AND DISCUSSION

The fifty-four (54) respondents completed the validated and reliable pre-test and post-test. The paper-and-pen multiple choice pre-test was administered before the conventional lecture-discussion of Classical Mechanics: Motion in Two Dimensions. The learning intervention was introduced to the experimental group. Parallel paper-and-pen multiple choice post-test was administered to both groups right after the researcher finished the learning plan.

The pre-test scores suggest that participants have limited prior knowledge of the subject matter, aligning with the findings of Almadrones and Tadifa (2024). Based on the gathered data, majority of students in both groups fell within the Moderately Satisfactory range (7–12), with a higher percentage in the Control Group (78%)

Table 4: Descriptive Statistics of Respondents' Performance Through Pre- and Post-Test Scores

Scores Interval	Pre-test				Post-test				Remarks
	Experimental Group		Control Group		Experimental Group		Control Group		
	f	%	f	%	f	%	f	%	
25 – 30	0	0%	0	0%	7	26%	0	0%	Outstanding
19 – 24	1	4%	0	0%	14	52%	6	22%	Very Satisfactory
13 – 18	10	37%	5	18%	5	18%	9	33%	Satisfactory
7 – 12	13	48%	21	78%	1	4%	12	45%	Fair
0 – 6	3	11%	1	4%	0	0%	0	0%	Needs Improvement
Total	27	100%	27	100%	27	100%	27	100%	
Mean % Score	38.40 %		34.32 %		72 %		49 %		
SD	2.93		2.97		4.4		4.4		

compared to the Experimental Group (48%). The mean percentage score (MPS = 38.40%; MPS = 34.32%) and standard deviation (SD = 2.93; SD = 2.97) of respective groups further proved that students have little background knowledge regarding Vectors and Projectile Motion topics. Guskey and McTighe (2018) stated that students' preconceived notions, misunderstandings, misconceptions, and knowledge gaps contribute to their low performance in pre-test assessments. The level of performance in pre-test of both groups were compared using an independent samples t-test, which showed ($t(52) = 1.523$, $p = 0.134$), indicating that there was no significant difference between the two groups before the intervention and are therefore comparable.

The Experimental Group demonstrated significant improvement, with 78% (21 out of 27 students) achieving scores in the Very Satisfactory to Outstanding categories. In contrast, the Control Group showed the opposite trend, with 78% of its students remaining in the Fair to Satisfactory categories, indicating a lower overall performance. Meanwhile, only 22% (6 out of 27 students) from the Control Group reached the Very Satisfactory to Outstanding levels. The substantial difference in MPS (72.0% vs. 49.0%) further suggests that the intervention had a positive impact on the learning outcomes of the Experimental Group. This improvement is attributed to the effectiveness of PhET Interactive Simulations, which provided an interactive and engaging learning experience that enhanced students' conceptual understanding. By allowing active exploration and visualization of abstract concepts, the intervention facilitated deeper comprehension, leading to better post-test performance. This result aligns with the findings of Bantuyong and Antonio (2018) and Chinaka (2021).

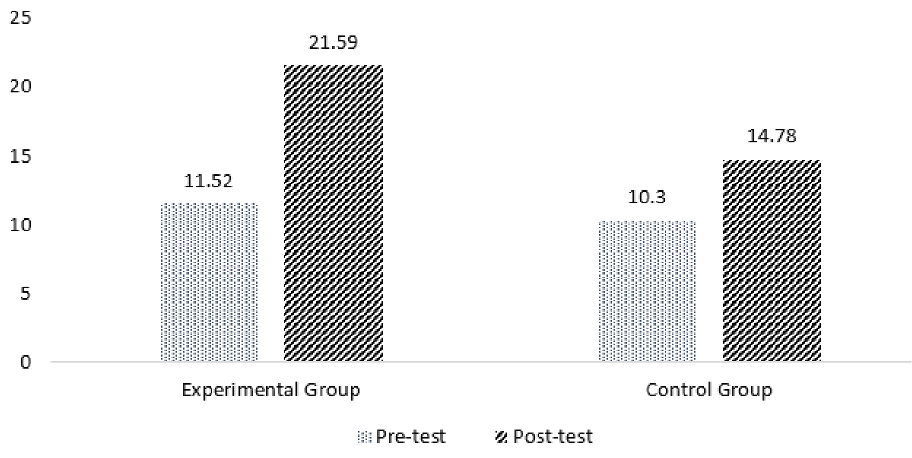

Figure 1: Overall Mean Scores: Compares Pre- and Post-test Scores

Figure 1 presents a comparison of the pre-test and post-test mean scores of the Experimental Group and Control Group, highlighting the improvement in performance after the intervention. The Experimental Group, which was taught using PhET Interactive Simulations, exhibited a substantial increase in their mean score from 11.52 in the pre-test to 21.59 in the post-test. In contrast, the Control Group, which received only conventional teaching strategies, showed a more modest increase from 10.3 to 14.78. The greater learning gains observed in the Experimental Group suggest that the use of PhET Interactive Simulations significantly enhanced students' conceptual understanding, leading to a more effective learning experience. These findings align with the study of Mallari and Lumanog (2020), which also reported that interactive simulations improve student engagement and conceptual mastery in physics. This further supports the potential of technology-enhanced learning in improving student performance, particularly in topics such as Motion in Two Dimensions.

Table 5: Related-samples Wilcoxon Singed-Rank test in the Improvement of Students' Performance (n = 54)

Pre- and Post-test Scores	Mean Rank	Sum of Ranks	Z	p	Decision	r
Negative Ranks	6.75	13.50	-6.222	< 0.001	Reject the null hypothesis	0.847
Positive Ranks	27.79	1417.5				

**Significance level is 0.05.*
**p value is asymptotic significance (2-tailed).*
**Effect size r*
<0.30 indicates a small effect
<0.50 indicates a medium effect
>0.50 indicates a large effect

The Wilcoxon Signed-Rank Test was conducted to determine whether there was a significant improvement in students' performance after the utilization of PhET Interactive Simulations. The results revealed that the mean rank of positive differences (27.79) was substantially higher than the mean rank of negative differences (6.75), indicating that most students scored higher in the post-test compared to the pre-test. Additionally, the sum of ranks for positive scores (1417.5) was significantly greater than that of negative scores (13.50), further supporting the observed improvement. The test yielded a Z-value of -6.222 and a p-value of less than 0.001, well below the 0.05 significance level. This led to rejecting the null hypothesis, confirming that the difference between pre-test and post-test scores was statistically significant. Furthermore, the effect size (r = 0.847) indicates a large effect, suggesting that using PhET Interactive Simulations had a strong and meaningful impact on students' learning outcomes. These results were further affirmed by the study of Warneri *et al.,* (2024).

Table 6: Mann-Whitney U Test in the Students' Post-test Scores (n = 54)

Group	Mean Rank	Mann-Whitney U	Z	p	Decision	r
Experimental	37.17	103.5	-4.528	< 0.001	Reject the null hypothesis	0.616
Control	17.83					

**Significance level is 0.05.*
**p value is asymptotic significance (2-tailed).*
**Effect size r*
<0.30 indicates a small effect
<0.50 indicates a medium effect
>0.50 indicates a large effect

A Mann-Whitney U test was conducted to compare the post-test performance of students in the experimental group and the control group. The results revealed a significant difference in student performance between the two groups (U = 103.5, Z = -4.528, p < 0.001). The mean rank for the experimental group (M = 37.17) was higher than that of the control group (M = 17.83), indicating that students in the experimental group performed better. Furthermore, the effect size (r = 0.616) suggests a large effect, meaning that the use of PhET Interactive Simulations had a strong impact on student performance. Given the significance level of 0.05, the null hypothesis was rejected, confirming that the learning intervention significantly influenced learning outcomes.

This finding suggests that students who used PhET Interactive Simulations as a learning intervention performed significantly better than those who were taught solely through conventional methods. These results align with the studies of Mallari and Lumanog (2020), and Bantuyong and Antonio (2018), which also highlight the effectiveness of interactive simulations in enhancing student learning. However, they contrast with the findings of Yunzal and Casinillo (2020), who reported little to no significance regarding the impact of such interventions.

Table 7: Students' Perception on the Use of PhET Interactive Simulations through Different Parameters

Statements	Weighted Mean	SD	Remarks
A. Ease of Access to PhET Interactive Simulations			
A1. It is easy to find and access PhET Interactive Simulations on the internet.	4.84	0.473	Highly Favorable
A2. The search functionality on the PhET website effectively helps me locate the desired simulations.	4.80	0.408	Highly Favorable
A3. The website provides clear and straightforward instructions for accessing and launching the simulation.	4.56	0.507	Highly Favorable
A4. PhET Interactive Simulations are readily accessible across different devices (e.g., smartphones, computers, tablets).	4.60	0.645	Highly Favorable
A5. The loading time of the simulations is reasonable, allowing for a smooth user experience.	4.44	0.712	Highly Favorable

A6. PhET Interactive Simulations are easily accessible without the need for extensive registration or account creation.	4.96	0.200	Highly Favorable
A7. The website provides helpful support and resources for troubleshooting access related issues.	4.52	0.653	Highly Favorable
Average	**4.674**	**0.514**	**Highly Favorable**
B. Physical Features and Display of PhET Interactive Simulations			
B1. The graphics in PhET Interactive Simulations are visually appealing and engaging.	4.72	0.458	Highly Favorable
B2. The physical models and representations used in the simulations are clear and easy to comprehend.	4.88	0.332	Highly Favorable
B3. The simulations effectively illustrate complex scientific concepts through intuitive and interactive displays.	4.76	0.436	Highly Favorable
B4. The labels and text descriptions within the simulations are legible and easy to read.	4.68	0.476	Highly Favorable
B5. The use of colors in the simulations effectively conveys information and enhances understanding.	4.80	0.408	Highly Favorable
B6. The display and arrangement of data or graphs within the simulations are well-organized and coherent.	4.80	0.408	Highly Favorable
B7. The inclusion of relevant animations or visual effects enhances the learning experience in the simulations.	4.80	0.408	Highly Favorable
Average	**4.777**	**0.418**	**Highly Favorable**
C. Ease of Manipulation of PhET Interactive Simulations			
C1. The interactive elements in PhET Interactive Simulations are easy to manipulate.	4.44	0.651	Highly Favorable
C2. It is straightforward to adjust parameters or variables within the simulations.	4.36	0.569	Highly Favorable
C3. It is easy to understand the purpose and functionality of each interactive simulation.	4.80	0.500	Highly Favorable
C4. I find it easy to explore different scenarios or experimental setups within the simulations.	4.56	0.712	Highly Favorable
C5. The range and flexibility of manipulations available in the simulations meet my needs.	4.60	0.577	Highly Favorable
C6. The interactive elements and controls are responsive and user-friendly.	4.72	0.458	Highly Favorable
C7. I can easily switch from one part of the simulation to another.	4.84	0.374	Highly Favorable
Average	**4.617**	**0.549**	**Highly Favorable**
D. Significance of PhET Interactive Simulations to the Topic			
D1. The PhET Interactive Simulations we used are significantly related to our topics vector addition and projectile motion.	5.00	0.000	Highly Favorable
D2. The simulations are useful for visualizing and comprehending the principles of vector addition and projectile motion.	4.92	0.277	Highly Favorable
D3. PhET Interactive Simulations improve my ability to analyze and solve problems involving vector addition and projectile motion.	4.92	0.277	Highly Favorable
D4. The simulation in vector addition helps me visualize the magnitude and direction of given vectors.	4.80	0.408	Highly Favorable
D5. The projectile motion simulation helps in understanding behavior of objects in motion.	4.76	0.436	Highly Favorable
D6. Using PhET Interactive Simulations boosts my confidence in applying the principles of vectors and projectile motion.	4.80	0.408	Highly Favorable

D7. PhET Interactive Simulations significantly enhance my understanding of vector addition and projectile motion.	4.80	0.408	Highly Favorable
Average	**4.857**	**0.316**	**Highly Favorable**
OVERALL	**4.731**	**0.449**	**Highly Favorable**

**Legend 4.2 – 5.0 Highly Favorable; 3.4 – 4.19 Favorable; 2.6 – 3.39 Neutral; 1.8 – 2.59 Unfavorable; 1.0 – 1.79 Highly Unfavorable*

Using a 5-point Likert scale, perceptions of students in the experimental group regarding the use of PhET Interactive Simulations were gathered. The overall weighted mean of 4.731, classified as Highly Favorable, reflects positive perceptions of the simulations—particularly Vector Addition and Projectile Motion—regarding accessibility, visual quality, ease of manipulation, and relevance to the topics discussed. These findings are consistent with the results of Blacer-Bacolod (2022) and Salame and Makki (2021), further supporting the effectiveness of PhET simulations and its positive impact in the learning process. For Parameter A: Ease of Access, the average weighted mean of 4.674 and standard deviation of 0.514 suggest that students find PhET simulations readily accessible, with ease of use without requiring registration (M = 4.96, SD = 0.200) receiving the highest rating. This underscores the convenience and user-friendliness of the platform. Parameter B: Physical Features and Display have an average weighted mean of 4.777 and a standard deviation of 0.418, indicating strong approval of the visual appeal, clarity of models, and interactive features. The highest-rated aspect was the clarity of physical representations (M = 4.88, SD = 0.332), emphasizing their role in enhancing conceptual understanding. For Parameter C: Ease of Manipulation, the average weighted mean of 4.617 and standard deviation of 0.549 suggest that respondents generally find PhET simulations intuitive and easy to use. The highest-rated aspect was the ease of switching between simulation sections (M = 4.84, SD = 0.374), highlighting the tool's smooth navigation and responsiveness. Finally, Parameter D: Significance to the Topic yielded the highest average weighted mean of 4.857 with a standard deviation of 0.316, demonstrating that students strongly recognize the simulations' direct relevance to learning vector addition and projectile motion. The highest-rated item was the direct alignment of simulations with the topics discussed (M = 5.00, SD = 0.000), indicating total agreement on their educational value. Moreover, all of the participants (n = 27) who used PhET Interactive Simulations supported these findings.

CONCLUSIONS

This study examined the effectiveness of PhET Interactive Simulations in teaching selected topics in physics by comparing the learning outcomes and perceptions of students who were taught using conventional teaching strategies with and without PhET. The results revealed that both groups demonstrated improvements in their post-test scores, with the experimental group—who utilized PhET simulations—showing greater gains. Statistical analysis indicated a significant difference in the pre-test and post-test scores within both groups and a significant difference in the post-test scores between the control and experimental groups, favoring the latter.

Moreover, student perceptions of PhET Interactive Simulations were highly favorable. The simulations were found to be accessible, visually engaging, easy to manipulate, and relevant to the topics studied. These findings suggest integrating PhET Interactive Simulations into physics instruction can enhance students' conceptual understanding and engagement.

Recommendations

Based on the findings of this study, it is highly recommended that physics teachers integrate PhET Interactive Simulations into their instructional strategies. The statistical evidence demonstrating significant improvements in students' learning outcomes, coupled with the positive perceptions of students regarding accessibility, visual appeal, ease of use, and relevance, highlights the effectiveness of PhET as a supplementary learning tool. Teachers are encouraged to incorporate these simulations to enhance engagement, improve conceptual understanding, and make abstract physics concepts more tangible for students.

Students are encouraged to utilize PhET Interactive Simulations as a self-directed learning tool actively. Given their interactive nature, these simulations allow students to explore physics concepts at their own pace, visualize abstract principles, and reinforce classroom learning through hands-on virtual experiments.

Educational institutions should consider providing training and resources to support the integration of PhET Interactive Simulations in physics instruction. Further studies may explore the long-term impact of these simulations on students' performance and their applicability to other areas of science education.

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