Enhancing Student Learning Motivation in Physics Through Interactive Physics Education Technology (PhET) Simulation

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ABSTRACT

Purpose of the study: This research study aims to determine the effect of PhET simulation on the learning motivation of grade 12 STEM students in physics, specifically in projectile motion.

Methodology: This study employed a quasi-experimental research design. A convenience sampling technique was utilized with a sample size of thirty-three (n=33) senior high school Grade 12 STEM students from a private institution in Malolos, Bulacan. The quantitative data of this research was obtained through the Students Motivation Toward Physics Learning Questionnaire (SMTPLQ) and a semi-structured interview with random students. The data was analyzed using average mean, p-value, and paired-samples t-test using SPSS 22 software.

Main Findings: The learning motivation of the students in physics before the implementation of the PhET simulation was 3.82 (76.4%), which was medium-level motivation. After the implementation of the PhET simulation, the student's motivation in physics was 3.85 (77%), suggesting there was no statistically significant effect after using the PhET simulation. Despite no significant impact on motivation, students appreciated the engaging interaction with PhET simulations.

Novelty/Originality of this study: This research introduces a novel approach by integrating PhET simulations to enhance student learning motivation in physics. By leveraging interactive and engaging virtual experiments, this study aims to foster a deeper understanding and interest in physics concepts among students. Using PhET simulations offers a dynamic learning environment that encourages active participation and exploration, revitalizing traditional teaching methods.

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1. INTRODUCTION

Over the years, physics has long been recognized as one of the most challenging subjects for students due to its strong connection to mathematical ideas [1]-[3]. One of the most significant difficulties that students face in physics class is that the computational aspects of the subject appear to test and even weaken their perceived physics knowledge [4]. In the study conducted by Hamerski et al., it was confirmed that students' preconceptions towards the physics subject can negatively affect their motivation to learn physics [4]. This is an ancient problem that has plagued physics teaching in high schools for decades.

Given the critical importance of physics in scientific and technological advancement, there is a pressing need to find effective solutions to increase the motivation of students to learn physics [5]. Integrating innovative educational technologies, such as computer-based simulations, has been identified as a promising approach to address this challenge [6]. Studies have shown that using engaging and interactive simulations, like those provided by the Physics Education Technology (PhET) platform, can positively impact students' motivation and learning outcomes in physics [7]. By leveraging the power of technology to create immersive and meaningful learning experiences, educators can overcome the traditional barriers that have hindered students' motivation in physics education.

The use of technology in the classroom has become a pervasive trend over the past few decades, and its significance was particularly evident during the COVID-19 pandemic [8]-[10]. This shift towards technology-based learning presents an opportunity to enhance students' motivation in learning physics. Previous research has shown that students are more motivated to study physics when they can access contemporary information technologies, including computers, the internet, and mobile phones [11]. Furthermore, computer-based simulations have been found to positively affect students' motivation in learning science [12]-[13]. This suggests that incorporating technology into physics education can be a valuable strategy for improving student engagement and motivation.

Physics Education Technology (PhET) Simulation is an engaging computer simulation that teaches physics and chemistry, offering a unique and interactive approach to learning these subjects. These simulations have frequently been utilized to teach physics and chemistry, providing students with an immersive and engaging experience [14], [15]. PhET simulations can be applied in various educational contexts, including lectures, solitary or small-group inquiry tasks, lab work, and homework, allowing educators to adapt their teaching methods to suit different learning styles and environments [16]. These simulations can assist with various educational tasks, including introducing a new topic, developing concepts or abilities, reinforcing ideas, and offering a final evaluation and reflection. One of the key benefits of PhET simulations is their ability to blur the lines between different educational activities, such as lectures, homework, in-class activities, and laboratory work, allowing for a more seamless and integrated learning experience [14].

Recent studies have shown that students' learning motivation can vastly improve by employing PhET simulations [17]-[19]. However, the study conducted by [20] revealed that using PhET simulations can only moderately improve students' learning motivation, with an intervention group using PhET simulations scoring 71.62% compared to 63.25% for the control group without the simulations. These inconsistencies in the research findings suggest that the impact of PhET simulations on student learning motivation may be more complex and nuanced than previously thought. While some studies have reported significant positive effects, others have found only moderate improvements [20]. This discrepancy in results could be attributed to various factors, such as the specific implementation strategies, the duration of the interventions, the characteristics of the student populations, and the overall learning environment.

Further research is needed to understand how PhET simulations influence student motivation in physics learning. The effectiveness of these simulations may depend on how they are integrated into the broader instructional approach, the level of support and guidance provided to students, and the alignment between the simulation activities and the learning objectives [21]. By delving deeper into the factors that contribute to the varying degrees of impact on student motivation, educators and researchers can develop more robust and reliable strategies for leveraging the potential of PhET simulations to enhance physics learning. This knowledge can inform the design and implementation of technology-enhanced learning environments that foster sustained student engagement and motivation in this challenging yet crucial subject area. This research introduces a novel approach by integrating PhET simulations to enhance student learning motivation in physics. By leveraging interactive and engaging virtual experiments, this study aims to foster a deeper understanding and interest in physics concepts among students.

Previous research conducted by Gani et al. indicated that integrating PhET simulations significantly impacted students' understanding of physics concepts and overall engagement [17]. However, there is a lack of strong evidence that PhET simulations can provide long-term improvements in learning motivation, especially in areas that require deep conceptual understanding, such as parabolic motion. Furthermore, while PhET simulations are often praised for facilitating the understanding of abstract concepts, these studies often overlook the integration of these simulations in diverse learning environments and differences in outcomes based on student demographics or prior knowledge. To fill this gap, we investigate the immediate effects of PhET simulations on learning motivation and explore how these simulations can be systematically integrated with other teaching methods to sustain long-term motivation to learn physics. Unlike previous studies focusing on short-term outcomes, this study will evaluate how using PhET simulations over the long term affects students' motivation and understanding, considering variables such as teaching method, student background, and the cognitive demands of the material being taught.

The novelty of this study lies in its attempt to not only measure the direct impact of using PhET simulations on students' learning motivation but also to explore how these simulations can be systematically integrated with other learning methods to continuously enhance physics learning motivation. This research study aims to determine the effect of PhET simulation on the learning motivation of grade 12 STEM students in physics, specifically in projectile motion. Specifically, this study seeks to answer the following objectives: (1) What is the student's learning motivation level before using PhET simulation? (2) What is the student's learning motivation level after using the PhET simulation? (3) Is there a significant effect of using PhET simulation on the learning motivation in physics as perceived by the students?

2. RESEARCH METHOD

2.1 Research Design

A quasi-experimental design was employed in this study, which utilized a one-group pretest-posttest design to efficiently measure the effect of PhET simulation on students' learning motivation. The one-group pretest-posttest design is a quasi-experimental research design where the outcome of interest is measured twice: once before and once after exposing a non-random group of participants to a certain intervention or treatment [22]. This design is used to evaluate the effect of the intervention, which can be a training program, policy change, medical treatment, or other interventions [22]. Only one group of grade 12 STEM students participated in the study. In evaluating the effect of PhET simulation, the questionnaire before the implementation of the intervention is called a pretest, and the questionnaire after the implementation of the intervention will be compared.

2.2 Research Participants

The researcher employed a convenience sampling technique to determine the students involved in the study. Convenience sampling is a non-probability method where the researcher selects participants based on availability and accessibility rather than through a random selection process [23]. In this technique, the researcher chooses the sample that is most convenient to access, often relying on individuals or groups that are readily available, such as their own students. The participants were Grade 12 STEM students taking General Physics 1 in the first semester of the academic year 2022-2023. Thirty-three participants were coming from one section of the STEM strand. The study was conducted from a private school institution in Malolos, Bulacan, Philippines. The students were taught Projectile Motion, in which the PhET simulation was embedded during the discussion. For ethical considerations, the consent form was given to the students before conducting this study.

2.3 Research Instruments & Data Analysis

The instruments utilized in this study were a survey questionnaire and an interview with random students. The researcher adapted a survey questionnaire and made a minor modification that was suitable for the study. The Students Motivation Toward Science Learning Questionnaire (SMTSLQ) was developed by [24].

Table 1. Sample Items of Students Motivation Toward Science Learning Questionnaire (SMTSLQ)

Subscales	No. of Items	Item Placement	Sample Question
Self-efficacy	7	3	I am sure that I can do well on physics tests.
Active-learning strategies	8	14	When I encounter physics concepts that I do not understand, I try to learn them.
Science learning value	5	18	I think it is important to learn to solve problems in physics.
Performance goal	4	21	I participated in physics courses to get good grades.
Achievement goal	5	27	During a physics course, I feel most fulfilled when I can solve a difficult problem.
Learning environment stimulation	6	35	I am willing to participate in this physics course because the students are involved in discussions.

The purpose of SMTSLQ was to develop a tool to adequately measure the students' learning motivation in science, but in this study, it was translated specifically to physics, Students Motivation Toward Physics Learning Questionnaire (SMTPLQ) by substituting the term "science" to "physics". Six sub-scales compromise the questionnaire: self-efficacy, active-learning strategies, science learning value, performance goal, achievement goal, and learning environment stimulation. The survey questionnaire was a five-point Likert scale to determine the students' motivation toward learning in Physics. A scale to interpret the data was adopted from the study of [25]. Random students were interviewed for honest comments about their experiences using PhET simulation in learning physics. The researcher developed the questions from the semi-structured interview.

In this study, the researcher employed descriptive statistics to analyze the data, which provided insights into the level of student motivation before and after the intervention using the PhET simulation. The researcher conducted a Shapiro-Wilk test to assess the normality of the data distribution, a crucial assumption for the subsequent statistical analysis. Finally, a paired sample t-test was performed to determine if there was a statistically significant difference in student motivation before and after implementing the interactive physics education technology. These statistical techniques, including descriptive statistics, the Shapiro-Wilk normality test, and the paired sample t-test, allowed the researchers to rigorously evaluate the impact of the PhET simulation on student learning motivation.

2.4 Research Procedure

In the pre-intervention stage, the researcher conducted a pretest survey questionnaire using the adopted and modified Student Motivation Towards Science Learning (SMTSL) questionnaire from Tuan et al., to measure the students' motivation before the implementation of PhET simulation [24]. This questionnaire assessed the students' attitudes, interests, and perceived usefulness of physics learning, which are key components of motivation [26]. Additionally, the researcher prepared the necessary activity on projectile motion, which would serve as the context for implementing the PhET simulation. This activity was designed to engage students in a hands-on and interactive learning experience, allowing them to explore projectile motion concepts through the simulation.

The pretest survey questionnaire was administered to the students before implementing the PhET simulation to gather baseline data on their motivation levels. This data would serve as a reference point for comparing the students' motivation levels after the intervention, providing valuable insights into the impact of PhET simulation on their motivation. The researcher also ensured that the necessary technical infrastructure and equipment were in place to support the implementation of the PhET simulation. This included ensuring that the computers, laptops, mobile phones, and internet connections function properly and that the necessary software and plugins are installed and configured correctly. By taking these steps, the researcher created a controlled environment that would allow for a rigorous evaluation of the impact of PhET simulation on student motivation in physics. The pre-intervention stage sets the stage for the intervention, which involves the implementation of PhET simulation and the subsequent assessment of its effects on student motivation.

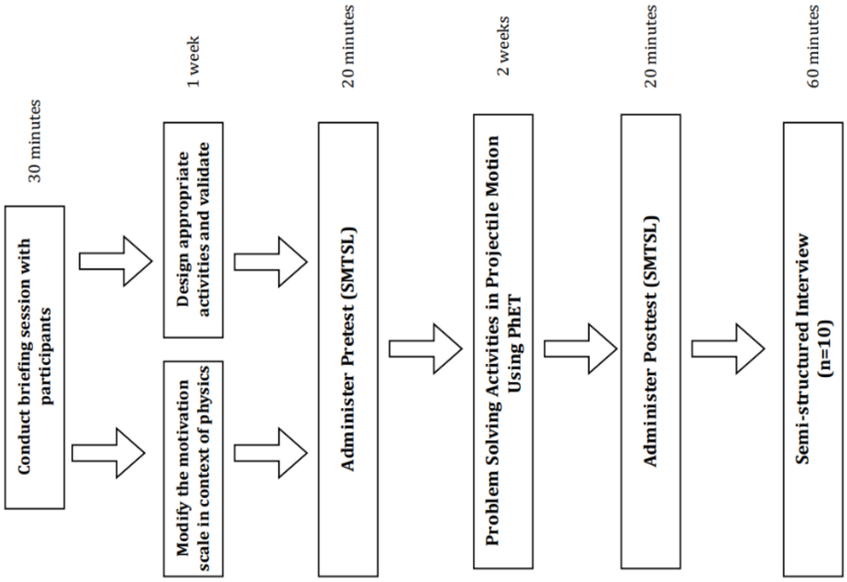

Figure 1. Procedure of Experiment

After collecting the data from the students, the researcher implemented the PhET simulation entitled "Projectile Motion" during the discussion of projectile motion. The researcher utilized this research to help students understand the mathematical concepts of projectile motion. The students used the interactive simulation to investigate the effect of the angle formed in projectile motion. In addition, they used PhET to observe the effect of the initial velocity of various objects on the range that objects will reach. The topic of projectile motion was selected for this study as it is a fundamental concept in classical mechanics that often poses difficulties for students due to its mathematical complexity and the need to visualize and apply principles of kinematics and dynamics [27]. The integration of interactive simulations, which allow students to manipulate variables and observe the resulting motion, has the potential to make this topic more engaging and accessible. Furthermore, the focus on grade 12 STEM students is particularly relevant, as this is a critical juncture in their educational journey, where their motivation and performance in physics can have significant implications for their future academic and career paths [28]. Understanding the impact of PhET simulations on this specific population can provide valuable insights for educators and policymakers in designing effective interventions to support student success in physics [7], [29].

After implementing the interactive PhET simulation, the researcher conducted a post-test survey questionnaire to measure if the utilization of the simulation had a significant effect on students' learning motivation toward the topic of projectile motion. The same survey instrument, the Student Motivation Towards Physics Learning Questionnaire (SMTPLQ), adapted from the SMTSL questionnaire used in the pretest, was administered as the post-test. Using the same survey tool for both the pre-and post-intervention assessments allowed the researcher to make direct comparisons and evaluate any changes in the student's motivation levels. By employing a consistent measurement instrument, the researcher could ensure that any observed differences in student motivation were attributable to implementing the PhET simulation rather than variations in the assessment method. The post-test survey questionnaire was carefully designed to capture the multifaceted nature of student motivation, including factors such as self-efficacy, active learning strategies, science learning value, performance goal, achievement goal, and learning environment stimulation. This comprehensive approach to measuring motivation provided the researcher with a nuanced understanding of how the PhET simulation impacted the students' attitudes, interests, and perceptions toward learning physics, particularly in the context of projectile motion.

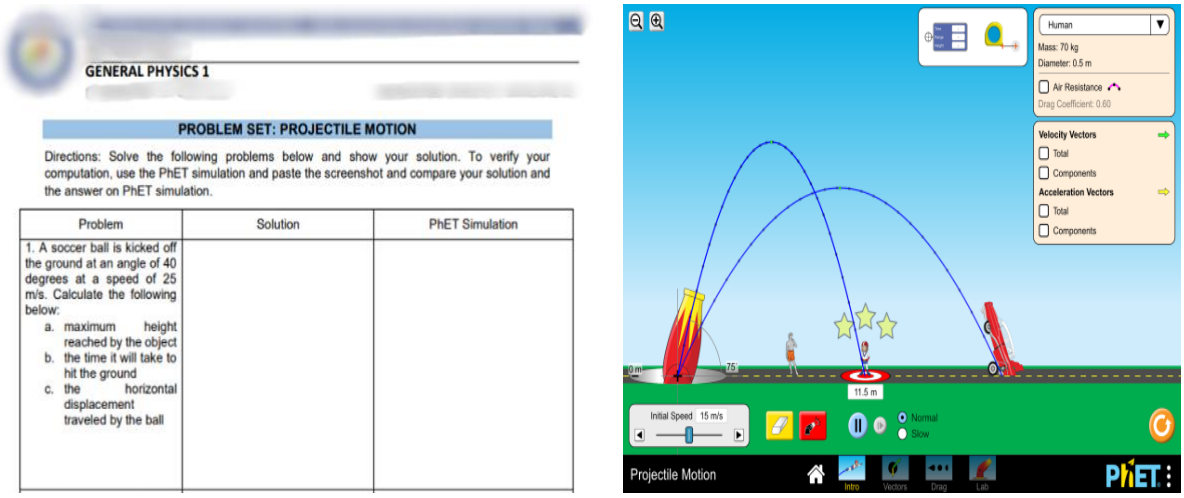

Figure 2. Sample Activity Using PhET Simultion

The administration of the post-test survey questionnaire immediately followed the completion of the PhET simulation-based activities, ensuring that the data collected was closely tied to the student's experiences with the interactive technology. This timely assessment allowed the researcher to gather fresh insights into the student's motivation levels, minimizing the potential influence of other factors that may have arisen over a longer period. By conducting both the pretest and post-test survey questionnaires, the researcher established a baseline of student motivation and then evaluated the changes after implementing the PhET simulation. This comparative analysis was crucial in determining the effectiveness of interactive technology in enhancing students' motivation to learn and engage with the physics content.

3. RESULTS AND DISCUSSION

This section presents the study's results, which provide insights into the impact of PhET simulations on the learning motivation of grade 12 STEM students in physics, specifically in the topic of projectile motion. The findings of this study contribute to the existing body of knowledge on the use of educational technologies, such as PhET simulations, in enhancing student learning motivation and engagement in physics education.

3.1. Students' Learning Motivation in Physics Before and After Intervention

The researcher followed Cavas'Cavas's classification system in interpreting learning motivation, categorizing students' motivation levels into high, medium, and low [25]. Specifically, a high level of motivation was defined as being between 4.41 and 5.00, a medium level in the range of 4.40 to 3.39, and a low level as less than 3.38. This classification system allowed the researcher to provide a nuanced understanding of the student's motivation levels, enabling a more detailed analysis of the impact of PhET simulations on their learning motivation. Table 2 presents the results of the descriptive analysis of the students' pretest scores, which were analyzed using SPSS 22 software.

The level of motivation of the students prior to the intervention was analyzed and shown in Table 2, which revealed that the students' self-efficacy, a measure of their confidence in their capacity to perform well on physics learning tasks, had a mean score of 3.36, indicating a low level of motivation. Additionally, the performance goal, which measures the students' competitiveness with classmates in class and desire for instructor attention Tuan et al., had a mean score of 3.33, indicating a low motivation level [24]. These findings suggest that the students were not highly motivated to learn physics before the intervention, highlighting the need for effective strategies to enhance their motivation and engagement in the subject.

Table 2. Descriptive Statistics of Students' Motivation in Physics (Pretest)

Sub-scales	N	Mean	Verbal Interpretation
Self-efficacy	33	3.36	Low-Level Motivation
Active-learning strategies	33	3.93	Medium Level Motivation
Science learning value	33	3.98	Medium Level Motivation
Performance goal	33	3.33	Low-Level Motivation
Achievement goal	33	4.12	Medium Level Motivated
Learning environment stimulation	33	3.92	Medium Level Motivation
Overall	33	3.82	Medium Level Motivation

Meanwhile, the analysis of the pre-intervention data revealed that the students' active-learning strategies, which measure their active engagement through a range of ways of generating new information based on their existing understanding, had a mean score of 3.93, indicating a medium level of motivation. Similarly, the science learning value, which measures the students' perceptions of significant values related to learning physics, had a mean score of 3.98, indicating a medium level of motivation.

Additionally, the achievement goal, which measures the students' satisfaction with their enhanced competence and performance during scientific learning, had a mean score of 4.12, indicating a higher level of motivation. Furthermore, the learning environment stimulation, which measures the learning environment that influences students' motivation in physics learning, had a mean score of 3.92, indicating a medium level of motivation. These findings suggest that the students were moderately motivated to learn physics before the intervention, with some aspects of their motivation being higher than others.

In the overall motivation of the students prior to the intervention, the mean score was 3.82, indicating a medium level of motivation. This suggests that the students were moderately interested and engaged in learning physics before implementing the PhET simulation. Furthermore, the data analysis revealed that the students' motivation levels were relatively stable, with no significant changes observed after the intervention. This finding is consistent with the results of previous studies that have shown that the use of educational technologies, such as PhET simulations, can positively impact student motivation and engagement in physics education.

Table 3. Descriptive Statistics of Students' Motivation in Physics (Post-test)

Sub-scales	N	Mean	Verbal Interpretation
Self-efficacy	33	3.71	Medium Level Motivation
Active-learning strategies	33	3.95	Medium Level Motivation
Science learning value	33	4.00	Medium Level Motivation
Performance goal	33	3.35	Low-Level Motivation
Achievement goal	33	4.22	Medium Level Motivation
Learning environment stimulation	33	3.80	Medium Level Motivation
Overall	33	3.85	Medium Level Motivation

After the intervention, the mean scores of the students on the various subscales of learning motivation were analyzed, as shown in Table 3. Specifically, the mean scores were: (1) Self-Efficacy (M=3.71), indicating a moderate level of confidence in their ability to perform well on physics learning tasks; (2) Active-learning Strategies (M=3.95), suggesting a moderate level of engagement in generating new information based on their existing understanding; (3) Science Learning Value (M=4.00), indicating a high level of perceived significance in learning physics; (4) Performance Goal (M=3.35), suggesting a low level of competitiveness with classmates and desire for instructor attention; (5) Achievement Goal (M=4.22), indicating a high level of satisfaction with their enhanced competence and performance during scientific learning; and (6) Learning Environment Stimulation (M=3.80), suggesting a moderate level of influence of the learning environment on their motivation in physics learning. The overall mean score of the students' learning motivation in physics was 3.85, indicating a medium level of motivation.

3.2. Effect of PhET on Students' Learning Motivation in Physics Before and After Intervention

Table 4. Statistical Data of Students' Motivation in Physics (Pretest and Post-test)

Subscales	N	Pretest				Post-test			
		Mean	Min.	Max.	Std. Dev.	Mean	Min.	Max.	Std. Dev
Self-efficacy	33	3.36	2.71	4.71	0.45	3.71	2.86	5.00	0.56
Active-learning strategies	33	3.93	2.88	5.00	0.50	3.95	3.25	5.00	0.46
Science learning value	33	3.98	3.20	5.00	0.48	4.00	3.00	5.00	0.46
Performance goal	33	3.33	1.00	5.00	0.93	3.35	1.75	5.00	0.98
Achievement goal	33	4.12	2.80	5.00	0.93	4.22	3.20	5.00	0.50
Learning environment stimulation	33	3.92	2.60	5.00	0.63	3.80	1.00	5.00	0.77
Overall	33	3.82	3.20	4.57	0.58	3.85	3.29	5.00	0.37

Table 4 shows the results of the descriptive analysis of the pretest and post-test of the students before and after using the intervention. Based on Table 4, the minimum and maximum overall scores of the pretest were 3.20 and 4.57, respectively, with a standard deviation of 0.58, indicating a moderate level of variation in the students' learning motivation in physics before the intervention. The performance goal subscale had the lowest minimum score compared to all other subscales, suggesting that the students were not highly competitive or motivated by the desire for instructor attention. In contrast, the post-test results showed a different picture, with the minimum and maximum overall scores being 3.29 and 5.00, respectively, and a standard deviation of 0.37. This indicates that the student's learning motivation in physics was more consistent and higher after the intervention, with a greater proportion of students scoring higher on the post-test. The difference between these results suggests that the PhET simulation positively impacted the students' learning motivation, although the magnitude of this impact was not substantial.

As the result reveals from Table 4, the mean scores of the pretest and post-test increased very little from 3.82 to 3.85, a mere 0.03% increase, indicating that the PhET simulation had a minimal impact on the students' learning motivation in physics. The pretest and post-test of subscales can be observed to show almost all of them a slight increase, except for the Learning Environment Stimulation subscale, which decreased from 3.92 to 3.80. This could mean that using PhET simulation negatively affected the students' learning environment, potentially leading to a decrease in their motivation and engagement.

Table 5. Results of Tests of Normality (Shapiro-Wilk Test)

Subscales	Shapiro-Wilk Test (Pretest)			Shapiro-Wilk Test (Post-test)		
	Statistic	df	Sig.	Statistic	df	Sig.
Self-efficacy	0.98	33	0.66	0.96	33	0.27
Active-learning strategies	0.96	33	0.21	0.94	33	0.06
Science learning value	0.93	33	0.04	0.92	33	0.02
Performance goal	0.98	33	0.66	0.92	33	0.01
Achievement goal	0.93	33	0.03	0.92	33	0.02
Learning environment stimulation	0.95	33	0.13	0.89	33	0.00
Overall	0.96	33	0.28	0.94	33	0.08

A paired-sample t-test with a 95% confidence level was employed to compare the students' pretest and post-test mean scores to determine any significant differences between the two [30]. Before conducting this test, it was necessary to ensure that the pretest and post-test results were normally distributed [31]. To achieve this, a normality test was performed, and the results are presented in Table 5.

As presented in Table 5, the overall pretest and post-test significant values were 0.28 and 0.08, respectively. The result reveals that $p>0.05$, indicating that the data is normally distributed. This is a crucial step in the analysis, ensuring that the data meets the normality assumption required for the paired-sample t-test. Therefore, we can test the hypothesis using a paired-sample t-test. The test result is shown in Table 5, which provides the necessary information to determine whether there are any significant differences between the students' pretest and post-test mean scores.

Table 6. Test of Significant Difference (Paired-samples t-test)

Pretest-Posttest Pair	t	df	Sig (2-tailed)
Self-efficacy	-1.08	32	0.29
Active-learning Strategies	-0.18	32	0.86
Science Learning Value	-0.21	32	0.83
Performance Goal	-0.19	32	0.85
Achievement Goal	-0.28	32	0.78
Learning Environment Stimulation	.090	32	0.38
Overall	-0.25	32	0.81

Based on the result presented in Table 6, the significance value obtained was 0.81. This value falls within the area of acceptance of the null hypothesis, which was set at $p>0.05$. This indicates no significant difference between the pretest and post-test scores. Therefore, the null hypothesis cannot be rejected, and it is concluded that there was no significant difference between the pretest and post-test scores. This result is similar to the findings reported by Agyei et al., as the integration of PhET simulation did not significantly affect the performance goal of the students [32]. In addition, based on the study by Olugbade et al., integrating PhET fosters a positive attitude toward learning physics [33]. However, the overall impact on long-term learning motivation was minimal, indicating that while students enjoyed the simulations, it did not significantly boost their motivation to continue learning these subjects without simulations [34]-[36].

This finding suggests that using PhET simulations did not significantly impact the students' motivation to learn physics. The results indicate that the students' motivation levels remained unchanged after using the PhET simulations, which implies that the simulations did not significantly affect their motivation. The lack of significant difference between the pretest and post-test scores suggests that the PhET simulations did not provide additional benefits to the students regarding learning motivation. This implies that the simulations may need to improve student motivation in physics more effectively.

The findings of this study have implications for the design and implementation of physics education programs. They suggest that educators consider alternative strategies for improving student motivation in physics, such as incorporating more interactive and engaging activities into the curriculum. Additionally, educators should consider the potential limitations of PhET simulations and the need for more research on their effectiveness in improving student learning outcomes.

3.3. Students' Comments After Using PhET Simulation

After two weeks of implementing the PhET simulation on grade 12 students, random students were asked about their honest opinions on using the PhET simulation in teaching and learning projectile motion. One student-participant has mentioned about the different values that can be obtained by solving the problem mathematically and using the simulation, *"Yung sagot ko po sa unang question ay mayroong pagkakaiba sa PhET Simulation and sure po ako correct yung nasolve ko na answer. I think po hindi sya meaningful gamitin kung ipapagamit nyo po siya sa students kasi baka po magkalituhan pa."* which translates to *"My answer on the first question has some discrepancy with the answer on PhET simulation but I am sure that my answer is correct. I think it is not meaningful to use if the students will use this application since this might confuse".*

Another student-participant had a difficulty in using the simulation itself, *"Yung naging disadvantage lang sa akin is everytime na isasakto ko yung amount, pagka alis lang ng kamay ko naiiba yubg pwesto or nadadamay din yung value na iniinpit ko. All in all, okay naman siya, sa pagadjust lang ng values medyo hectic or mas natatagalan since maliit lang din screen ng phone."* This translates to *"The disadvantage of using PhET, in my opinion, is that the application cannot provide an exact answer. The interface gets displaced when I remove my fingers and the value changes. Overall, it's good to use; it is just quite difficult since the screen phone is just small.* "

The result revealed that using PhET simulation does not improve the student's motivation to learn projectile motion and teaching. However, a number of students had a meaningful experience using the interactive simulation. One of them said that *"Super useful ng PhET bukod sa madali gamitin at okay siya gamitin every act or lesson para sa akin, kasi may nakikita kaming visual para mas madali maintindihan yung bawat problem na sinosolve."* which translates to *"Using PhET is ver useful, it is very easy to use and it is good to be integrated in every lesson because of the visual it provide and it would be easy to solve problems".* The student-participant highlighted the feature of PhET simulation as a good tool for visualizing the problems to be solved in projectile motion.

Another student added, *"The PhET simulation helps me a little bit in learning physics because it gives a positive feeling when you can see that your answer is correct, and it is somehow fun."* This student had a positive experience using the PhET simulation.

The novelty of this study suggests that although PhET simulations do not significantly improve students' learning motivation in the short term, proper integration with other learning methods can positively impact a deeper understanding of physics concepts. The study also found that variables such as student background and teaching approach play an important role in the effectiveness of PhET simulations, which has yet to be widely studied. The study's limitations are that it only involved one group of students, so the results may need to be more generalizable to a wider population. Other factors, such as the learning environment and technological support, have also not been explored, which may affect the study results.

4. CONCLUSION

The results of this study led to the following conclusions: First, the learning motivation of the students before the implementation of PhET simulation was found to be at a medium level, indicating that prior to the usage of PhET simulation, the students were already motivated in learning physics. This suggests that the students had a certain level of interest and engagement in the subject, which could have been influenced by their prior experiences, teaching methods, and learning environments. Second, after the implementation of the PhET simulation, the students' motivation was still at a medium level, indicating that the use of the PhET simulation did not improve the student's motivation in physics. The meta learner to the implementation was 3.82 (76.4%), and the mean score after the intervention was 3.85 (77%). This lack of significant improvement in learning motivation can be attributed to the short duration of the implementation of the PhET simulation. A more extended implementation period could have led to more significant changes in the students' motivation levels. Lastly, although there was no significant effect of using PhET simulation on students' learning motivation, there was positive feedback from the students about their meaningful interaction with PhET simulation. This suggests that the students found the simulation engaging and interactive, contributing to their overall satisfaction with the learning experience.

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REFERENCES

[1] D. Wangchuk, D. Wangdi, S. Tshomo, and J. Zangmo, "Exploring students' perceived difficulties of learning physics," Educ. Innov. Pract., vol. 6, May 2023, doi: 10.17102/eip.6.2023.03.
[2] S. Y. Sari, F. R. Rahim, P. D. Sundari, and F. Aulia, "The importance of e-books in improving students' skills in physics learning in the 21st century: a literature review," J. Phys. Conf. Ser., vol. 2309, no. 1, p. 012061, Jul. 2022, doi: 10.1088/1742-6596/2309/1/012061.
[3] E. Manlapig Jr, E. B. Acuña, and A. M. Manuel, "Exploring student academic performance and motivation in physics through electronic-strategic intervention material (e-SIM)," Int. J. Instr., vol. 9, no. 1, pp. 145–156, Apr. 2024, doi: 10.29333/aje.2024.9110a.
[4] P. C. Hamerski, D. McPadden, M. D. Caballero, and P. W. Irving, "Students' perspectives on computational challenges in physics class," Phys. Rev. Phys. Educ. Res., vol. 18, no. 2, p. 020109, Aug. 2022, doi: 10.1103/PhysRevPhysEducRes.18.020109.
[5] N. Safarati and F. Zuhra, "Use of problem-solving based physics comic media on global warming material in increasing learning motivation and students' understanding concept," J. Penelit. Pendidik. IPA, vol. 9, no. 11, pp. 9193–9199, Nov. 2023, doi: 10.29303/jppipa.v9i11.4828.
[6] A. Alhadlaq, "Computer-based simulated learning activities: Exploring Saudi students' attitude and experience of using simulations to facilitate unsupervised learning of science concepts," Appl. Sci., vol. 13, no. 7, p. 4583, Apr. 2023, doi: 10.3390/app13074583.
[7] H. J. Banda and J. Nzabahimana, "Effect of integrating physics education technology simulations on students' conceptual understanding in physics: A review of literature," Phys. Rev. Phys. Educ. Res., vol. 17, no. 2, p. 023108, Dec. 2021, doi: 10.1103/PhysRevPhysEducRes.17.023108.
[8] K. Sage, S. Jackson, E. Fox, and L. Mauer, "The virtual COVID-19 classroom: surveying outcomes, individual differences, and technology use in college students," Smart Learn. Environ., vol. 8, no. 1, p. 27, Dec. 2021, doi: 10.1186/s40561-021-00174-7.
[9] E. Winter, A. Costello, M. O'Brien, and G. Hickey, "Teachers' use of technology and the impact of Covid-19," Ir. Educ. Stud., vol. 40, no. 2, pp. 235–246, Apr. 2021, doi: 10.1080/03323315.2021.1916559.

[10] S. A. Courtney, M. E. S. Miller, and M. J. Gisondo, "The impact of COVID-19 on teachers' integration of digital technology," Contemp. Educ. Technol., vol. 14, no. 4, p. ep387, Sep. 2022, doi: 10.30935/cedtech/12420.
[11] R. Holubova, "How to motivate our students to study physics?," Univers. J. Educ. Res., vol. 3, no. 10, pp. 727–734, Oct. 2015, doi: 10.13189/ujer.2015.031011.
[12] E. Nsabayezu et al., "Impact of computer-based simulations on students' learning of organic chemistry in the selected secondary schools of Gicumbi District in Rwanda," Educ. Inf. Technol., vol. 28, no. 3, pp. 3537–3555, Mar. 2023, doi: 10.1007/s10639-022-11344-6.
[13] F. Almasri, "Simulations to teach science subjects: Connections among students' engagement, self-confidence, satisfaction, and learning styles," Educ. Inf. Technol., vol. 27, no. 5, pp. 7161–7181, Jun. 2022, doi: 10.1007/s10639-022-10940-w.
[14] I. I. Salame and J. Makki, "Examining the Use of PhET Simulations on Students' Attitudes and Learning in General Chemistry II," Interdiscip. J. Environ. Sci. Educ., vol. 17, no. 4, p. e2247, May 2021, doi: 10.21601/ijese/10966.
[15] C. A. Mrani, A. E. Hajjami, and K. E. Khattabi, "Effects of the integration of PhET simulations in the teaching and learning of the physical sciences of common core (Morocco)," Univers. J. Educ. Res., vol. 8, no. 7, pp. 3014–3025, Jul. 2020, doi: 10.13189/ujer.2020.080730.
[16] R. Taibu, Ll. Mataka, and V. Shekoyan, "Using PhET simulations to improve scientific skills and attitudes of community college students," Int. J. Educ. Math. Sci. Technol., vol. 9, no. 3, pp. 353–370, Apr. 2021, doi: 10.46328/ijemst.1214.
[17] A. Gani, M. Syukri, K. Khairunnisak, M. Nazar, and R. P. Sari, "Improving concept understanding and motivation of learners through Phet simulation word," J. Phys. Conf. Ser., vol. 1567, no. 4, p. 042013, Jun. 2020, doi: 10.1088/1742-6596/1567/4/042013.
[18] W. Jannah, E. Evendi, S. Safrida, S. Ilyas, and M. Syukri, "Improvement of learning outcomes, motivation, and achievement of students' social skills by applying student teams achievement division cooperative learning Model through PhET simulation media," J. Penelit. Pendidik. IPA, vol. 7, no. 4, pp. 775–781, Oct. 2021, doi: 10.29303/jppipa.v7i4.796.
[19] I. E. Prasetya, M. Yusuf, and T. J. Buhungo, "Description of students learning motivation towards the use of phet simulation in physics online learning in terms of self-efficacy and anxiety levels," J. Pijar Mipa, vol. 17, no. 1, pp. 23–27, Jan. 2022, doi: 10.29303/jpm.v17i1.3218.
[20] E. C. Prima, A. R. Putri, and N. Rustaman, "Learning solar system using PhET simulation to improve students' understanding and motivation," J. Sci. Learn., vol. 1, no. 2, p. 60, Mar. 2019, doi: 10.17509/jsl.v1i2.10239.
[21] M. N. M. Najib, A. Yaacob, and R. Md-Ali, "Exploring the effectiveness of interactive simulation as blended learning approach in secondary school physics," in International Academic Symposium of Social Science 2022, MDPI, Oct. 2022, p. 103. doi: 10.3390/proceedings2022082103.
[22] L. Romano et al., "Minimally invasive gingival phenotype modification in gingival recession associated with a non-carious cervical lesion using the root plastique technique: A quasi-experimental one-group pretest-posttest study," J. Periodontol., vol. 94, no. 5, pp. 641–651, May 2023, doi: 10.1002/JPER.22-0414.
[23] U. A. Salikha, H. Sholihin, and N. Winarno, "The influence of STEM project-based learning on students' motivation in heat transfer learning," J. Phys. Conf. Ser., vol. 1806, no. 1, p. 012222, Mar. 2021, doi: 10.1088/1742-6596/1806/1/012222.
[24] H. Tuan, C. Chin, and S. Shieh, "The development of a questionnaire to measure students' motivation towards science learning," Int. J. Sci. Educ., vol. 27, no. 6, pp. 639–654, Jan. 2005, doi: 10.1080/0950069042000323737.
[25] P. Cavas, "Factors affecting the motivation of Turkish primary students for science learning," Sci. Educ. Int., vol. 2, no. 1, pp. 31–42, 2011.
[26] A. R. Albalate et al., "Students' motivation towards science learning (SMTSL) of stem students of University of Batangas, Lipa City," PEOPLE Int. J. Soc. Sci., vol. 3, no. 3, pp. 1262–1274, Feb. 2019, doi: 10.20319/pijss.2018.33.12621274.
[27] S. Kusairi, S. Imtinan, and P. Swasono, "Increasing students' understanding in the concept of projectile motion with modelling instruction accompanied by embedded formative e-assessment," J. Phys. Conf. Ser., vol. 1387, no. 1, p. 012081, Nov. 2019, doi: 10.1088/1742-6596/1387/1/012081.
[28] R. J. Rafanan, C. Y. De Guzman, and D. Jr. Rogayan, "Pursuing STEM careers: Perspectives of senior high school students," Particip. Educ. Res., vol. 7, no. 3, pp. 38–58, Dec. 2020, doi: 10.17275/per.20.34.7.3.
[29] Melvin C. Eleo and Ylcy B. Manguilimotan, "Physics education technology (phet) interactive simulations as teaching aid in enhancing students' performance in physics," EPRA Int. J. Multidiscip. Res. IJMR, pp. 60–64, Mar. 2024, doi: 10.36713/epra15991.
[30] B. Cheval et al., "Relationships between changes in self-reported physical activity, sedentary behaviour and health during the coronavirus (COVID-19) pandemic in France and Switzerland," J. Sports Sci., vol. 39, no. 6, pp. 699–704, Mar. 2021, doi: 10.1080/02640414.2020.1841396.
[31] T. K. Kim and J. H. Park, "More about the basic assumptions of t-test: normality and sample size," Korean J. Anesthesiol., vol. 72, no. 4, pp. 331–335, Aug. 2019, doi: 10.4097/kja.d.18.00292.
[32] P. Agyei, M. Abukari, P. Dorsah, T. Tindan, A. Najah, and I. Gonyalug, "PhET simulation instruction and its effects on students' motivation to learn physics," Lond. J. Press Ltd., vol. 23, no. 15, pp. 21–32.
[33] D. Olugbade, S. S. Oyelere, and F. J. Agbo, "Enhancing junior secondary students' learning outcomes in basic science and technology through PhET: A study in Nigeria," Educ. Inf. Technol., Jan. 2024, doi: 10.1007/s10639-023-12391-3.
[34] E. Pujono, F. Maulana, A. David, and B. Opeyemi, "Exploring Innovative approaches: optimizing google classroom for enhanced motivation in science learning", *Sch. Jo. Phs. Ed*, vol. 5, no. 2, pp. 39-45, Jun. 2024, doi: 10.37251/sjpe.v5i2.965
[35] M. Sulaiman, Yetti Latifah, Y. Deneri, and J. R. Gonzales, "Exploring character dynamics: Unveiling dominant values in physics education," *Sch. Jo. Phs. Ed*, vol. 5, no. 2, pp. 46-52, Jun. 2024, doi: 10.37251/sjpe.v5i2.964
[36] A. Fatonah, H. Worku, and F. Inyang, "Improving student learning outcomes on earth layers material by using audio visual media", *Sch. Jo. Phs. Ed*, vol. 5, no. 2, pp. 53-61, Jun. 2024, doi: 10.37251/sjpe.v5i2.887