

Integrating Virtual Laboratory in Learning Projectile Motion

Villavelez, Meka Jane C., Aguillon, Jelian Rose T., Argente, Alexandra Sophia Marie U., Romero, Mary Erlianche B., Sayaboc, Chandelle B., Cabanas, Eliezer

Senior High School, University of Cebu-Pardo and Talisay, Cebu, Philippines

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ABSTRACT

Physics is fundamental in influencing students' understanding of the world around them. However, physics concepts are complex for most students, especially in traditional classrooms that focus heavily on theoretical instruction. These results, in most cases, indicate disengagement, low retention levels, and elevated anxiety. One of the more common areas of difficulty is projectile motion, in which visualization and interaction ultimately give a better understanding. This research measures the effectiveness of virtual laboratories, the PhET Projectile Motion Simulator, in increasing Grade 9 students' knowledge of projectile motion.

The study used a pre-experimental design with purposive sampling of 38 students from Section Scorpio. Data were collected through a three-part instrument covering demographics, ICT effectiveness, and projectile motion assessment. Students completed a pre-test, used the PhET simulator as an intervention, and then took a post-test. Paired t-tests measured score improvement, while regression analysis examined relationships between variables.

The PhET Projectile Motion Simulator significantly improved students' understanding of projectile motion, with the majority moving from "Beginning" pre-test scores to "Advanced" post-test scores. A paired t-test verified this gain as significant, demonstrating the effectiveness of virtual labs in improving academic achievement. Although female students performed well in the pre-test, post-test results did not express any meaningful difference between the sexes, meaning that the virtual lab narrowed performance disparities. Moreover, outcomes and perceptions did not differ by sex or age, demonstrating the inclusiveness of the tool. Students also stated that the virtual lab was well designed and executed, with a composite mean of 3.48 under "agree", suitable for entertaining, and a better alternative than the conventional approaches. Although the findings suggest the usefulness of the simulator, limitations such as the absence of a control group and the possibility of response bias from data of reported responses by the participants take away the perspective of long-term retention due to the short intervention time. The narrow scope applied to one issue also narrows the application to other areas of physics.

Keywords: Virtual laboratories, Projectile motion, PhET Simulator, Physics Education

INTRODUCTION

Mastering physics today involves more than just memorizing formulas; it also requires interactive and visual learning. The concepts of abstract physics theory are challenging for many students to understand, especially in traditional classrooms where theoretical learning dominates (Wangchuk et al., 2023). To help overcome this challenge, this study seeks to explore the effectiveness of virtual laboratories, taking PhET (Physics Education Technology) Projectile Motion Simulator, as a tool of teaching projectile motion to Grade 9 students which the University of Colorado Boulder developed, PhET allow the students to explore key variables such as angle, initial speed and air resistance. Its research-based design supports inquiry-based and student-centered learning by encouraging visualization, prediction, and experimentation (Banda & Nzabahimana, 2023; Chinaka, 2021).

Physics is an essential part of STEM education, but traditional teaching approaches often result in low engagement, poor performance, and increased anxiety among students (Awandia, 2021; Onah, 2022).

According to Villanueva (2021), students who are taught conventionally have poorer participation and retention rates. In the Philippines, the 2019 Trends in International Mathematics and Science Study (TIMSS) report found that only 13% of Grade 4 students met the low science criterion, indicating a critical need for novel initiatives such as virtual laboratories. These tools are handy in schools without complete laboratory facilities, making hands-on experimentation difficult. Studies suggest that students who use the PhET simulations understand projectile motion better than traditional lab activities (Chinaka, 2021). Despite the variable results in some studies, particularly concerning hands-on skills (Onah, 2022), Virtual Labs can make a difference in conceptual understanding. This topic was chosen for study on grade 9 students because it is a topic of study in the Grade 9 physics curriculum. Even though many studies have been conducted on virtual laboratories across disciplines, there is minimal research on projectile motion, which makes this study both timely and relevant.

This study aims to contribute essential knowledge on how virtual laboratory instruction can enhance physics teaching and learning by comparing it with traditional approaches. The findings may be helpful for educators and those seeking to improve academic outcomes by applying more engaging and effective instructional methods.

METHODS AND MATERIALS

Research Design

The researchers utilized a pre-experimental design, specifically the one-group pretest-posttest type, a research method that investigates cause-and-effect relationships without using a control group or random assignment (Sreekumar, 2024). This design involved measuring a single group before and after an intervention, making it a practical choice for studies where complete experimental control is not feasible, such as in educational settings (Sreekumar, 2024). This design aims to evaluate the effectiveness of virtual laboratory simulations in helping students understand the fundamentals of projectile motion. While the study focuses on improvements after the intervention, it does not compare the results to a separate control group, highlighting the strengths and limitations of pre-experimental research.

Research Instrument

The research study employed an adapted questionnaire to assess students' learning outcomes using a virtual laboratory to study projectile motion. The instrument consisted of three main parts: a demographic profile, an evaluation of the effectiveness of Information and Communication Technology (ICT) Integration using Virtual Laboratory, and an assessment of projectile motion.

The virtual laboratory section of the instrument, which addresses student engagement, conceptual understanding, and the perceived benefits of using virtual labs, was adapted from the study by Shaafi et al., "Enhancing Physics Engagement among school students through virtual laboratory inquiry". Responses were measured with a 5-point Likert scale, ranging from one would disagree strongly to one would agree strongly. The initial study did not provide a Cronbach's Alpha value. However, the questionnaires' items were appropriately matched to the research goals and tested through consultants' consultation to check for the relevance of measuring ICT-integrated instruction.

The researchers created the pre-test and post-test used in the study to check how well the students understood projectile motion. Each test had three parts. The first part was about horizontal projectile motion and had three problem-solving questions. The second part focused on oblique projectile motion and included four questions. The last part, about projectile motion on an inclined plane, also had four questions. All questions were open-ended, so students had to demonstrate how they solved each problem. These exams enabled the researchers to determine the students' initial knowledge and their progress over time. To ensure the validity of the tests, the researchers consulted with their research advisor, who reviewed the content and structure of the questions to ensure they accurately measured the students' understanding of projectile motion.

Research Environment

The study and survey for data collection were conducted among Senior High School students at a private educational institution in Cebu City.

Research Respondents

This pre-experimental study involved Grade 9 students studying projectile motion as part of their science curriculum, making them appropriate participants for the research. A total of 38 students participated, with 21 females (55.26%) and 17 males (44.74%). Regarding age, 31 students (81.58%) were aged 14 to 15, while seven (18.42%) were aged 16 to 17.

Research Procedures

Data Gathering. Before data collection, the researchers sent a transmittal letter to the Senior High School Principal explaining the study's purpose, methodology, and ethical considerations. The Senior High School Coordinator and 3I adviser were consulted to ensure that the study followed academic standards and to approve the implementation of the study and its framework. Before conducting research, students were given a parental consent form. Upon approval, students were randomly selected from one section of Grade 9 to avoid biased selection. A consent letter was distributed, which included the study's purpose, voluntary participation, and confidentiality. The first observation involved standard teaching techniques, followed by a pre-test, the integration of the PhET simulator, and a post-test.

Data Analysis. The data collected from the survey were processed and analyzed using Microsoft Excel. Descriptive statistics, including frequency and percentage, were used to summarize the demographic characteristics of respondents' profiles, such as sex and age groups. Weighted mean scores and their respective virtual interpretations were computed to assess the effectiveness of the virtual laboratory. The paired t-test was also used to compare pre-test and post-test scores. Additionally, an independent samples t-test was used to compare readiness and test scores by sex and age group. Finally, regression analysis was employed to examine the relationship between the predictor and outcome variables.

Ethical Considerations. The study followed ethical standards to protect participants' rights and privacy. Consent was obtained, and no personal data was collected. All responses were kept secure, and participants could withdraw at any time without penalty. Surveys were safely stored, and printed copies were properly disposed of, ensuring reliable results while respecting participants' well-being.

RESULTS AND DISCUSSIONS

Table 1. Respondent's Profile in Terms of Age

Questions	Pre-Test		Post-Test	
	Transmuted Grade	Interpretation	Transmuted Grade	Interpretation
1. Horizontal Projectile	60	Beginning	95	Advanced
2. Oblique Projectile	67	Developing	90	Advanced
3. Inclined Plane Projectile	60	Beginning	91	Advanced
Average	62	Beginning	92	Advanced

Legend: 90–100 = Advanced; 85–89 = Proficient; 65–84 = Developing; Below 65 = Beginning

Table 1 reveals a significant enhancement of students' comprehension of projectile motion after using the Virtual Laboratory. Students obtained relatively low results for all three topics in the pre-test, with an average score of 62, corresponding to the "Beginning" level. This implies they had relatively less prior knowledge or understanding of the concepts before the intervention. In contrast, students had higher post-test scores after interacting with the PhET Projectile Motion Simulator. The three categories, including Horizontal Projectile, Oblique Projectile, and Inclined Plane Projectile Motion, achieved a good score with an average of 92. The "Advanced" level indicates that students demonstrated mastery of the content after completing the virtual laboratory. This result implies that virtual laboratories can help students learn complex physics concepts more

effectively than traditional methods. This supports Hiwot Bazie's (2024) findings that students using virtual labs perform significantly better than those with lecture-only instruction.

Figure 1. PhET Projectile Motion Simulator Interface

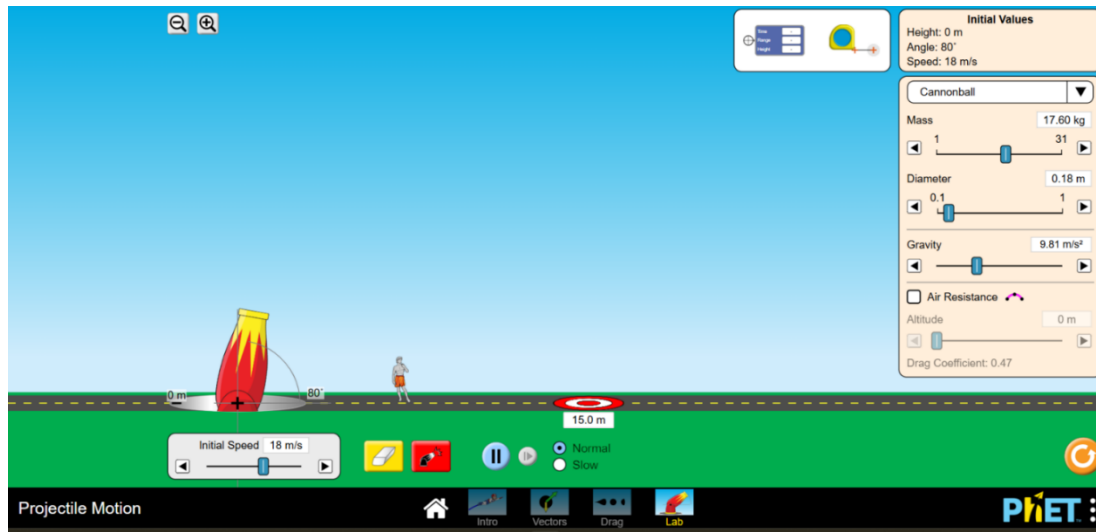


Image taken from <https://phet.colorado.edu/en/simulations/projectile-motion>

Table 2. Effectiveness of ICT Integration using Virtual Laboratory

Statements	(W _x)	Verbal Description	Interpretations
I was very excited to learn Physics using virtual lab	3.42	Neutral	Moderate
Virtual lab increased my interest in learning Physics.	3.53	Agree	Effective
I like to participate in computer simulation activities during teaching and learning process.	3.50	Agree	Effective
Virtual lab motivated me to Male 20 4.05 pay more attention towards Physics lesson.	3.21	Neutral	Moderate
Virtual lab engages me more in learning Physics	3.53	Agree	Effective
I would like to continue to learn Physics using virtual lab in future.	3.55	Agree	Effective
It is helpful to learn Physic using computer simulation.	3.68	Agree	Effective
Virtual lab is an appropriate technique to learn about concepts in Physics.	3.53	Agree	Effective
Virtual lab has made the learning more interesting than traditional method	3.63	Agree	Effective
I prefer virtual lab method of teaching rather than traditional method in learning Physics.	3.61	Agree	Effective
Learning with the virtual lab improved my understanding of the basic principles of Physics.	3.47	Agree	Effective
Learning with the virtual lab increased my factual knowledge of physics.	3.39	Neutral	Moderate
Virtual lab improved my ability to think logically.	3.29	Neutral	Moderate
Virtual lab improved my ability to learn independently.	3.29	Neutral	Moderate
Virtual lab should be used more frequently in Physics learning and instruction.	3.63	Agree	Effective
Virtual lab develops good and effective interaction between me and my teacher.	3.45	Agree	Effective
Composite Mean	3.48	Agree	Effective

Legend: 4.21–5.00 = Strongly Agree; 3.41–4.20 = Agree; 2.61–3.40 = Neutral; 1.81–2.60 = Disagree; 1.00–1.80 = Strongly Disagree

Overall, the composite mean value for student perceptions of the virtual laboratory was 3.56, which supports the conclusion that, in general, the students were positively responding to using the PhET Projectile Motion Simulator as a learning tool. This composite mean indicates consistency in three identified effectiveness indicators: engagement, clarity of concept, and ease of use. This implies that the virtual laboratory affected student satisfaction and provided a more interactive and supportive learning experience of projectile motion. These results support previous findings (Tatira & Mshanelo, 2022; Ahmed et al., 2024; Asrizal et al., 2023) that virtual labs enhance motivation, participation, and conceptual learning in Physics.

Table 3. Difference between the Respondent's Sex and their Test Scores

Variables	$W_{\bar{x}}, \sigma^2$	df	p-value	Remarks
Pre-test				
Male	0.35,1.12	2.03	2.27	Reject the H_0 (Significant)
Female	1.33,2.53	(df = 35)	(p = 0.03)	
Post-test				
Male	10.24,28.94	2.05	1.71	Do not reject H_0 (Not Significant)
Female	12.86,13.83	(df = 27)	(p = 0.10)	

Table 3 shows the sex difference in test scores between male and female participants. In the pre-test, the p-value was less than 0.05, indicating a significant difference between male and female scores on the weighted mean. However, in the post-test, the p-value was more than 0.05, meaning there was no significant difference between male and female scores. Although females still had a higher mean score, the performance gap was reduced after the intervention. This implies that the virtual laboratory provided a fair learning environment for male and female participants, enabling them to reach similar comprehension levels. Our results were identical to those of Alabi et al. (2023), who found a higher Pre-test score for female participants and equal achievement gains after simulation-based instruction.

Table 4. Difference between the Respondent's Age and their Test Scores

Variables	$W_{\bar{x}}, \sigma^2$	df	p-value	Remarks
Pre-test				
14-15	0.90,2.09	2.31	0.07	Do not reject H_0 (Not Significant)
16-17	0.86,2.48	(df = 8)	(p = 0.95)	
Post-test				
14-15	11.81,18.49	2.36	0.26	Do not reject H_0 (Not Significant)
16-17	11.14,41.14	(df = 7)	(p = 0.80)	

Table 4 presents the difference between respondents' age and their test scores. Both pre-test and post-test p-values exceeded the 0.05 significance level, indicating no significant difference between the two age groups. The nearly identical pre-test means ($\bar{x}=0.90$ for ages 14–15; $\bar{x}=0.86$ for ages 16–17) suggest similar prior understanding. Post-test results also showed no significant difference, with slightly higher mean scores for the younger group but greater variability among older students. These findings imply that both age groups benefited equally from the virtual laboratory intervention. This aligns with studies that found no significant effect of age or year level on learning outcomes in virtual labs, highlighting their broad and equitable effectiveness (Griffin et al., 2025; Amano et al., 2022; Al-Duhani et al., 2023).

Table 5. Difference between the Respondent's Profile and their Level of Effectiveness.

Variables	$W_{\bar{x}}, \sigma^2$	Critical t-value (df)	Computed Value (p-value)	Decision (Remarks)
Sex				
Male	3.44,0.97	2.05	0.24	Do not reject H_0 (Not Significant)
Female	3.51,0.42	(df = 27)	(p = 0.41)	
Age				
14-15	3.47,0.53	2.36	0.12	Do not reject H_0 (Not Significant)
16-17	3.53,1.33	(df = 7)	(p = 0.45)	

Table 5 shows the differences in respondents' profiles and perceptions of the value of the virtual laboratory. There were no significant differences in the criteria for all sampled gender groups and the age group, as indicated by p-values well above the 0.05 significance level. Therefore, the null hypothesis is maintained that respondents from the same gender or age agreed on the strategy, implying that virtual laboratories are general and available across all population groupings. These findings align with Hanine et al. (2021) and Alabi et al. (2023), who found that virtual laboratories enhanced student learning and engagement, reducing performance gaps and benefiting both sexes equally.

Table 6. Difference Between the Level of Effectiveness and Post-Test

Variables	Computed r	Tabular r (df)	p-value	Decision	Remark	Coefficient of Determination
Level of Effectiveness Vs. Post-Test Scores	0.02 (negligible)	0.32 ($df = 36$) $\alpha = 5\%$	0.93	Do not Reject H_0	Not Significant	0.000242

Table 6 shows the correlation between the perceived effectiveness of the virtual laboratory and post-test scores. Pearson correlation coefficient ($r = 0.02$) and p-value of 0.93 suggest no statistically significant relationship. The coefficient of determination ($r^2 = 0.00024$) indicates that only 0.024% of score variation can be explained by perceived effectiveness, suggesting no significant association. Based on this finding, students felt the virtual laboratory was functional, but such perceptions were not necessarily correlated with higher performance. This aligns with Alsharif (2024) and Amanio et al. (2022), who found minimal links between perceived effectiveness and academic outcomes.

Table 7. Difference between the Pre-Test and Post-Test Scores of the Respondents

Variables	$\bar{W}_x, \sigma^2$	Critical t-value (df)	Computed Value (p-value)	Decision (Remarks)
Pre-test	0.89, 2.10	2.02	13.62	Reject the H_0
Post-test	11.68, 21.74	($df = 44$)	($p < 0.05$)	(Significant)

Table 7 presents a comparison of respondents' pre-test and post-test scores. The computed t-value (13.62) exceeds the critical value (2.02, $df = 44$) with a p-value less than 0.05, leading to the rejection of the null hypothesis. The weighted mean rose from 0.89 ($\sigma^2 = 2.10$) to 11.68 ($\sigma^2 = 21.74$), indicating a significant improvement after the virtual laboratory session. This implies that the intervention effectively enhanced students' comprehension of projectile motion, highlighting the potential of ICT-based tools to support deeper learning and academic achievement.

CONCLUSION

In conclusion, the outcomes of this study confirm the appropriateness of using virtual laboratories, specifically the PhET Projectile Motion Simulator, in physics teaching. Students gained considerable knowledge of projectile motion, with a noticeable improvement from pre-test "Beginning" level scores to Advanced Post-test scores. Results of statistical analyses of paired t-tests revealed this advancement as being statistically significant, demonstrating that the virtual lab intervention positively affected students' academic achievement.

Demographic factors (sex, age) did not significantly influence on the post-testing results or the students' perceptions of the effectiveness of the virtual laboratory. This implies that virtual labs have an inclusive and equitable learning experience across different profiles of students. Remarkably, despite the initial superior performance of female students in the pre-test compared to the male students, post-test scores did not reveal any special difference, which means that the virtual lab minimized the performance gaps.

Overall, students' perception of the virtual laboratory was positive, with a composite mean of 3.48 under the category "Agree". They discovered the tool entertaining, effective, and an alternative to conventional methods that they would rather use. However, correlation analysis made between perceived effectiveness and post-test scores revealed no significant statistical association. This suggests that while students valued the virtual

learning experience, their experiences did not correspond with improved academic performance, indicating that other factors, such as learning strategies or pre-existing knowledge, may have influenced the results.

This implies that, although the students found value in the virtual learning experience, their experiences were not translated into improved academic outcomes, suggesting that other variables, such as learning strategies or preexisting knowledge, also play a role. Virtual laboratories are an effective ICT-based tool for stimulating deeper learning, narrowing performance gaps, and increasing achievement in physics education, as seen by the significant gain in scores. As a result, it is strongly advocated that junior high school students use virtual laboratories as a strategic tool for improving scientific literacy and conceptual comprehension.

RECOMMENDATION

Future research should stress the need to include virtual labs, such as PhET, into classrooms to offer dynamic, hands-on learning experiences, particularly for difficult ideas like projectile motion. Even without physical resources, these labs give students a safe, accessible environment in which to experiment with variables, promoting individualized learning and quick feedback, thereby improving involvement and retention.

Researchers need to create a well-defined action plan to help teachers make good use of virtual labs for instruction on projectile motion. This plan should include structured recommendations for incorporating the PhET simulation into courses, enabling teachers to easily integrate the tool into their courses and enhance student learning outcomes.

REFERENCES

1. Alabi, A.-H. A., Mohammed, R. E., & Yusuf, A. A. (2023). Gender influence of PhET simulation on students' score level. *Physics Education Research Journal*, 5(2), 61–68. <https://doi.org/10.21580/perj.2023.5.2.14141>
2. Ahmed, Z., Odidi, I. G., & Musa, Z. (2024). Comprehensive review of the integration of ICT in improving physics education. *Top Journal of Educational Technology*, 9(6), 99–110. <https://doi.org/10.5281/zenodo.14616167>
3. Al-Duhani, F., Saat, R. M., & Abdullah, M. N. S. (2023). Effectiveness of virtual laboratory on grade eight students' achievement in learning electricity. *Malaysian Online Journal of Educational Sciences*, 11(3), 1–15.
4. Alsharif, A. (2024). Virtual simulation lab experiments versus conventional experiments in teaching physics: Comparative study. *International Journal of Education*, 16(1), 34–40. <https://doi.org/10.5296/ije.v16i1.20957>
5. Amanio, Y. K. V., Legaspino, C. O., Mondido, J. R. C., Somosot, I. S., & Borlio, J. G. (2022). Investigating the academic experience of science education students with virtual laboratory classes: A convergent parallel approach. *Asia Pacific Journal of Educators and Education*, 37(2), 281–299. <https://doi.org/10.21315/apjee2022.37.2.14>
6. Asrizal, A., Annisa, N., Festiyed, F., Ashel, H., & Amnah, R. (2023). STEM-integrated physics digital teaching material to develop conceptual understanding and new literacy of students. *EURASIA Journal of Mathematics, Science and Technology Education*, 19(7), em2289. <https://doi.org/10.29333/ejmste/13275>
7. Awandia, J. T. (2021). Impact of teaching methods on students' negative attitudes towards physics. *Global Journal of Educational Research*. <https://gjournals.org/GJER/Publication/2021/1/HTML/041821039%20Awandia.ht>
8. Banda, H. J., & Nzabahimana, J. (2022). The impact of Physics Education Technology (PHET) Interactive Simulation- Based Learning on motivation and academic achievement among Malawian physics students. *Journal of Science Education and Technology*, 32(1), 127–141. <https://doi.org/10.1007/s10956-022- 10010-3>
9. Bandura Koutroubas, V., & Galanakis, M. (2022). Bandura's social learning theory and its importance in the organizational psychology context. *Psychology*, 12(6), 315–322. https://www.researchgate.net/publication/360837107_Bandura's_Social_Learning_Theory_and_Its_Importance_i_n_the_Organizational_Psychology_Context

10. Bazie, H., Lemma, B., Workneh, A., & Estifanos, A. (2024). The effect of virtual laboratories on the academic achievement of undergraduate chemistry students: Quasi-experimental study. *JMIR Formative Research*, 8(3), e64476. <https://doi.org/10.2196/64476>
11. Chinaka, T. W. (2021). The Effect of PhET Simulation vs. Phenomenon-based Experiential Learning on Students' Integration of Motion Along Two Independent Axes in Projectile Motion. *African Journal of Research in Mathematics, Science and Technology Education*, 25(2), 185–196. <https://doi.org/10.1080/18117295.2021.1969739>
12. Griffin, C. S., Loughran, S., Kelly, B., Healy, E., Lambe, G., van Rossum, A., Murphy, B., Moore, E., Burke, C., Morrin, A., Breslin, C., Heaney, F., Rooney, D., Bree, R., & Drumm, B. T. (2025). Virtual laboratories complement but should not replace face-to-face classes: Perceptions of life science students at Dundalk Institute of Technology, Ireland. **Advances in Physiology Education*, 49*(2), 314–330. <https://doi.org/10.1152/advan.00227.2024>
13. Gunawan, G., Nisrina, N., Suranti, N. M. Y., Herayanti, L., & Rahmatiah, R. (2018). Virtual laboratory to improve students' conceptual understanding in physics learning. *Journal of Physics Conference Series*, 1108, 012049. <https://doi.org/10.1088/1742-6596/1108/1/012049>
14. Hanine, M., Aaboud, M., & Chekour, M. (2024). Effectiveness of virtual labs for physics learning in Moroccan secondary schools. *International Journal of Interactive Mobile Technologies (ijim)*, 18(15), 129–143. <https://doi.org/10.3991/ijim.v18i15.48447>
15. Nisrina, N., Suranti, N. M., Ekasari, R., & Herayanti, L. (2018). The effect of virtual labs toward students' understanding of physics based on sex. In *1st International Conference on Education Innovation (ICEI 2017)* (pp. 128–131). Atlantis Press. <https://www.atlantis-press.com/proceedings/icei-17/25892909>
16. Onah, K. T. (2022). Effect of mind-mapping teaching approach on students' academic achievement in physics concepts of motion and kinematics. *Global Journal of Educational Research*, 1–8. <https://www.gjournals.org/2022/09/28/071122069-onah-et-al/>
17. Shaafi, N. F., Zakaria, R., & Mohd Yuso, M. M. (2024). Enhancing physics engagement among school students through virtual laboratory inquiry. *Jurnal Penelitian dan Pembelajaran IPA (JPPI)*, 10(1), 98–114. <https://doi.org/>
18. Sreekumar, D. (2024). What is Experimental Research Design? Definition, Types, and Examples | Researcher.Life. <https://researcher.life/blog/article/what-is-experimental-research-design-definition-examples-types/>
19. Tatira, B., & Mshanelo, T. (2022). The impact of virtual laboratories on the academic performance of students in physics education. *Learning Gate*, 5(3), 45–52. <https://learning-gate.com/index.php/2576-8484/article/download/2909/1091/4419>
20. TIMSS & PIRLS International Study Center. (2019). TIMSS 2019 international results in mathematics and science. <https://timss2019.org/reports/wp-content/themes/timssandpirls/download-center/TIMSS-2019-International-Results-in-Mathematics-and-Science.pdf?utm>
21. Villanueva, M. J. S. (2021). The effect of peer tutoring on students' performance in physics. *ResearchGate*. <https://www.researchgate.net/publication/350123456>
22. Wangchuk, D., Wangdi, D., Tshomo, S., & Zangmo, J. (2023). Exploring students' perceived difficulties of learning physics. *Educational Innovation and Practice*, 6. <https://doi.org/10.17102/eip.6.2023.03>