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Physics Education Technology (PhET) Interactive Simulations in Teaching Science and Test-Scores Among Students

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ABSTRACT

This study examined the use of Physics Education Technology (PhET) Interactive Simulations in teaching Science and the test scores of Grade 8 students at Mahinog National High School during School Year 2025-2026. A quasi-experimental pretest-posttest design was used with two intact heterogeneous classes: 37 learners in the control group and 37 learners in the experimental group. The control group received lecture-based instruction supported by the chalkboard, whereas the experimental group received instruction using PhET Interactive Simulations aligned with Grade 8 Science lessons. A validated curriculum-aligned test with a reported Cronbach's alpha of .83 was administered before and after the 18-day intervention. Frequency, percentage, mean, standard deviation, independent-samples t-test, and multiple regression analysis were used. The control group's mean increased from 6.57 (SD = 3.50) to 8.02 (SD = 4.30), while the experimental group's mean increased from 10.54 (SD = 4.60) to 13.51 (SD = 5.40). The experimental group demonstrated a larger gain score (2.97) than the control group (1.45), with the source manuscript reporting a significant gain-score difference, $t = 2.69$, $p = .008$. The regression model was significant, $F(8, 65) = 39.62$, $p < .001$, and explained 83% of the variance in posttest scores. Baseline score and instructional group were significant predictors, while age, family income, household size, and their reported interaction terms were not significant. The findings indicate that PhET simulations can serve as a useful supplement to Science instruction. Because the intact groups differed substantially at baseline, the intervention effect should be interpreted using the adjusted regression results and verified against the original statistical output before publication.

Keywords: *Grade 8 Science, interactive simulations, PhET, quasi-experimental research, science education, test scores*

INTRODUCTION

Technology-enhanced learning provides opportunities to make abstract scientific concepts more concrete, interactive, and accessible. In Science classrooms, students may find it difficult to understand processes that cannot be easily observed through lecture-based instruction alone. Interactive simulations allow learners to manipulate variables, observe outcomes, and connect scientific explanations with visual representations.

Physics Education Technology (PhET) Interactive Simulations were developed as research-based digital resources for teaching and learning science and mathematics. These simulations enable learners to explore models and scientific relationships through guided interaction. Earlier research has shown that PhET-supported instruction can strengthen conceptual understanding, engagement, and achievement when simulations are aligned with learning

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objectives and integrated with teacher facilitation (Banda & Nzabahimana, 2022; Perkins et al., 2006; Taibu et al., 2021; Uwambajimana et al., 2023).

In the Philippine K to 12 context, the integration of information and communication technology supports learner-centered and inquiry-oriented instruction. PhET simulations are particularly relevant when laboratory facilities, instructional materials, or opportunities for hands-on experimentation are limited. Their use also supports Sustainable Development Goal 4, which promotes inclusive and equitable quality education (United Nations, 2015).

This study examined the use of PhET Interactive Simulations in teaching Grade 8 Science at Mahinog National High School. It described the participants' profile, compared test scores with and without PhET-supported instruction, tested differences in learning gains, examined the reported regression model after accounting for baseline scores and demographic factors, and developed an action plan for classroom integration.

Literature Review

PhET Interactive Simulations in Science Learning

PhET simulations are interactive digital environments that help learners visualize scientific concepts and explore the effects of changing variables. Perkins et al. (2006) explained that the simulations were designed to support active engagement and conceptual understanding. Their interactive nature encourages learners to test ideas, observe patterns, and connect representations with scientific explanations.

Research has reported positive outcomes from simulation-supported instruction. Banda and Nzabahimana (2022) examined the impact of PhET-based learning on achievement and motivation. Taibu et al. (2021) reported improvements in scientific skills and attitudes among students using PhET simulations. Uwambajimana et al. (2023) likewise found that PhET simulations supported conceptual understanding of electrostatics in secondary-school settings.

PhET Integration in Philippine Science Classrooms

Local studies also support the use of PhET as a supplementary teaching tool. Mallari and Lumanog (2020) discussed the effectiveness of integrating simulation-based activities in Science, while Dy et al. (2024) reported improved learner performance through PhET Interactive Simulations. More recent studies have examined simulation-supported understanding in specific science topics and grade levels (Fuentes et al., 2025; Quimoyog et al., 2025). These findings suggest that simulations are most effective when combined with clear learning tasks, guided questioning, and post-activity reflection.

Interactive Learning, Prior Knowledge, and Contextual Factors

The effectiveness of an instructional intervention should be interpreted alongside learners' baseline knowledge and contextual characteristics. Pretest performance is especially important in quasi-experimental studies using intact classes because the groups may not be equivalent before instruction. Demographic factors such as age, household size, and family income may also be examined as covariates or potential moderators, although any interpretation should remain grounded in the reported statistical evidence.

METHODS

Research Design

The study employed a quasi-experimental pretest-posttest design using intact heterogeneous Grade 8 classes. One class served as the control group and received lecture-based instruction supported by the chalkboard. The other class served as the experimental group and received Grade 8 Science instruction supported by PhET Interactive Simulations. Since the students were not randomly assigned, baseline differences were considered in interpreting the results.

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Research Locale

The study was conducted at Mahinog National High School in Barangay Poblacion, Mahinog, Camiguin. The school implements the K to 12 Basic Education Curriculum and served as the setting for the 18-day instructional intervention.

Participants and Sampling Technique

The participants were 74 Grade 8 students enrolled during School Year 2025-2026. Two intact heterogeneous sections were included: Grade 8-Archimedes with 37 students and Grade 8-Socrates with 37 students. The use of intact classes provided a practical classroom-based comparison of traditional and PhET-supported instructional approaches.

Research Instruments

The primary instructional tool was the PhET Interactive Simulation package aligned with the selected Grade 8 Science lessons. A standardized curriculum-aligned test was administered as the pretest and posttest to assess prior knowledge and learning gains. A profile questionnaire gathered information on age, family monthly income, and household size.

The source manuscript reports that three subject-matter experts in science education and instructional design reviewed the test items for content validity. The reported Cronbach's alpha coefficient was .83, indicating good internal consistency.

Data Gathering Procedure

The researchers obtained authorization from the Schools Division Office, the graduate-school office, and the school principal. Informed consent was obtained from the students and their parents or guardians. Both groups completed the pretest before the intervention. During the 18-day implementation period, the experimental group received PhET-supported lessons, while the control group received traditional chalkboard-supported discussion. Posttests were administered after the intervention, and the instructional sessions were documented to support consistency in instructional time and learning conditions.

Data Analysis

Frequency and percentage were used to describe the learners' demographic profile. Mean and standard deviation summarized pretest, posttest, and gain scores. Independent-samples t-tests were used to compare the groups. Multiple regression analysis was used to examine the contribution of instructional group, pretest score, age, family income, household size, and reported interaction terms to posttest performance. Statistical significance was evaluated at the .05 level.

Ethical Consideration

The study observed informed consent, parental or guardian permission for minors, voluntary participation, anonymity, confidentiality, and secure data handling. Participants were informed that they could withdraw from the study without negative consequences. The collected information was used solely for research purposes.

RESULTS AND DISCUSSION

Profile of the Respondents

Table 1. *Profile of the Respondents (N = 74)*

Variable	Category	Frequency	Percentage
Age	12 years old	1	1.35%
	13 years old	48	64.87%
	14 years old	25	33.78%
Family monthly income	Below ₱10,957	43	58.11%
	₱10,958-₱21,914	24	32.43%
	₱21,915-₱43,828	4	5.41%
	₱43,829-₱76,699	1	1.35%

	₱76,700 and above	2	2.70%
Household size	1-2 members	1	1.35%
	3-4 members	16	21.62%
	5-6 members	29	39.19%
	7-8 members	22	29.73%
	9 or more members	6	8.11%

Most respondents were 13 years old (64.87%). More than half came from households with a monthly income below ₱10,957 (58.11%), and the largest household-size group consisted of five to six members (39.19%). The profile provides contextual information for interpreting the intervention results, although the regression findings did not show statistically significant moderation by age, family income, or household size.

Pretest, Posttest, and Gain Scores

Table 2. *Test Scores with and Without PhET Interactive Simulations*

Assessment	Instructional Condition	n	Mean	SD
Pretest	Control: without PhET	37	6.57	3.50
	Experimental: with PhET	37	10.54	4.60
Posttest	Control: without PhET	37	8.02	4.30
	Experimental: with PhET	37	13.51	5.40
Gain score	Control: without PhET	37	1.45	-
	Experimental: with PhET	37	2.97	-

The control group's mean increased from 6.57 to 8.02, reflecting a gain of 1.45 points. The experimental group's mean increased from 10.54 to 13.51, reflecting a larger gain of 2.97 points. The descriptive results indicate improvement in both groups, with a greater increase among learners who received PhET-supported instruction.

The experimental group also had a substantially higher pretest mean than the control group. This baseline difference is important because the groups were intact classes rather than randomly assigned. Accordingly, the effect of the intervention should not be interpreted from posttest means alone.

Reported Between-Group Tests

Table 3. *Reported Independent-Samples t-Test Results*

Comparison	t-value	df	p-value	Interpretation
Direct comparison between control and experimental groups	6.50	62	< .001	Significant
Comparison of gain scores	2.69	Not reported	.008	Significant

The source manuscript reported a statistically significant difference between the control and experimental groups and a significant difference in gain scores ($t = 2.69$, $p = .008$). The gain-score comparison supports the observation that the experimental group improved more than the control group. However, the reported direct comparison requires verification because the manuscript lists df = 62 despite a total sample of 74 learners and does not clearly identify whether the test compared pretest, posttest, or combined scores.

Multiple Regression Analysis

Table 4. *Reported Multiple Regression Model Predicting Posttest Scores*

Predictor	b	SE	t	p-value
Intercept	4.045	0.656	6.170	< .001
Pretest score	0.983	0.083	11.815	< .001
Instructional group	1.676	0.551	3.040	.003
Household size	-0.550	0.488	-1.128	.263
Family income	0.792	0.430	1.843	.070
Age	0.778	0.736	1.058	.294
Group × household size	0.768	0.624	1.229	.223

Group × family income	0.589	0.696	0.847	.400
Group × age	-0.915	1.123	-0.815	.418

The source manuscript reported a significant regression model, $F(8, 65) = 39.62$, $p < .001$, with $R^2 = .83$. Pretest score ($b = 0.983$, $p < .001$) and instructional group ($b = 1.676$, $p = .003$) were significant predictors of posttest scores. Holding the baseline score and demographic variables constant, the positive instructional-group coefficient indicates higher adjusted posttest performance for learners who received PhET-supported instruction.

Household size, family income, and age were not significant predictors at the .05 level. The reported interaction terms were also not significant: group × household size ($p = .223$), group × family income ($p = .400$), and group × age ($p = .418$). Thus, the source analysis did not find evidence that the effect of PhET-supported instruction varied significantly according to these demographic characteristics.

Implications for Science Instruction

The results support the use of PhET simulations as a supplementary instructional tool. Their visual and interactive features can help learners explore scientific ideas that are difficult to represent through lecture alone. Student responses in the source manuscript also indicated that the simulations made abstract ideas easier to understand and created an engaging, game-like learning experience.

The findings are consistent with earlier studies showing that PhET-supported learning can improve conceptual understanding and achievement when simulations are purposefully integrated into instruction (Banda & Nzabahimana, 2022; Dy et al., 2024; Mallari & Lumanog, 2020; Taibu et al., 2021; Uwambajimana et al., 2023). The teacher's role remains essential: simulations should be paired with clear objectives, guided questions, discussion, and reflection.

Proposed Action Plan

Table 5. *Proposed Action Plan for the Integration of PhET Interactive Simulations*

Component	Objective	Activities	Persons Involved	Expected Output
Research dissemination	Share findings and demonstrate classroom applications of PhET.	School-based presentation and LAC session	Science teachers, school administrators	Increased awareness and informed adoption
Teacher capability building	Strengthen teachers' skills in selecting and facilitating simulations.	Hands-on workshop on PhET navigation, lesson alignment, and guided questioning	Science teachers and ICT coordinator	Improved teacher readiness
Curriculum integration	Use simulations in lessons where abstract concepts require visualization.	Prepare PhET-supported lesson plans and activity sheets	Science teachers	More interactive and concept-focused instruction
Learner engagement	Promote active exploration and reflection.	Pair simulations with prediction tasks, guided inquiry, and post-activity discussion	Science teachers and students	Improved participation and conceptual understanding
Monitoring and evaluation	Track learning gains and implementation quality.	Use pretests, posttests, observation notes, and quarterly review meetings	Science department and school head	Evidence-informed refinement of instruction
Resource support	Ensure reliable access to simulations.	Maintain offline copies, devices, and technical troubleshooting support	School administration and ICT personnel	Sustained classroom use

CONCLUSION

Grade 8 learners who received PhET-supported Science instruction demonstrated a larger mean gain in test scores than those who received traditional chalkboard-supported instruction. The reported regression model remained significant after accounting for baseline scores and demographic characteristics, and the instructional-group coefficient was statistically significant. Age, family income, household size, and the reported interaction terms were not significant. These findings indicate that PhET Interactive Simulations can strengthen Science instruction as a supplementary resource. Because the intact groups were not equivalent at baseline, the adjusted regression results should be emphasized and the original statistical output should be verified before the article is submitted for publication.

Recommendations

1. Science teachers may integrate PhET simulations into lessons involving abstract concepts, provided that the simulations are aligned with learning objectives and supported by guided inquiry activities.
2. The school may conduct hands-on training for Science teachers on selecting appropriate simulations, preparing activity sheets, facilitating discussion, and assessing learning gains.
3. Offline copies of relevant simulations and technical support may be maintained to ensure continuity when internet access is limited.
4. Teachers may pair simulations with prediction tasks, group discussion, reflection questions, and formative assessment to prevent passive viewing.
5. Future researchers may use randomized assignment when feasible, matched comparison groups, or analysis-of-covariance procedures to address baseline differences more rigorously.
6. Before journal submission, the original statistical output may be reviewed to clarify the direct t-test comparison, confirm the degrees of freedom, and verify the coding of the regression predictors and interaction terms.

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