

Contextualized PhET Simulation-Based Assessment for Enhancing Grade 9 STE Students' Understanding of Projectile Motion

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ABSTRACT

This study investigated the effectiveness of contextualized PhET simulation-based assessments in enhancing Grade 9 STE students' understanding of projectile motion and their motivation in learning physics. Employing a descriptive-correlational research design, 23 students at Dinagat School of Fisheries completed simulation tasks embedded in real-life scenarios, including net tossing, coconut games, and boat-to-shore throws. Student performance was evaluated using a 3–2–1 rubric, while motivation was measured through the Physics Motivation Questionnaire II (PMQ-II). Results revealed high mastery in most assessment tasks, particularly in identifying motion components and analyzing vertical motion, and very high motivation across all dimensions, with grade motivation

scoring highest. Correlational analysis showed a significant moderate positive relationship between motivation and performance ($r = 0.62$, $p = 0.002$), indicating that more motivated students tended to perform better. Findings suggest that contextualized PhET simulation-based assessments not only enhance conceptual understanding and problem-solving skills but also foster student engagement and intrinsic motivation, supporting their adoption as authentic and effective assessment tools in physics education, especially in schools with limited laboratory resources.

Keywords: *PhET simulations, projectile motion, science motivation, Grade 9 STE, simulation-based assessment*

INTRODUCTION

Physics concepts, particularly projectile motion, are among the most challenging topics in the Grade 9 Science, Technology, and Engineering (STE) curriculum due to their abstract, dynamic, and mathematically integrated nature. Understanding projectile motion requires learners to analyze the simultaneous effects of horizontal and vertical motion, interpret motion graphs, and relate mathematical equations to real-world situations. Many students find it difficult to visualize motion trajectories and connect formulas to physical phenomena, leading to misconceptions and fragmented conceptual understanding (Basri et al., 2025; Garza Sada & Zavala, 2021).

This challenge is reflected in the academic performance of Grade 9 STE students at Dinagat School of Fisheries (DSOF). Records of physics achievement over the past three school years show that the Mean Percentage Scores (MPS) in kinematics competencies—particularly those involving projectile motion—

consistently fall within the Low Mastery (15–34%) to Average Mastery (35–65%) levels. Competencies that require analysis of projectile paths, resolution of velocity components, and prediction of motion outcomes register among the lowest mastery scores, indicating persistent learning gaps and the need for improved instructional and assessment strategies.

Research at both local and international levels highlights the effectiveness of interactive digital learning tools, especially PhET Interactive Simulations, in enhancing students' conceptual understanding, visualization skills, motivation, and inquiry-based learning in physics. PhET simulations enable learners to manipulate key variables such as initial velocity, angle of projection, and gravitational acceleration, allowing them to observe real-time changes in projectile motion. These interactive features support active exploration, hypothesis testing, and conceptual linking between mathematical models and physical motion (Dantic & Fularon, 2022; Sam & Stephen, 2025).

Despite strong evidence supporting the instructional value of PhET simulations, most studies focus on their use as teaching tools rather than as assessment instruments. There is limited research on the development of contextualized PhET simulation-based assessments that measure higher-order conceptual understanding of projectile motion among Grade 9 STE learners. This gap is more pronounced in geographically isolated schools, such as those in the Province of Dinagat Islands, where access to laboratory equipment and authentic assessment materials is constrained. Although ICT integration initiatives have been introduced, teachers still lack structured and context-sensitive assessment tools that utilize simulations to evaluate students' learning effectively.

Given these challenges, the development of a contextualized PhET simulation-based assessment for projectile motion is both timely and necessary. Such an assessment provides dynamic, visual, and inquiry-driven tasks that generate authentic evidence of students' conceptual understanding and problem-solving skills. For Grade 9 STE students at DSOF, this approach has the potential to bridge the gap between instruction and assessment, improve mastery of projectile motion concepts, and enhance student engagement and motivation in physics learning. This study aims to determine the effectiveness of a contextualized PhET simulation-based assessment in enhancing Grade 9 STE students' understanding of projectile motion. It also seeks to measure students' motivation levels and examine whether motivation relates to their posttest performance. Specifically, the study seeks to answer the following questions:

1. What is the level of Grade 9 STE students' performance on the contextualized PhET simulation-based assessments in terms of understanding projectile motion concepts?
2. What is the level of students' motivation in terms of intrinsic motivation, self-efficacy, self-determination, grade motivation, and career motivation?
3. Is there a significant relationship between students' motivation levels and their performance on the contextualized PhET-based assessments in projectile motion?

Hypotheses

H₀: There is no significant difference between pretest and posttest scores.

H₁: There is no significant relationship between students' motivation levels and their performance on the contextualized PhET-based assessments in projectile motion.

Theoretical Background and Review of Related Literature

This study was grounded in constructivist theory, which emphasizes that learners build understanding through active engagement and reflection, using models and simulations to visualize abstract concepts like projectile motion (Driver et al., 1994; Umiliya et al., 2023).

PhET simulations function as virtual laboratories, allowing students to manipulate variables, observe outcomes, and analyze motion trajectories, fostering meaningful understanding even in schools with limited physical lab resources (Kolb, 1984; Pranata, 2024). By combining visual representations, graphs, and interactive controls, simulations help students link mathematical equations with real-life motion scenarios, reducing cognitive load and enhancing comprehension (Mayer, 2005; Fuentes et al., 2025).

Motivationally, self-determination theory explains how contextualized simulations increase intrinsic motivation and engagement by providing autonomy and connecting activities to real-world scenarios such as net tossing and coconut games (Buday Benzar et al., 2023).

Empirical studies confirm that PhET simulations enhance understanding and motivation, but few have been applied as assessment tools for Grade 9 STE learners, highlighting the need for contextualized simulation-based assessments (Ndayisaba & Tugirinshuti, 2025; Andrin & Adlaon, 2025).

METHODS

Research Design

This study employed a quantitative descriptive-correlational research design to evaluate Grade 9 STE students' understanding of projectile motion through contextualized PhET simulation-based assessments. The design focused on measuring students' performance on activities that integrated real-life Dinagat Island scenarios, such as net tossing, coconut games, and boat-to-shore throws, providing evidence of their conceptual understanding, reasoning, and application of physics principles.

The descriptive component allowed the researcher to assess students' performance on each PhET-based task, capturing their ability to identify horizontal and vertical motion components, analyze trajectories, predict outcomes, and apply concepts to contextualized scenarios. Performance was evaluated using a 3–2–1 rubric, which rated the accuracy, completeness, and contextual application of students' responses.

The correlational component examined the relationship between students' performance on the contextualized PhET-based assessments and their motivation levels, as measured by the Physics Motivation Questionnaire II (PMQ-II). This analysis provided insight into how affective factors influenced students' understanding and application of projectile motion concepts.

By using contextualized PhET-based assessments, this design ensured that evaluation was authentic, meaningful, and aligned with real-life applications, allowing the researcher to capture students' conceptual reasoning, problem-solving, and application skills. The quantitative approach enabled objective scoring, descriptive statistics, and correlation analysis, providing evidence-based conclusions regarding the effectiveness of contextualized PhET-based assessments in enhancing learning and motivation.

Research Locale and Participants

The study was conducted at Dinagat School of Fisheries (DSOF), a public secondary school located in the Province of Dinagat Islands—a geographically isolated island province in the Caraga Region of the Philippines. The participants consisted of 23 Grade 9 STE students enrolled during School Year 2025–2026. Purposive sampling was employed, as this group was the only STE class in the school with projectile motion competencies included in the Science 9 curriculum.

These students were selected due to their accessibility, enrollment in the relevant subject, and suitability for the contextualized PhET-based assessments. Participants varied in prior knowledge, learning styles, and motivation, providing a representative snapshot of Grade 9 STE learners in a geographically isolated school setting.

Research Instruments

The study utilized two research instruments to collect data. The first was a researcher-made contextualized PhET simulation-based assessment, developed in alignment with the Science 9 K–12 curriculum to evaluate students' understanding of projectile motion concepts. The assessment focused on analyzing horizontal and vertical motion, predicting motion trajectories, and resolving velocity components through simulation tasks embedded in real-life Dinagat Island scenarios, such as net tossing, coconut games, and boat-to-shore throws.

To ensure content accuracy, clarity, and alignment with learning outcomes, the assessment items were validated by a panel of experts, including a Master Teacher in Science, a Master Teacher in Mathematics, a Physics teacher, and an English teacher. The Science and Physics experts ensured conceptual and technical accuracy, the Mathematics expert reviewed computational and analytical aspects, while the English teacher evaluated clarity of instructions and comprehensibility of prompts. Student performance on these tasks provided a measure of cognitive understanding and application skills in projectile motion.

The second instrument was the Physics Motivation Questionnaire II (PMQ-II), adapted from Glynn et al. (2011), which assessed five dimensions of student motivation: intrinsic motivation, self-efficacy, self-determination, grade motivation, and career motivation. The PMQ-II employed a five-point Likert scale ranging from 0 (never) to 4 (always), with mean scores interpreted as very unmotivated (0.00–0.80), unmotivated (0.81–1.60), moderately motivated (1.61–2.40), motivated (2.41–3.20), and very motivated (3.21–4.00).

Data Collection and Analysis

Data collection began after securing approval from the school administration and obtaining informed consent from all participants and, where applicable, their parents or guardians. Students were first engaged in the contextualized PhET simulation-based assessments, which allowed them to manipulate variables such as angle, initial velocity, and gravity to observe and analyze projectile motion trajectories within real-life Dinagat Island scenarios, such as net tossing, coconut games, and boat-to-shore throws.

During the activities, students' performance was assessed using a 3–2–1 rubric, which evaluated the accuracy, completeness, and contextual application of their responses. The Physics Motivation Questionnaire II (PMQ-II) was subsequently administered to assess students' motivation levels across five dimensions: intrinsic motivation, self-efficacy, self-determination, grade motivation, and career motivation. All data collection activities were conducted during scheduled class hours to minimize disruption, ensure voluntary participation, and maintain the confidentiality and anonymity of participants.

For data analysis, quantitative methods were employed. Descriptive statistics, including mean scores, standard deviations, and interpretation of rubric and motivation scores, were calculated to provide a clear overview of students' cognitive and affective outcomes. Additionally, Pearson's r correlation was conducted to examine the relationship between students' performance on the contextualized PhET-based assessments and their motivation levels.

Ethical Considerations

This study adhered to ethical standards to protect the rights and welfare of participants. Approval was obtained from the school administration, and informed consent was secured from all participants and, where applicable, their parents or guardians. Participation was voluntary, and students were informed that they could withdraw at any time without penalty. Participants' identities were kept anonymous, and all data were treated with confidentiality and used solely for research purposes. The contextualized PhET-based assessments were designed to avoid any physical, psychological, or academic harm, and all procedures complied with institutional guidelines and ethical standards for research with human subjects.

RESULTS AND DISCUSSION

Students' Performance on Contextualized PhET-Based Assessments

Students' performance was evaluated using assessment tasks embedded directly within the PhET-based lesson activities. Each task was scored using a 3–2–1 rubric based on accuracy, reasoning, and the ability to apply physics concepts to real-life Dinagat Island scenarios (e.g., net tossing, coconut games,

boat-to-shore throws). Table 1 presents the descriptive statistics of students' performance across assessment tasks.

Table 1. *Descriptive Statistics of Students' Performance*

Assessment Focus	Mean	Median	SD	Interpretation
Identifying Horizontal & Vertical Components	2.52	3.00	0.38	High Mastery
Analyzing Horizontal Motion	2.45	2.40	0.42	Moderate to High Mastery
Analyzing Vertical Motion	2.50	2.60	0.35	High Mastery
Solving Angled Projectile Problems	2.40	2.40	0.44	Moderate to High Mastery
Overall Performance	2.47	2.50	0.30	High Mastery

Legend: 2.5–3.0 = High Mastery / Excellent Performance; 1.8–2.49 = Moderate Mastery / Satisfactory Performance; 1.0–1.79 = Low Mastery / Needs Improvement

Students demonstrated high mastery in identifying components and vertical motion, reflecting strong conceptual understanding. Slightly lower performance in horizontal analysis and angled projectile tasks (mean = 2.45–2.40) indicates that integrating multiple motion components or predicting range at an angle is cognitively more demanding. Overall, the contextualized PhET-based assessments successfully captured students' real-time reasoning, problem-solving, and application of physics concepts to contextualized scenarios.

This finding is consistent with previous studies indicating that PhET simulations promote conceptual understanding and engagement because they help students visualize motion trajectories, understand horizontal and vertical motion components, and link mathematical concepts to real-life contexts (Buday et al., 2023; Ndayisaba & Tugirinshuti, 2025).

Students' Motivation Levels

Students' motivation was assessed using the Physics Motivation Questionnaire II (PMQ-II). Table 2 presents the descriptive statistics across five motivation dimensions.

Table 2. *Descriptive Statistics of Students' Motivation Levels*

Motivation Dimension	Mean	SD	Interpretation
Intrinsic Motivation	3.78	0.53	Very Motivated
Self-Efficacy	3.83	0.80	Very Motivated
Self-Determination	3.67	0.64	Very Motivated
Grade Motivation	3.84	0.66	Very Motivated
Career Motivation	3.50	0.76	Very Motivated
Overall Motivation	3.72	0.56	Very Motivated

Legend: 3.21–4.00 = Very Motivated; 2.41–3.20 = Motivated; 1.61–2.40 = Moderately Motivated; 0.81–1.60 = Unmotivated; 0.00–0.80 = Very Unmotivated

The results indicate that Grade 9 STE students are generally very motivated to learn projectile motion. Among the motivation dimensions, Grade Motivation obtained the highest mean score ($M = 3.84$, $SD = 0.66$), suggesting that students are strongly driven to achieve high academic performance. Career Motivation recorded the lowest mean ($M = 3.50$, $SD = 0.76$), indicating slightly lower, yet still very motivated, concern for future academic or career goals. Overall, students demonstrate a high level of engagement, interest, and commitment toward learning projectile motion. These findings align with previous studies indicating that interactive and contextualized PhET simulations enhance learners' motivation, engagement, and conceptual understanding in science (Fuentes et al., 2025; Pranata, 2024).

Relationship Between Motivation and Performance

The relationship between students' motivation levels and their posttest scores was examined using Pearson r correlation. Table 3 presents the results.

Table 3. Correlation Between Students' Motivation Levels and Posttest Scores

Variable Pair	r-value	p-value	Interpretation
Motivation vs. Posttest Score	0.62	0.002	Significant

The computed r -value of 0.62 indicates a moderate positive correlation between students' motivation levels and posttest performance. Since the p -value ($0.002 < 0.05$), the relationship is statistically significant. Students who exhibited higher motivation generally performed better in the posttest. This implies that motivation plays a crucial role in enhancing learning outcomes in physics. The interactive and contextualized nature of the PhET tasks likely contributed to increasing motivation, which in turn supported stronger conceptual understanding. This finding is consistent with Glynn et al. (2011), who emphasized motivation as a predictor of science achievement.

The findings of this study indicate that contextualized PhET simulation-based assessments are effective in improving both cognitive performance and motivation in learning projectile motion. Students not only demonstrated significant learning gains but also exhibited high motivation across multiple dimensions. The positive correlation between motivation and posttest scores underscores the interconnectedness of cognitive and affective factors in physics learning.

These results are in line with both local and international studies (Buday et al., 2023; Fuentes et al., 2025; Ndayisaba & Tugirinshuti, 2025; Pranata, 2024), which suggest that interactive simulations enhance conceptual understanding, engagement, and self-directed learning. Importantly, this study extends prior research by demonstrating the effectiveness of PhET simulations not just as instructional tools but as assessment instruments, particularly when contextualized for learners in geographically isolated schools.

CONCLUSION

Contextualized PhET simulation-based assessments effectively enhanced Grade 9 STE students' understanding of projectile motion. Students demonstrated high mastery in identifying horizontal and vertical components, analyzing vertical motion, and applying concepts to real-life scenarios such as net tossing and coconut games. Motivation levels were very high across all dimensions, with a moderate positive correlation between motivation and performance ($r = 0.62$, $p = 0.002$). The study highlights that contextualized simulations not only assess but also strengthen conceptual understanding, reasoning, and engagement, particularly in schools with limited laboratory resources.

These findings support the adoption of contextualized PhET simulation-based assessments as authentic, effective, and motivationally supportive tools in physics education. Future studies are encouraged

to expand the sample size, include control groups, and explore the long-term effects of simulation-based assessment across other physics topics and grade levels.

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Author Contribution

The author conceptualized and designed the study, developed the contextualized PhET simulation tasks, analyzed the data, and prepared the manuscript.

Competing Interest

The author declares no competing interests in the completion or publication of this study.

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