

Physics Education Technology (PhET) Simulation Assisted Instruction towards Students' Academic Achievement and Motivation in Electromagnetism

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ABSTRACT

This study examined the effectiveness of Physics Education Technology (PhET) simulation-assisted instruction on students' academic achievement and motivation in electromagnetism. A quasi-experimental quantitative design was employed involving second-year Bachelor of Secondary Education major in Science students, with one group exposed to PhET-integrated instruction and another taught using traditional methods. Academic achievement was measured through pretests and posttests, while motivation was assessed using a validated questionnaire covering intrinsic motivation, amotivation, extrinsic-career motivation, and social-extrinsic motivation. Results revealed that both groups initially demonstrated very low academic achievement, with most students classified under the failure category during the pretest. After the intervention, the PhET group exhibited a marked improvement, with all students attaining good to very good performance levels and no failures recorded. In contrast, although the non-PhET group showed some improvement, the majority of students remained at a satisfactory level. ANCOVA results indicated a statistically significant difference in posttest academic achievement between the two groups when pretest scores were controlled ($p < 0.01$), favoring the PhET simulation-assisted instruction. In terms of motivation, students in the PhET group demonstrated higher levels across all motivational dimensions compared to those in the non-PhET group. Overall motivation for the PhET group was interpreted as motivated, while the non-PhET group displayed lower motivational levels. Independent samples t-test results confirmed a statistically significant difference in overall motivation between the groups ($p < 0.001$). These findings suggest that integrating PhET simulations into physics instruction significantly enhances both conceptual understanding and student motivation in electromagnetism.

Keywords: PhET simulations, electromagnetism, academic achievement, student motivation, physics education

INTRODUCTION

Background of the Study

Amid the ongoing challenges in Philippine science education, the integration of technological advancements into teaching and learning has become increasingly significant (OECD, 2018). Philippine Higher Education Institutions (PHEIs) have adopted technology to remain relevant in a rapidly evolving global landscape (Staddon, 2023), although limitations in resources, infrastructure, and faculty readiness may slow this transition and affect the preparation of graduates for global demands. This need is particularly evident in physics, a discipline closely linked to technological progress, where many modern innovations are grounded in physics principles and are now used to promote hands-on, inquiry-based learning that complement traditional classroom instruction, creating a continuous cycle between physics and technological innovation (Winter & Hardman, 2020).

Technology has expanded educational access by enabling real-time learning beyond geographical limits (Talib et al., 2021). However, as a developing country, the Philippines still faces gaps in effectively applying technology in education, with many schools lacking adequate computers and reliable internet, particularly in rural areas (Servallos, 2023; UNESCO). Despite generally positive attitudes toward technology, limited devices and connectivity hinder students' learning opportunities. Alongside these challenges, Filipino learners continue

to show low scientific literacy, as reflected in recent PISA results in science and mathematics. These concerns underscore the need for meaningful instructional interventions to help 21st-century learners progress toward becoming scientifically literate citizens.

This study highlights an advancement in technology-enhanced education through the use of Physics Education Technology (PhET) simulations, developed by Dr. Carl Wieman and his team at the University of Colorado Boulder. A Nobel Prize-winning physicist, Wieman launched the PhET project in 2002 to create free, research-based, and interactive simulations that make science and mathematics learning more engaging and accessible (Leytham-Powell, 2017). Studies show that PhET is particularly effective at the secondary level; however, its use is also relevant in tertiary education. Filipino learners' literacy and numeracy proficiency declines sharply from Grade 3 to Grade 12, with only about 0.47% of senior high school students meeting expected standards, and many continuing to struggle with basic reading, computation, and problem-solving skills. This decline in cognitive competencies suggests that some college students may perform at levels comparable to secondary learners, making *PhET* simulations, although commonly recommended for high school, could still be both appropriate and beneficial in the college instruction.

A study of Agyei et al. (2023) on the use of *PhET* simulations to teach electricity concepts found that students' motivation to learn physics increased significantly, including improvements in self-efficacy, perceived value of physics, and active learning strategies after instruction with PhET simulations. Another study from Banda & Nzabanimana (2022) with secondary students in Malawi showed that PhET simulation-based learning significantly enhanced students' motivation, including self-efficacy and engagement components, when learning oscillations and waves, compared with conventional instruction. A phenomenological study by Lagon (2023) with Filipino pre-service science teachers found that using PhET interactive simulations enhanced conceptual understanding, engagement, and interactivity in learning optics, while also fostering critical thinking and motivation among participants, despite challenges such as limited connectivity and device access. Similarly, a study by Manlapig (2024) involving senior high STEM students in Bulacan reported that students valued the interactive nature of PhET simulations and experienced more engaging learning interactions. Although the quantitative increase in motivation was not statistically significant, the findings suggest that PhET can promote positive learner experiences closely associated with motivational factors. These studies suggest that by providing interactive, visual, and exploratory learning experiences, simulations help students better understand abstract concepts while fostering positive attitudes and persistence, supporting both their cognitive and affective development in science education (Leytham-Powell, 2017).

This study aims to explore the impact of Physics Education Technology (*PhET*) simulation assisted instruction towards students' academic achievement and motivation in electromagnetism. The study will be conducted during the Academic Years 2025–2026 at Don Carlos Polytechnic College (DCPC), a local higher education institution in Don Carlos, Bukidnon. The institution has been experiencing notable challenges in integrating and implementing various educational technologies, making it a relevant and compelling setting for this research.

Statement of the Problem

Generally, this study aims to explore the impact of Physics Education Technology (*PhET*) simulation assisted instruction towards students' academic achievement and motivation in electromagnetism.

Specifically, the study seeks to answer the following questions:

1. What is the students' level of academic achievement before and after the intervention of Physics Education Technology (*PhET*) Simulation Assisted Instruction?
2. What is the students' level of motivation after the intervention of Physics Education Technology (*PhET*) Simulation Assisted Instruction in terms of:
 - a. Intrinsic motivation;
 - b. Amotivation;

- c. Extrinsic–career motivation; and
 - d. Social–extrinsic motivation?
3. Is there a significant difference in academic achievement in Electromagnetism when students are exposed to Physics Education Technology (*PhET*) Simulation Assisted Instruction and Non-Physics Education Technology (*PhET*) Simulation Assisted Instruction?
 4. Is there a significant difference in motivation in Electromagnetism when students are exposed to Physics Education Technology (*PhET*) Simulation Assisted Instruction and Non-Physics Education Technology (*PhET*) Simulation Assisted Instruction?

Objectives of the Study

Generally, this study aims to assess the impact of Physics Education Technology (*PhET*) simulation assisted instruction towards students' academic achievement and motivation in electromagnetism.

Specifically, the study seeks to:

1. identify the students' level of academic achievement before and after the intervention of Physics Education Technology (*PhET*) Simulation Assisted Instruction;
2. determine the students' level of motivation after the intervention of Physics Education Technology (*PhET*) Simulation Assisted Instruction;
 - a. Intrinsic motivation;
 - b. Amotivation;
 - c. Extrinsic–career motivation; and
 - d. Social–extrinsic motivation;
3. evaluate if there is a significant difference in academic achievement in Electromagnetism when students are exposed to Physics Education Technology (*PhET*) Simulation Assisted Instruction and Non-Physics Education Technology (*PhET*) Simulation Assisted Instruction; and
4. find out if there is a significant difference in motivation in Electromagnetism when students are exposed to Physics Education Technology (*PhET*) Simulation Assisted Instruction and Non-Physics Education Technology (*PhET*) Simulation Assisted Instruction.

Significance of the Study

This study seeks to provide insights into how Physics Education Technology (*PhET*) simulation-assisted instruction impacts students' academic achievement and motivation in Electromagnetism. The findings of this study are envisioned to benefit the following:

To students, the study may increase their awareness of how interactive simulations like *PhET* can support their understanding of abstract and complex concepts in Electromagnetism. By engaging in simulation-assisted learning, students may develop deeper conceptual understanding, improved problem-solving skills, and greater motivation to learn physics through active and inquiry-based experiences.

To educators, the study may offer valuable insights into how *PhET* simulations can be effectively integrated into physics instruction to enhance student engagement and learning outcomes. These insights can guide teachers in designing more interactive, technology-supported lessons that make difficult topics more accessible and meaningful for learners.

To curriculum designers and administrators, the study may serve as a basis for incorporating simulation-assisted strategies into physics and science curricula. The results may help identify the instructional value of *PhET* as a supplemental learning tool and support decisions related to technology integration, instructional innovation, and resource allocation for science education.

To future researchers, this study may contribute to the growing body of literature on technology-enhanced learning and simulation-based instruction in science education. It also provides a local context for understanding how *PhET* simulations affect student achievement and motivation, opening opportunities for further studies in other science topics and educational settings.

Scope and Delimitation of the Study

This study focused on examining the effects of Physics Education Technology (PhET) simulation-assisted instruction on students' academic achievement and motivation in Electromagnetism at Don Carlos Polytechnic College (DCPC) in Don Carlos, Bukidnon. Specifically, it investigated how the integration of PhET simulations into physics instruction supported students' understanding of complex electromagnetic concepts and enhanced their motivation to learn physics through interactive, technology-supported learning experiences.

The participants of the study were second-year students enrolled in an Electromagnetism course during the Second Semester of the School Year 2025–2026. These students were exposed to lessons delivered through PhET simulation-assisted instruction as part of their regular classroom learning activities. Data were gathered using validated research instruments that measured two primary variables: students' academic achievement and motivation in learning Electromagnetism. The academic achievement was assessed using teacher-made tests aligned with Electromagnetism topics, while motivation was measured through a structured survey questionnaire adapted and modified for the study. The investigation was limited to these two outcome variables as influenced by PhET simulation-assisted instruction.

The scope of the study was further confined to selected Electromagnetism topics for which appropriate PhET simulations were available and to the duration of the instructional intervention conducted during the semester. Moreover, the study acknowledged limitations related to its quasi-experimental design, sample size, institutional context, reliance on self-reported motivation data, and the relatively short duration of the intervention. Consequently, causal claims were moderated, and findings were interpreted as indicative of associations rather than definitive causal effects. Despite these delimitations, the study aimed to provide foundational evidence on the instructional value of PhET simulations in enhancing students' achievement and motivation in learning Electromagnetism within the context of DCPC.

Definition of Terms

For a better understanding of this study, the following terms will be defined operationally:

Academic Achievement refers to the post-test scores obtained by the students in electromagnetism course.

Amotivation refers to the lack of intentionality or direction in learning, where students feel uncertain about the purpose of studying. This is reflected in unclear reasons for studying, limited understanding of the benefits of lessons or newly learned content, weak motivation to participate in learning activities, and insufficient personal drive to pursue academic tasks.

Extrinsic-career motivation refers to students' engagement in academic tasks driven by career-related goals and external outcomes. It is observed when learners connect their studies to future professions, recognize the importance of aligning learning with career paths, understand their chosen specialization and its opportunities, and are aware of potential future job options.

Intrinsic motivation refers to the learner's internal desire to engage in learning activities because these are personally enjoyable, interesting, or satisfying. It is demonstrated through students' enjoyment of studying, interest in discussing subject content, willingness to share newly learned ideas, enjoyment of reading academic materials, and genuine interest in classroom learning.

Motivation refers the process whereby goal-directed activity is instigated and sustained. It influences how students engage with tasks, persist in challenges, and construct new understanding.

Social–extrinsic motivation refers to the students’ drive to perform academically to gain social approval, recognition, or validation from themselves, family, peers, and community. This includes proving personal success, demonstrating abilities, influencing their environment positively, and establishing a respected role in the community.

Theoretical Framework

Conceptual Framework

Based on the research’s reviews, the present study will be anchored to the following theoretical concepts:

Constructivism is a learning theory positing that learners actively construct knowledge by integrating new information with prior experiences, rather than passively receiving facts; in education it is commonly traced to Jean Piaget’s genetic epistemology (mid-20th century, 1930s–1970s) emphasizing cognitive structures and processes such as assimilation, accommodation, and equilibration, and to Lev Vygotsky’s socio-cultural perspective (1930s) highlighting the social origins of higher mental functions and the Zone of Proximal Development (ZPD). Together, Piaget’s “cognitive constructivism” and Vygotsky’s “social constructivism” underpin learner-centered, inquiry-oriented pedagogy where meaning is built through activity and interaction. PhET simulations are grounded in constructivist principles, which emphasize that learners build their own understanding by actively interacting with concepts, manipulating variables, and making sense of observed outcomes. Because electromagnetism involves abstract and highly conceptual ideas, these simulations offer dynamic, visual representations that help students construct meaning through hands-on exploration rather than passive reception of information. In this environment, students develop deeper conceptual understanding as they investigate fields, charges, and circuits through real-time, interactive models.

Another theory is the Self-Determination Theory (SDT) by Deci & Ryan formally articulated in 1985 and synthesized in 2000. Self-Determination Theory is a macro-theory of human motivation that explains optimal functioning in terms of the satisfaction of three basic psychological needs—autonomy, competence, and relatedness. This theory explains how social contexts that support these needs enhance self-motivation, engagement, and well-being across domains like education. From the perspective of Self-Determination Theory (SDT), PhET simulations also support the basic psychological needs that foster motivation. PhET promotes autonomy by allowing students to freely explore simulation environments and experiment at their own pace. It enhances competence by giving immediate, intuitive feedback as students adjust variables and manipulate physical systems, helping them feel capable and successful in learning electromagnetism. The simulations also contribute to relatedness when used in pairs or groups, as students collaborate, discuss findings, and receive guidance from peers and teachers. By fulfilling these needs, PhET boosts intrinsic motivation and, in collaborative settings, strengthens social–extrinsic motivation as students engage socially and academically with others.

Moreover, the Experiential Learning Theory (ELT), advanced by David A. Kolb in 1984, defines learning as the process whereby knowledge is created through the transformation of experience and models it as a four-stage cycle: Concrete Experience, Reflective Observation, Abstract Conceptualization, and Active Experimentation. ELT also describes associated learning style preferences and is grounded in pragmatist and constructivist traditions, providing a widely used framework for designing hands-on, reflective learning in classrooms and professional training. PhET is further aligned with Kolb’s Experiential Learning Theory, which frames learning as a four-stage cycle. Students first engage in Concrete Experience as they manipulate electromagnetic phenomena in the simulations. Through Reflective Observation, they interpret changes and patterns that emerge from their interactions. These reflections lead to Abstract Conceptualization, where students form or refine principles related to electric fields, circuits, or induction. Finally, during Active Experimentation, learners manipulate new variables or test predictions, applying and reinforcing the concepts they developed. PhET’s design embodies this experiential cycle, enabling learning by doing, thinking, and applying.

Lastly, this study is grounded by Inquiry-Based Learning (IBL) Theory rooted from John Dewey and was formalized as a pedagogy in the 1960s. Inquiry-Based Learning is an active, question-driven approach in which learners investigate problems or scenarios to construct understanding, with the teacher acting as a facilitator rather than a transmitter of facts. IBL emphasizes developing reasoning and problem-solving through cycles of questioning, investigating, explaining, and reflecting. Lastly, PhET supports the core ideas of Inquiry-Based Learning, as it encourages students to predict outcomes, test hypotheses, analyze results, and refine their understanding through evidence-based reasoning. Rather than following step-by-step instructions, learners engage in guided or open inquiry, asking questions, adjusting parameters, and drawing conclusions based on observable phenomena. This process aligns strongly with modern physics pedagogy, which emphasizes sense-making and investigation, making PhET an effective tool for deepening conceptual understanding in electromagnetism.

Research Paradigm

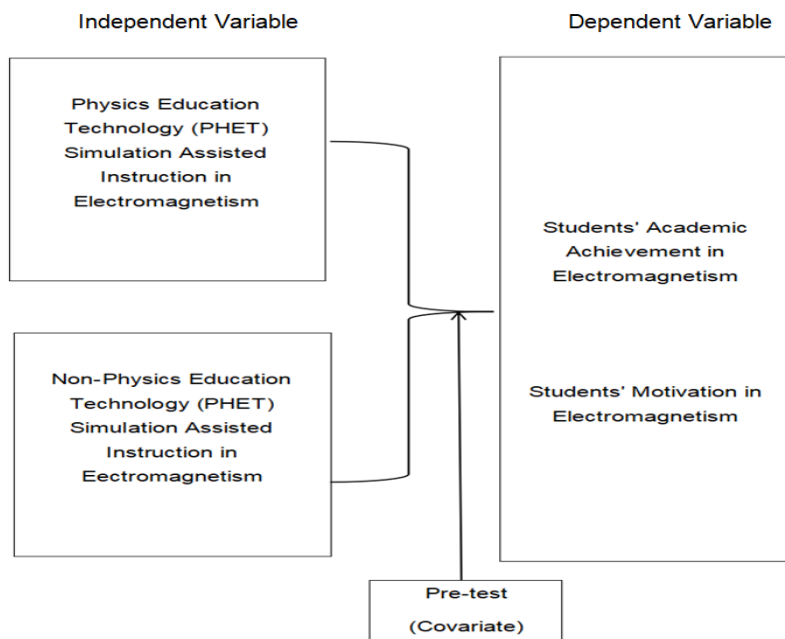


Figure 1. A schematic diagram of the interplay of the independent and dependent variables.

Hypotheses of the Study

The following null hypotheses were drawn from the objectives of the study and tested at 0.5 level of significance:

H₀₁: There is no significant difference in the students' academic achievement in electromagnetism before and after the *PhET* Simulation Assisted intervention.

H₀₂: There is no significant difference in the students' motivation in electromagnetism before and after the *PhET* Simulation Assisted intervention.

METHODOLOGY

This chapter presents the methodology of the study. It includes the research design, participants of the study, the locale of the study, research instruments, data gathering procedure, implementation, and statistical techniques used in the investigation.

Research Design

This study utilized a quasi-experimental quantitative research design to examine the effectiveness of PhET Simulation-Assisted Instruction on students' academic achievement and motivation in Electromagnetism. This quasi-experimental design determined the effectiveness of the intervention by comparing it with traditional

instruction under similar conditions. Using students from the same institution, year level, and program helped control external variables, thereby increasing the validity and reliability of the study's results. In this design, the experimental group received instruction augmented with PhET interactive simulations, while the control group were taught using traditional methods without the PhET. Pretests and posttests were administered to measure changes in the students' academic achievement in electromagnetism, and an adapted and validated survey questionnaire assessed shifts in motivation in terms of intrinsic, extrinsic, and amotivational constructs. This quantitative framework enabled the study to determine inferential influences of the intervention by comparing measurable differences in student achievement and motivation before and after the instructional treatment.

Participants of the Study

The participants of the study were from the Bachelor of Secondary Education (BSED) major in Science, second year, at Don Carlos Polytechnic College, as they were the appropriate participants for research focused on science instruction and learning strategies. As future science educators, these students were expected to develop both content mastery and pedagogical skills. Second-year BSED Science students were chosen because they already possessed foundational knowledge in science and education courses, enabling them to meaningfully engage with the intervention while still being at a formative stage of their professional preparation. Two sections of second-year BSED Science students formed the control group, while the other section served as the experimental group to allow for an objective comparison of learning outcomes.

Locale of the Study

The study was conducted at Don Carlos Polytechnic College (DCPC) in Purok 2, Norte, Don Carlos, Bukidnon, an institution offering programs such as Bachelor of Secondary Education, Bachelor of Elementary Education, Bachelor of Science in Criminology, and Bachelor of Science in Industrial and Security Management. Based on initial enrollment statistics, a significant number of first-year students at DCPC came from non-science-related senior high school strands. This academic background gap presented challenges in understanding abstract science concepts, particularly in Physics topics such as electromagnetism. This situation highlighted the need for innovative instructional approaches, such as Physics Education Technology (PhET) simulation-assisted instruction, to support students' learning and adjustment to science-focused courses.

Understanding students' academic achievement and motivation through the use of PhET simulations was especially important in a local college setting like DCPC, where resources were often limited and learners came from diverse educational backgrounds. PhET simulations offered an interactive and cost-effective instructional tool that helped visualize complex physics concepts and increase student engagement. By examining the effects of PhET simulation-assisted instruction on students' academic achievement and motivation in electromagnetism, the study generated evidence-based insights that could guide the adoption of practical, context-sensitive teaching strategies suited to the needs and realities of DCPC and similar institutions.

Research Instruments

This study examined students' levels of academic achievement and motivation before and after the implementation of PhET Simulation-Assisted Instruction. To measure academic achievement, the researcher developed a fifty-item pretest and posttest examination that was both validated and reliable. The instrument yielded a Cronach's alpha value of .849, indicating high internal consistency.

Students' levels of motivation were measured using an adapted survey questionnaire administered before and after the intervention. Prior to the adaptation and use of the instrument, the researcher sought and obtained permission from the original author via email. The questionnaire consisted of four sub-constructs: intrinsic motivation, amotivation, extrinsic-career motivation, and social-extrinsic motivation. A 4-point Likert scale was employed to quantify students' responses, enabling the analysis of motivational levels and trends. The modified questionnaire demonstrated acceptable reliability, with a Cronbach's alpha value of .775.

The scale shown below presents the scoring procedures for the academic and motivational aspects of the study, respectively.

Academic Achievement in Electromagnetism

| Grade | Percentage Equivalent | Qualitative Interpretation |
|-------------|-----------------------|----------------------------|
| 1.00 - 1.25 | 88 - 100 | Excellent |
| 1.50 - 1.75 | 76 - 87 | Very good |
| 2.00 - 2.25 | 64 - 75 | Good |
| 2.50 - 3.00 | 50 - 63 | Satisfactory |
| 5.00 | 49 below | Failure |

Motivation of Students in Electromagnetism

| Scale | Range | Descriptive Rating | Qualitative Interpretation |
|-------|-------------|------------------------|----------------------------|
| 4 | 3.26 – 4.00 | Strongly Agree (SA) | Highly Motivated |
| 3 | 2.51 – 3.25 | Agree (A) | Motivated |
| 2 | 1.76 – 2.50 | Disagree (D) | Less Motivated |
| 1 | 1.00 – 1.75 | Strongly Disagree (SD) | Not Motivated |

Data Gathering Procedure

The study was conducted during the second semester of the academic year 2025–2026 among second-year Bachelor of Secondary Education (BSED) major in Science students. Prior to the implementation of the PhET Simulation-Assisted Instruction, the researcher administered a pretest to determine the students’ initial level of academic achievement in electromagnetism. At the same time, a pretest motivation survey was administered to assess the students’ baseline level of motivation toward learning physics. These instruments provided initial data that served as the basis for comparison after the intervention.

Following the pretests, the researcher implemented a series of instructional classes using PhET simulations as the primary teaching tool in electromagnetism for the experimental group. The intervention was conducted over a specified period and integrated interactive simulations to support concept visualization, exploration, and student engagement. After the completion of the intervention, a posttest was administered to measure any changes in students’ academic achievement. Likewise, a post-motivation survey was administered to determine any improvement in students’ level of motivation as a result of the PhET simulation-assisted instruction. The pretest and posttest results for academic achievement, as well as the motivation survey responses, were then collected, tabulated, and analyzed to evaluate the effectiveness of the intervention.

Implementation of Physics Education Technology (PhET)

Simulation Assisted Instruction

The ASSURE learning cycle model was adapted to implement the Physics Education Technology (PhET) Simulation Assisted Instruction as the intervention. Gagne described this model in the book instructional media and technologies for learning as a model that can pique students' interests through a hands-on experience and ensures that they are fully involved through various engagement processes (Olayinka et al., 2018). Moreover, according to Hassan (2014), the model is highly good for any teaching plan, especially if the concept of retentive learning is strongly emphasized (Utama et al., 2022). This model consisted of a six-step instructional system design process imbedded with the Physics Education Technology (PhET) Simulation Assisted Instruction.

Analyze Learners. A pre-test was done in this part during the first day of the conduct. In the subsequent meetings, students' prior knowledge of the new topic and what they have learned in the previous lesson was assessed in this part through questioning.

State Standards and Objectives. The lesson's learning objectives were presented in the class on what they expected to achieve at the end of the lessons. The identified content standard was also presented, along with the conditions that they are going to meet.

Select Strategies, Technology, Media, and Materials. Linking modality to the lesson's learning objectives is in this part. Modality decisions offer the greatest opportunities for success. In this part, the researcher selected PhET simulations that suits the learning content and objectives. The PhET simulation-assisted instruction utilized a range of interactive simulations designed to support students' conceptual understanding of electricity and magnetism. These simulations included Balloons and Static Electricity, John Travoltage, Battery-Resistor Circuit, Capacitor Lab: Basics, Charges and Fields, Circuit Construction Kit: AC, Coulomb's Law, Ohm's Law, Resistance in a Wire, Faraday's Electromagnetic Lab, Faraday's Law, Generator, Magnet and Compass, Magnets and Electromagnets, Magnetism, and simulations illustrating the relationship between electricity and magnetism. Additionally, structured activities such as Resistor Networks and Kirchhoff's Rules, Experiments with Bar Magnets and Electromagnets, and the inquiry-based Induction (College Homework Version) were incorporated. These simulations were selected to align with the Electromagnetism topics covered in the course and were employed to promote active learning through visualization, manipulation of variables, and guided exploration of abstract concepts.

Utilize Technology, Media, and Materials. This part maximizes the use of PhET simulations as instructional technologies. PhET simulations mentioned in the previous phase are employed as the primary intervention to provide interactive, inquiry-based visualizations of abstract scientific concepts, allowing students to manipulate variables and observe real-time outcomes. Through guided exploration and structured tasks, the simulations support conceptual understanding, promote active engagement, and enable students to construct knowledge through virtual experimentation that would otherwise be difficult to achieve using traditional instructional materials alone.

Require Learner Participation. This makes the learning process active and engaging. Students and teachers take time to engage ideas, correct misconceptions, and clear out clarifications in an inquiry manner, and this is also where the approaches were implemented, which addressed the students conceptual understanding and motivation in electromagnetism.

Evaluate and Revise. This phase involved administering a post-test after the final meeting or discussion of the lesson to measure students' learning gains. During regular instructional meetings, evaluation focused on determining the extent to which the learning objectives were achieved, as well as assessing students' motivation and conceptual understanding of electromagnetism. The results of these evaluations were used to identify areas for instructional improvement and to refine subsequent lessons to better support student learning.

Statistical Techniques

This study utilized descriptive and inferential statistics to summarize and interpret the data gathered from the respondents. Specifically, frequency, percentage, and mean were computed to describe students' levels of academic achievement, while the mean was used to describe students' levels of motivation. The study employed Analysis of Covariance (ANCOVA) to determine the significant difference in academic achievement between students exposed to PhET simulation-assisted instruction and those exposed to non-PhET simulation-assisted instruction, controlling for pretest scores. Furthermore, an independent samples t-test was employed to ascertain the significant difference in students' motivation between those exposed to PhET simulation-assisted instruction and those exposed to non-PhET simulation-assisted instruction.

Presentation, Analysis, And Interpretation Of Data

This chapter contains the presentation, analysis, and interpretation of data gathered on the Physics Education Technology (*PhET*) Simulation Assisted Instruction Towards Students' Academic Achievement and Motivation in Electromagnetism. The order of presentation is based on the order of specific objectives of the study.

Level of Academic Achievement of students when exposed to

PhET and Non-PhET

Tables 1 and 2 show the students' academic achievement before and after exposure to Physics Education Technology (*PhET*) Simulation Assisted Instruction and those exposed to non-PhET through pretest and post test, respectively. The level of academic achievement was shown through frequency distribution and statistical analysis of students' percentage scores.

Table 1. Academic achievement of students in their pretest in electromagnetism.

| Grade | PhET (<i>n</i> =38) | | | Non-PhET (<i>n</i> =42) | | |
|-------------|----------------------|-------|----------------------------|--------------------------|-------|----------------------------|
| | Pretest | | | Pretest | | |
| | f | % | Qualitative Interpretation | f | % | Qualitative Interpretation |
| 1.00 - 1.25 | 0 | 0 | Excellent | 0 | 0 | Excellent |
| 1.50 - 1.75 | 0 | 0 | Very good | 0 | 0 | Very good |
| 2.00 - 2.25 | 0 | 0 | Good | 0 | 0 | Good |
| 2.50 - 3.00 | 5 | 13.10 | Satisfactory | 11 | 26.20 | Satisfactory |
| 5.00 | 33 | 86.90 | Failure | 31 | 73.80 | Failure |
| Total | 38 | 100 | | 42 | 100 | |

Legend:

| Grade | Percentage Equivalent | Qualitative Interpretation |
|-------------|-----------------------|----------------------------|
| 1.00 - 1.25 | 88 - 100 | Excellent |
| 1.50 - 1.75 | 76 - 87 | Very good |
| 2.00 - 2.25 | 64 - 75 | Good |
| 2.50 - 3.00 | 50 - 63 | Satisfactory |
| 5.00 | 49 below | Failure |

Table 1 presents the academic achievement of students in electromagnetism prior to the intervention, comparing those assigned to the PhET group and the Non-PhET group. The results show that in the PhET group, the highest frequency was recorded under the grade 5.00 (Failure) with 33 students (86.9%), while the lowest frequencies were observed in the Excellent (1.00–1.25), Very Good (1.50–1.75), and Good (2.00–2.25) categories, all registering zero respondents. Similarly, in the Non-PhET group, the highest percentage also fell under the Failure category with 31 students (73.80%), while no students were classified as Excellent, Very Good, or Good. Both groups showed limited representation in the Satisfactory range, indicating generally low performance prior to instruction.

The dominance of the Failure category in both the PhET and Non-PhET groups indicates that students entered the study with very weak prior knowledge of electromagnetism. The absence of students in the higher achievement categories suggests that electromagnetism concepts were largely unfamiliar or poorly understood

before formal instruction. Although both groups exhibited nearly the same academic standing, the slightly higher failure rate in the PhET group implies that the two groups were comparable and statistically appropriate for the experimental design. This baseline similarity strengthens the validity of any post-test improvements, as changes in achievement can be more confidently attributed to the instructional intervention rather than pre-existing differences.

The findings imply an urgent need for instructional strategies that can address students’ initial learning gaps in electromagnetism. The overwhelmingly low pre-test performance highlights the abstract and cognitively demanding nature of the subject, which may be difficult for students to grasp through traditional lecture-based approaches alone. These results justify the integration of innovative and technology-assisted instructional tools, such as PhET simulations, to support conceptual understanding before students advance to more complex applications. Establishing this weak baseline further emphasizes the potential impact of the intervention in transforming students’ learning outcomes after exposure to interactive and inquiry-based instruction.

The low academic achievement observed in the pretest is consistent with findings which emphasize that physics particularly electromagnetism is one of the most difficult science domains for students due to its abstract nature and heavy cognitive demands (Chi, 2023). International assessment data further support this result, as the Programme for International Student Assessment (PISA) revealed that Filipino learners ranked near the bottom in science achievement, with persistent difficulties in understanding fundamental concepts and applying scientific reasoning (OECD, 2023). Banda and Nzabahimana (2023) and Mutende (2025) also discussed students’ weak prior performance to resource-related constraints, such as limited laboratory facilities and reliance on traditional lecture-based instruction, which restrict opportunities for hands-on conceptual exploration. These documented challenges help explain the predominance of failing pre-test scores in both groups and reinforce the rationale for introducing technology-assisted instructional strategies, such as PhET simulations, to address gaps in students’ foundational understanding.

Table 2. Academic achievement of students in their post test in electromagnetism.

| Grade | PhET (n=38) | | | Non-PhET (n=42) | | |
|-------------|-------------|-------|----------------------------|-----------------|-------|----------------------------|
| | Post Test | | | Post Test | | |
| | f | % | Qualitative Interpretation | f | % | Qualitative Interpretation |
| 1.00 - 1.25 | 0 | 0 | Excellent | 0 | 0 | Excellent |
| 1.50 - 1.75 | 20 | 52.70 | Very good | 0 | 0 | Very good |
| 2.00 - 2.25 | 18 | 47.40 | Good | 5 | 11.90 | Good |
| 2.50 - 3.00 | 0 | 0 | Satisfactory | 37 | 88.10 | Satisfactory |
| 5.00 | 0 | 0 | Failure | 0 | 0 | Failure |
| Total | 38 | 100 | | 42 | 100 | |

Legend:

| Grade | Percentage Equivalent | Qualitative Interpretation |
|-------------|-----------------------|----------------------------|
| 1.00 - 1.25 | 88 - 100 | Excellent |
| 1.50 - 1.75 | 76 - 87 | Very good |

| | | |
|-------------|----------|--------------|
| 2.00 - 2.25 | 64 -75 | Good |
| 2.50 - 3.00 | 50 -63 | Satisfactory |
| 5.00 | 49 below | Failure |

Table 2 presents the post-test academic achievement of students in electromagnetism after the implementation of PhET-assisted instruction and traditional non-PhET instruction. In the PhET group, the highest frequency was recorded in the Very Good (1.50–1.75) category with 20 students (52.70%), followed by Good (2.00–2.25) with 18 students (47.40%). Notably, no students in the PhET group fell under the Satisfactory or Failure categories. In contrast, the Non-PhET group registered its highest frequency in the Satisfactory (2.50–3.00) category with 37 students (88.10%), while only 5 students (11.90%) achieved the Good level. None of the students in the Non-PhET group reached the Very Good or Excellent categories, and no failing marks were recorded in either group.

The post test results reveal a marked improvement in academic achievement for both groups compared with their pretest performance; however, the extent of improvement differed substantially. Students exposed to PhET-assisted instruction demonstrated higher levels of mastery, as evidenced by the concentration of scores in the Very Good and Good categories. This indicates a stronger conceptual understanding of electromagnetism, likely facilitated by the interactive and visual affordances of the simulations. Conversely, while the Non-PhET group showed progress by eliminating failing scores, most students remained at the Satisfactory level, suggesting surface-level understanding rather than conceptual mastery. The absence of high-achieving categories in the Non-PhET group highlights the limited effectiveness of traditional instruction when dealing with abstract physics concepts.

These findings imply that PhET simulations are a more effective instructional tool for enhancing students’ academic achievement in electromagnetism compared with conventional teaching methods alone. The shift of PhET students from predominantly failing pretest scores to high post-test achievement levels underscores the capacity of simulation-assisted instruction to promote deeper understanding and meaningful learning. For physics educators, this suggests the need to integrate interactive simulations into instruction, particularly in resource-constrained settings where physical laboratory activities are limited. Moreover, the results indicate that while traditional instruction may prevent failure, it may not be sufficient to elevate students to higher levels of academic performance without the support of technology-enhanced learning strategies.

The superior post test performance of the PhET group is supported by several studies is consistent to the study of Fadillah et al. (2026) who reported that PhET simulations significantly improve students’ academic achievement in physics, especially in abstract topics such as electricity and magnetism. This is also supported by the study of Pranata (2024) found that students exposed to PhET simulations achieved higher post-instruction scores due to the opportunity to manipulate variables and visualize physical phenomena, leading to improved conceptual understanding. Similarly, Dy et al. (2024) reported substantial gains in students’ physics achievement in Philippine classrooms following the integration of PhET simulations. These studies corroborate the present results, explaining the concentration of higher achievement levels among students taught using PhET-assisted instruction.

Motivation of Students in Electromagnetism when exposed to

PhET and Non-PhET

This section presents the level of motivation in Electromagnetism when students are exposed to PhET and Non-PhET. The level of motivation was shown in Table 3 through a statistical analysis of students’ mean scores with corresponding qualitative interpretation.

Table 3 presents the level of intrinsic motivation of students exposed to PhET-assisted instruction and those taught using non-PhET methods. In the PhET group, the highest mean was obtained by the item “I enjoy discussing Electromagnetism topics with others” with a mean of 3.08, interpreted as Motivated. The lowest mean for the same group was 2.84, corresponding to the statement “I enjoy reading and learning materials related to

electricity, magnetism, and fields,” which nonetheless remained within the Motivated category. For the Non-PhET group, the highest mean recorded was 2.50 for “I enjoy discussing Electromagnetism topics with others,” while the lowest mean was 2.43 for “I like sharing new things I learn about Electromagnetism,” both qualitatively interpreted as Less Motivated. Overall, the PhET group registered a higher intrinsic motivation mean (2.99 – Motivated) compared to the Non-PhET group (2.47 – Less Motivated).

Table 3. Mean scores of intrinsic motivation of students when exposed to PhET and non-PhET.

| Intrinsic Motivation | PhET | | Non-PhET | |
|---|------|----------------------------|----------|----------------------------|
| | Mean | Qualitative Interpretation | Mean | Qualitative Interpretation |
| I enjoy discussing Electromagnetism topics with others. | 3.08 | Motivated | 2.50 | Less Motivated |
| I enjoy studying Electromagnetism and its concepts. | 3.03 | Motivated | 2.48 | Less Motivated |
| I am genuinely interested in learning Electromagnetism during class activities. | 3.03 | Motivated | 2.48 | Less Motivated |
| I like sharing new things I learn about Electromagnetism. | 2.97 | Motivated | 2.43 | Less Motivated |
| I enjoy reading and learning materials related to electricity, magnetism, and fields. | 2.84 | Motivated | 2.45 | Less Motivated |
| Overall Mean | 2.99 | Motivated | 2.47 | Less Motivated |

Legend:

| Range | Descriptive Rating | Qualitative Interpretation |
|-------------|------------------------|----------------------------|
| 3.26 – 4.00 | Strongly Agree (SA) | Highly Motivated |
| 2.51 – 3.25 | Agree (A) | Motivated |
| 1.76 – 2.50 | Disagree (D) | Less Motivated |
| 1.00 – 1.75 | Strongly Disagree (SD) | Not Motivated |

The results indicate that students exposed to PhET-assisted instruction demonstrated stronger intrinsic motivation than those taught through non-PhET methods. The highest mean in the PhET group suggests that simulation-based instruction effectively promotes enjoyment in discussing and exploring electromagnetism concepts, likely due to its interactive and learner-centered design. The lowest mean, related to reading materials, implies that while students remain motivated, PhET activities may shift learning preferences toward exploratory and discussion-based engagement rather than traditional text-based learning. In contrast, the Non-PhET group exhibited consistently lower mean scores, reflecting limited intrinsic interest and enjoyment in learning electromagnetism, which may stem from reliance on conventional instructional approaches that offer fewer opportunities for active engagement with abstract concepts.

These findings imply that PhET simulations can significantly enhance students’ intrinsic motivation by fostering interest, enjoyment, and active participation in learning electromagnetism. The consistent “Motivated” ratings across all intrinsic motivation indicators in the PhET group suggest that simulation-assisted instruction supports

curiosity-driven learning and sustained engagement. For educators, this highlights the importance of integrating interactive technologies to create learning environments that stimulate students’ internal desire to learn, especially in conceptually demanding subjects such as physics. However, the relatively lower mean in items related to independent reading also suggests the need for balanced instructional strategies that integrate PhET simulations with structured academic reading to strengthen comprehensive learning habits.

The higher intrinsic motivation observed among students exposed to PhET-assisted instruction is supported by Urhahne and Wijnia (2023) that intrinsic motivation is strengthened when learners experience autonomy, competence, and meaningful engagement conditions strongly aligned with the design of PhET simulations. Pranata (2024) also reported that the interactive and game-like features of PhET simulations increase students’ enjoyment and interest in learning physics concepts, particularly by encouraging active exploration and discussion. Similarly, Qian (2024) found that students involved in PhET-supported instruction demonstrated increased interest and self-efficacy, contributing to higher intrinsic motivation. These findings are further reinforced by studies emphasizing that technology-enhanced, inquiry-based learning environments promote deeper engagement and enjoyment in science learning, thereby explaining the higher intrinsic motivation levels recorded in the PhET group compared to the Non-PhET group (Alonso et al., 2023; Ishida & Sekiyama, 2024).

Table 4 presents the mean scores of students’ amotivation when exposed to PhET and non-PhET instruction. The results show that students in the PhET group obtained an overall mean of 3.05, while those in the non-PhET group obtained a lower overall mean of 2.32. These findings indicate a difference in the level of amotivation between the two groups. Anchored in Self-Determination Theory (Deci & Ryan, 2000), amotivation represents a negative motivational state, characterized by a lack of purpose, uncertain value, and weak personal reasons for engaging in learning tasks. Accordingly, higher mean scores indicate higher levels of amotivation, reflecting less favorable motivational conditions, while lower mean scores indicate reduced amotivation.

Table 4. Mean scores of amotivation of students when exposed to PhET and non-PhET.

| Amotivation | PhET | | Non-PhET | |
|---|------|----------------------------|----------|----------------------------|
| | Mean | Qualitative Interpretation | Mean | Qualitative Interpretation |
| I am unsure about the future benefits of learning Electromagnetism.* | 2.40 | Motivated | 3.21 | Less Motivated |
| I do not clearly understand why I need to study Electromagnetism.* | 2.33 | Motivated | 3.16 | Less Motivated |
| I participate in Electromagnetism learning activities without a clear sense of purpose. | 2.33 | Motivated | 2.97 | Less Motivated |
| I am unsure about the usefulness of the new Electromagnetism concepts I learn.* | 2.29 | Motivated | 2.95 | Less Motivated |
| I do not feel strong personal reasons to study Electromagnetism.* | 2.24 | Motivated | 2.95 | Less Motivated |
| Overall Mean | 2.32 | Motivated | 3.05 | Less Motivated |

Legend: (* for reverse scoring)

| Range | Descriptive Rating | Qualitative Interpretation |
|-------------|---------------------|----------------------------|
| 3.26 – 4.00 | Strongly Agree (SA) | Not Motivated |

| | | |
|-------------|------------------------|------------------|
| 2.51 – 3.25 | Agree (A) | Less Motivated |
| 1.76 – 2.50 | Disagree (D) | Motivated |
| 1.00 – 1.75 | Strongly Disagree (SD) | Highly Motivated |

Table 4 presents the mean scores of students’ amotivation when exposed to PhET and non-PhET instruction. Results indicate that students in the PhET group obtained an overall mean of 2.32, which was qualitatively interpreted as Motivated, while students in the non-PhET group obtained a higher overall mean of 3.05, interpreted as Less Motivated. Across all amotivation indicators, the PhET group consistently registered lower mean scores than the non-PhET group, suggesting more favorable motivational conditions among students exposed to PhET simulation-assisted instruction.

Based on the qualitative interpretation used in the study, the PhET group’s overall mean falling within the Motivated range indicates that students generally disagreed with amotivation-related statements, such as uncertainty about the usefulness, purpose, and future relevance of Electromagnetism. In contrast, the non-PhET group’s higher overall mean, interpreted as Less Motivated, suggests greater agreement with amotivation-related statements. This pattern indicates that students who experienced traditional instruction were more likely to feel uncertain about the value and purpose of learning Electromagnetism. The consistent difference across all indicators highlights that students exposed to PhET simulations exhibited lower levels of amotivation and stronger motivational orientation compared to their non-PhET counterparts.

The results imply that PhET simulation-assisted instruction is effective in reducing students’ amotivation and promoting motivation in learning Electromagnetism. The interactive and visual nature of PhET simulations may help students better understand abstract concepts, thereby strengthening their sense of purpose and perceived value of learning physics. Consequently, students exposed to PhET simulations were more motivated and less likely to experience uncertainty regarding why they needed to study Electromagnetism. For instructional practice, these findings suggest that integrating PhET simulations into physics instruction can serve as an effective strategy for addressing motivational challenges, particularly in abstract and conceptually demanding topics. However, to further enhance motivational outcomes, simulation-based instruction should be complemented with clear learning objectives and guided discussions that explicitly connect simulation activities to real-world applications and future relevance.

The observed patterns of amotivation are supported by Ishida and Sekiyama (2024) which emphasize that amotivation is closely linked to learners’ perceptions of purpose, relevance, and self-beliefs in academic tasks. Research indicates that when students are placed in active, inquiry-based environments, such as those facilitated by PhET simulations, they become more cognitively engaged and reflective, which can surface feelings related to uncertainty, usefulness, and goal clarity (Alahmari, 2024). Patierez (2024) similarly reported that students exposed to more demanding and interactive learning environments demonstrate increased awareness of their motivational states, including amotivation, as they reflect on their academic purpose and expectations. These findings help explain why students in the PhET group expressed lower amotivation means while remaining actively involved in learning, compared with students in more passive, non-PhET instructional settings.

Table 5 presents the level of extrinsic-career motivation of students exposed to PhET-assisted instruction and those taught using non-PhET methods. In the PhET group, the highest mean was recorded for the statement “I know the opportunities available in fields that require knowledge of Electromagnetism” with a mean of 3.03, interpreted as Motivated.

The lowest mean obtained was 2.84 for the item “I am aware of future job opportunities that require an understanding of Electromagnetism,” which is likewise interpreted as Motivated. In contrast, the Non-PhET group posted its highest mean at 2.57 for the same item related to awareness of job opportunities, while the lowest mean of 2.31 was recorded for the statements “I understand how Electromagnetism is connected to future careers” and “I recognize the importance of applying Electromagnetism to real-world professions,” all interpreted as Less Motivated. Overall, the PhET group achieved a higher extrinsic-career motivation mean (2.94 – Motivated) than the Non-PhET group (2.41 – Less Motivated).

Table 5. Mean scores of extrinsic-career motivation of students when exposed to PhET and non-PhET.

| Extrinsic-Career Motivation | PhET | | Non-PhET | |
|--|------|----------------------------|----------|----------------------------|
| | Mean | Qualitative Interpretation | Mean | Qualitative Interpretation |
| I know the opportunities available in fields that require knowledge of Electromagnetism. | 3.03 | Motivated | 2.36 | Less Motivated |
| I understand how Electromagnetism is connected to future careers in science, engineering, or technology. | 3.00 | Motivated | 2.31 | Less Motivated |
| I understand how Electromagnetism relates to my chosen academic track or specialization. | 2.95 | Motivated | 2.50 | Less Motivated |
| I recognize the importance of applying Electromagnetism to real-world professions. | 2.89 | Motivated | 2.31 | Less Motivated |
| I am aware of future job opportunities that require an understanding of Electromagnetism. | 2.84 | Motivated | 2.57 | Motivated |
| Overall Mean | 2.94 | Motivated | 2.41 | Less Motivated |

Legend:

| Scale | Range | Descriptive Rating | Qualitative Interpretation |
|-------|-------------|------------------------|----------------------------|
| 4 | 3.26 – 4.00 | Strongly Agree (SA) | Highly Motivated |
| 3 | 2.51 – 3.25 | Agree (A) | Motivated |
| 2 | 1.76 – 2.50 | Disagree (D) | Less Motivated |
| 1 | 1.00 – 1.75 | Strongly Disagree (SD) | Not Motivated |

The results indicate that students exposed to PhET-assisted instruction exhibited stronger career-related motivation than those taught through non-PhET methods. The highest mean in the PhET group suggests that simulation-based learning helped students better recognize the relevance of electromagnetism to future career opportunities, likely due to the real-world representations and applied contexts embedded in the simulations. The slightly lower mean for job awareness may suggest that while students understand the importance of electromagnetism conceptually, explicit discussions linking simulations to specific professions may further strengthen career clarity. Conversely, the uniformly lower means in the Non-PhET group indicate limited awareness of how electromagnetism connects to future careers, suggesting that traditional instruction may insufficiently emphasize real-world and career-oriented applications of physics concepts.

These findings imply that PhET simulations are effective in enhancing students' extrinsic-career motivation by making learning more relevant to future academic and professional goals. For educators, this highlights the importance of integrating simulation-based instruction with explicit career-focused discussions to help students connect scientific concepts with real-world professions. Strengthening this connection may encourage persistence in STEM pathways and support informed career planning. Meanwhile, the lower motivation levels among Non-PhET students suggest that without engaging, applied instructional strategies, learners may struggle to perceive the long-term value of learning abstract physics topics such as electromagnetism.

The higher extrinsic-career motivation observed among PhET-exposed students is supported Floris et al. (2024) which emphasized that learners are more motivated when they clearly perceive the connection between academic content and future career opportunities, as this awareness strengthens effort regulation and academic persistence. Similarly, Masliyenko and de Sousa Reis (2023) noted that instructional environments that explicitly link coursework to professional applications enhance students’ motivation and career decisiveness. Banda and Nzabahimana (2023) and Dy et al. (2024) further explain that interactive and contextualized learning tools, such as PhET simulations, help students visualize how scientific knowledge applies to real-world professions, thereby increasing career-oriented motivation. These findings support the present results, explaining why students in the PhET group demonstrated stronger extrinsic-career motivation compared to those taught using traditional instructional methods.

Table 6 presents the mean scores of students’ social-extrinsic motivation in electromagnetism when exposed to PhET-assisted instruction and non-PhET instruction.

Table 6. Mean scores of social-extrinsic motivation of students when exposed to PhET and non-PhET.

| Social-Extrinsic Motivation | PhET | | Non-PhET | |
|--|------|----------------------------|----------|----------------------------|
| | Mean | Qualitative Interpretation | Mean | Qualitative Interpretation |
| I want to establish a good position in the community by excelling in Electromagnetism. | 3.05 | Motivated | 2.45 | Less Motivated |
| I want to succeed in learning Electromagnetism to prove something to myself. | 3.00 | Motivated | 2.31 | Less Motivated |
| I want to do well in Electromagnetism to make my family proud. | 3.00 | Motivated | 2.40 | Less Motivated |
| I want to show my classmates that I am capable of understanding Electromagnetism. | 2.95 | Motivated | 2.26 | Less Motivated |
| I want my knowledge of Electromagnetism to have a positive influence on my surroundings. | 2.95 | Motivated | 2.50 | Less Motivated |
| Overall Mean | 2.99 | Motivated | 2.39 | Less Motivated |

Legend:

| Scale | Range | Descriptive Rating | Qualitative Interpretation |
|-------|-------------|------------------------|----------------------------|
| 4 | 3.26 – 4.00 | Strongly Agree (SA) | Highly Motivated |
| 3 | 2.51 – 3.25 | Agree (A) | Motivated |
| 2 | 1.76 – 2.50 | Disagree (D) | Less Motivated |
| 1 | 1.00 – 1.75 | Strongly Disagree (SD) | Not Motivated |

For the PhET-exposed students, all five indicators registered motivated responses. The highest mean score (M = 3.05) was recorded for the statement “I want to establish a good position in the community by excelling in Electromagnetism,” suggesting that students perceived success in the subject as socially meaningful and valued. Likewise, motivated responses were observed in students’ desire to succeed in learning electromagnetism to prove personal capability (M = 3.00), make their families proud (M = 3.00), and demonstrate competence to

classmates ($M = 2.95$). In contrast, the non-PhET group consistently demonstrated lower mean scores across all indicators, all of which were qualitatively interpreted as Less Motivated. Mean values ranging from 2.26 to 2.50 suggest that students exposed to traditional instruction were less inclined to associate learning electromagnetism with social recognition, peer affirmation, or positive social impact.

These results indicate that PhET simulation-assisted instruction strengthened students’ awareness of the social value of learning electromagnetism and encouraged effort that is reinforced by social affirmation and recognition. While the findings for non-PhET implies that non-interactive instructional approaches may limit opportunities for students to express competence, build confidence, and perceive learning as socially rewarding. The implications of these findings suggest that PhET simulations, when embedded within supportive social and instructional environments, can effectively leverage peer norms, teacher influence, and social support systems to promote socially driven motivation. Thus, beyond improving conceptual understanding, PhET simulations serve as a pedagogical tool that channels social-extrinsic motivational drivers toward sustained engagement and improved learning outcomes in electromagnetism.

This aligns with Adie et al. (2024), who highlighted that peer-created learning climates significantly influence externally regulated motivation, particularly in environments where participation and performance are socially visible. Through collaborative PhET activities, students are likely motivated to contribute, demonstrate competence, and maintain social standing among peers—mechanisms that strengthen social-extrinsic motivation. Consistent with Wentzel’s (2023) assertion that teacher–student and peer relationships shape academic striving, the interactive and teacher-facilitated nature of PhET simulations may have heightened students’ desire to meet expectations and gain positive feedback. Furthermore, the visibility of learning progress during simulation-based tasks supports the findings of Shao et al. (2024), who found that positive peer relationships and socially engaging instructional settings enhance motivation through increased engagement and confidence.

Table 7 summarizes the motivation levels of students in electromagnetism across four motivational constructs— intrinsic motivation, amotivation, extrinsic–career motivation, and social–extrinsic motivation—for both PhET and Non-PhET groups.

Table 7. Summary of the mean scores of students’ motivation in electromagnetism in PhET and Non-PhET groups.

| Motivation | PhET | | Non-PhET | |
|-----------------------------|------|----------------------------|----------|----------------------------|
| | Mean | Qualitative Interpretation | Mean | Qualitative Interpretation |
| Intrinsic motivation | 2.99 | Motivated | 2.47 | Less Motivated |
| Amotivation | 3.05 | Motivated | 2.32 | Less Motivated |
| Extrinsic–career motivation | 2.94 | Motivated | 2.41 | Less Motivated |
| Social–extrinsic motivation | 2.99 | Motivated | 2.39 | Less Motivated |
| Overall Mean | 2.72 | Motivated | 2.49 | Less Motivated |

Legend:

| Scale | Range | Descriptive Rating | Qualitative Interpretation |
|-------|-------------|---------------------|----------------------------|
| 4 | 3.26 – 4.00 | Strongly Agree (SA) | Highly Motivated |
| 3 | 2.51 – 3.25 | Agree (A) | Motivated |

| | | | |
|---|-------------|------------------------|----------------|
| 2 | 1.76 – 2.50 | Disagree (D) | Less Motivated |
| 1 | 1.00 – 1.75 | Strongly Disagree (SD) | Not Motivated |

Among the PhET group, the highest mean was recorded in amotivation (3.05), followed by intrinsic motivation and social–extrinsic motivation (2.99), while the lowest mean was observed in extrinsic–career motivation (2.94); all were qualitatively interpreted as Motivated. In contrast, the Non-PhET group posted its highest mean in intrinsic motivation (2.47), followed by extrinsic–career motivation (2.41), with the lowest mean recorded in amotivation (2.32); all dimensions were interpreted as Less Motivated. Overall, the PhET group achieved a higher overall motivation mean (2.72 – Motivated) compared with the Non-PhET group (2.49 – Less Motivated).

The summary results indicate that students exposed to PhET-assisted instruction demonstrated consistently higher motivation levels across all dimensions compared to their Non-PhET counterparts. The highest mean in the PhET group being observed in amotivation suggests increased learner awareness and reflection regarding the purpose and value of learning tasks, which often accompanies deeper cognitive engagement. Meanwhile, strong intrinsic and social–extrinsic motivation scores indicate that PhET simulations effectively foster enjoyment, interest, and socially driven engagement in learning electromagnetism. In contrast, the uniformly lower motivation means across all constructs in the Non-PhET group suggest a more passive learning experience, with limited stimulation of students’ internal interest, career awareness, and social engagement in physics learning.

These findings imply that PhET-assisted instruction is effective not only in enhancing academic achievement but also in strengthening multiple dimensions of student motivation. The consistently “Motivated” ratings across the PhET group highlight the capacity of simulation-based instruction to engage students cognitively, socially, and goal-orientedly. For educators, this underscores the importance of adopting interactive and technology-enhanced instructional strategies to address motivational challenges in abstract subjects such as electromagnetism. Moreover, the results suggest that instructional interventions should intentionally guide students in connecting their heightened engagement to clear academic goals and future relevance, ensuring that increased motivation translates into sustained learning and performance gains.

The overall higher motivation levels observed among students exposed to PhET-assisted instruction are supported by Wentzel (2023) which highlighted that positive teacher–student and peer relationships significantly influence students’ academic engagement, motivation, and willingness to exert effort in challenging subjects. Similarly, Adie et al. (2024) found that peer-created learning climates foster autonomy-supportive and participatory environments, which enhance students’ motivation through social interaction and shared learning experiences. Shao et al. (2024) further emphasized that peer influence plays a vital role in sustaining motivation, as learners are often driven to engage and perform when learning activities are collaborative and socially visible. In addition, Cho (2023) stressed that social support from classmates and teachers strengthens students’ emotional and academic motivation, particularly in demanding learning contexts. These studies collectively support the present findings, explaining why students in the PhET group who frequently engaged in interactive, collaborative, and feedback-rich simulation activities demonstrated higher overall motivation compared to those in the Non-PhET group.

The significant difference in academic achievement when students are exposed to PhET and Non-PhET

Table 8 shows the results of the significance of the difference in the academic performance of the two (2) groups, PhET and Non-PhET, using Analysis of Covariance (ANCOVA). The pretest was used as a covariate to equate different predictive variables, affecting the analysis statistically.

Table 8. Test of significant difference in the academic achievement when students are exposed to PhET from those in Non-PhET.

| GROUP | N | Mean | Standard Deviation |
|-------|----|-------|--------------------|
| PhET | 38 | 45.74 | 2.96 |

| | | | | | |
|-----------------|-------------------------|----|-------------|----------|------|
| Non-PhET | | 42 | 35.36 | 2.50 | |
| Total | | 80 | 40.29 | 5.88 | |
| Source | Type III Sum of Squares | df | Mean Square | F | Sig. |
| Corrected Model | 2714.594 ^a | 2 | 1357.30 | 7577.04 | .000 |
| Intercept | 60.436 | 1 | 60.44 | 337.38 | .000 |
| PRETEST | 565.218 | 1 | 565.22 | 3155.30 | .000 |
| GROUP | 2484.207 | 1 | 2484.21 | 13867.96 | .000 |
| Error | 13.793 | 77 | .179 | | |
| Total | 132575.000 | 80 | | | |
| Corrected Total | 2728.388 | 79 | | | |

a. R Squared = .995 (Adjusted R Squared = .995)

**p=<0.01

Table 8 presents the results of the analysis of covariance (ANCOVA) comparing the post-test academic achievement of students in electromagnetism between the PhET and Non-PhET groups. The PhET group obtained a higher adjusted mean score (M = 45.74) compared to the Non-PhET group (M = 35.36). The analysis revealed a statistically significant difference between the two groups, with the group effect yielding an F-value of 13867.958 and a significance level of $p < 0.01$, indicating a highly significant result. These findings suggest that the instructional method had a substantial effect on students' post-test academic achievement.

The statistically significant group effect indicates that students exposed to PhET-assisted instruction performed significantly better in electromagnetism than those taught using traditional non-PhET methods, even after controlling for differences in pretest performance. This confirms that while both groups started with comparably low pretest scores, the PhET group gained greater academic improvement following the intervention. The result underscores the effectiveness of simulation-assisted instruction in facilitating deeper conceptual understanding of abstract electromagnetism concepts.

These findings imply that PhET simulations significantly enhance students' academic achievement in electromagnetism and can serve as a powerful instructional alternative to traditional teaching approaches. For physics instructors, this suggests that integrating interactive simulations into classroom instruction can lead to measurable learning gains, particularly in conceptually difficult topics. The results further imply that educational institutions especially those with limited laboratory resources may adopt PhET simulations as a cost-effective and pedagogically sound strategy for improving students' learning outcomes. At the policy level, the findings support the inclusion of technology-assisted learning tools in science curricula to help address persistent achievement gaps in physics education.

The significant difference in academic achievement favoring the PhET group is strongly supported by Fadillah et al. (2026), in their meta-analysis of 20 empirical studies, reported a large effect size for PhET-enhanced instruction, particularly in abstract topics such as electricity and magnetism. Similarly, Pranata (2024) found that students who learned physics concepts through PhET simulations achieved significantly higher post-test scores due to improved visualization and interactive manipulation of variables. Philippine-based studies further corroborate this finding, as Dy et al. (2024) reported substantial improvements in students' physics performance following the integration of PhET simulations in classroom instruction. These empirical findings align with the present results, confirming that PhET-assisted instruction exerts a significant positive effect on students' academic achievement in electromagnetism.

The significant difference in motivation when students are exposed to

PhET and Non-PhET

Table 9 shows the results of the significance of the difference in the motivation of the two (2) groups, ILE & non-ILE. The test result indicated an overall post test mean score from the PhET of 3.4128 (SD = .123) and the non-PhET group 3.3520 (SD = .130) with a p-value of <.001. Hence, the null hypothesis failed to be accepted. This means that there is significant difference exists in the motivation between students exposed to PhET and those in non-PhET.

Table 9. Test of significant difference in the motivation when students are exposed to PhET from those in Non-PhET.

| Group | N | Mean | Standard Deviation | t-value | p-value |
|----------|----|------|--------------------|---------|---------|
| PhET | 42 | 2.72 | 0.123 | -8.22 | <.001 |
| Non-PhET | 38 | 2.49 | 0.130 | | |

Table 9 presents the results of the test of significant difference in the students’ motivation in electromagnetism between those exposed to PhET-assisted instruction and those taught using non-PhET methods. Based on the computed overall motivation means, students in the PhET group obtained a higher mean score (M = 2.72, SD = 0.123) than those in the Non-PhET group (M = 2.49, SD = 0.130). The analysis revealed a statistically significant difference in motivation between the two groups at the specified level of significance, indicating that the instructional approach contributed to the observed variation in students’ motivation.

The significant difference in motivation suggests that students who experienced PhET-assisted instruction were more motivated in learning electromagnetism compared with those taught through traditional methods. This finding confirms that the higher motivation levels observed in the PhET group across intrinsic, extrinsic-career, social-extrinsic motivation, and amotivation dimensions were not due to chance. The result indicates that simulation-assisted instruction creates a more engaging and supportive learning environment that positively influences students’ motivational orientation toward a challenging and abstract physics topic.

These findings imply that PhET simulations are not only effective in improving academic achievement but also play a crucial role in enhancing students’ motivation in learning electromagnetism. For teachers, the results highlight the importance of integrating interactive and technology-enhanced instructional strategies to foster greater student engagement, interest, and persistence in physics learning. From an institutional perspective, the findings support the adoption of PhET simulations as a practical intervention to address motivational issues in science classrooms, particularly in contexts where traditional instruction may fail to sustain students’ interest and effort.

The significant difference in motivation in favor of the PhET group is supported by Wentzel (2023) which explained that positive teacher–student and peer relationships enhance students’ engagement and willingness to invest effort in academic tasks. Similarly, Adie et al. (2024) reported that autonomy-supportive and peer-created learning climates strengthen learners’ motivation by encouraging participation and shared responsibility in learning. Shao et al. (2024) further highlighted the powerful role of peer influence in sustaining motivation, particularly in collaborative and interactive learning contexts. In addition, Cho (2023) stressed that social support from teachers and classmates contributes significantly to students’ academic motivation, especially in demanding subjects such as science. These findings support the present result, explaining why students exposed to PhET-assisted, interactive, and collaborative learning experiences demonstrated significantly higher motivation than those in the Non-PhET group.

SUMMARY, CONCLUSION, RECOMMENDATION

This chapter presents the summary of findings, conclusions, and recommendations of the study.

Summary of Findings

This study investigated the impact of Physics Education Technology (PhET) simulation-assisted instruction on students' academic achievement and motivation in electromagnetism. Based on the analysis and interpretation of data, the following findings were obtained:

On students' academic achievement before and after the intervention, results revealed that both the PhET and Non-PhET groups demonstrated very low academic achievement in electromagnetism prior to instruction, with the majority of students falling under the Failure category. After the intervention, students exposed to PhET simulation-assisted instruction showed a substantial improvement, with all students achieving either Good or Very Good performance levels, while no failures were recorded. In contrast, although the Non-PhET group showed improvement in the post-test, most students remained at the Satisfactory level, indicating limited mastery of the concepts.

On students' motivation after the intervention, findings showed that students exposed to PhET simulation-assisted instruction attained higher motivation levels across all dimensions—intrinsic motivation ($M=2.99$), amotivation ($M=3.05$), extrinsic-career motivation ($M=2.94$), and social-extrinsic motivation ($M=2.99$)—compared to those exposed to non-PhET instruction. The PhET group consistently obtained qualitative interpretations of Motivated ($M=2.72$), whereas the Non-PhET group remained Less Motivated ($M=2.49$) across all motivational constructs.

On the significant difference in academic achievement, the ANCOVA results indicated a statistically significant difference in post-test academic achievement between students exposed to PhET and Non-PhET instruction when controlling for pretest scores ($p < 0.01$). Students in the PhET group obtained a significantly higher adjusted mean score than those in the Non-PhET group, confirming the effectiveness of PhET simulation-assisted instruction in improving academic achievement in electromagnetism.

On the significant difference in motivation, the independent samples t-test results revealed a statistically significant difference in motivation between the PhET and Non-PhET groups ($p < 0.001$). Students exposed to PhET simulations demonstrated significantly higher overall motivation compared to their Non-PhET counterparts, indicating that the instructional approach had a meaningful influence on students' motivational orientation toward learning electromagnetism.

Conclusions

Based on the findings of the study, the following conclusions were drawn:

The students' level of academic achievement improved after the intervention, with the Non-PhET group progressing from Failure to Satisfactory, while the PhET group advanced from Failure to Very Good performance levels in the post-test.

The students in the PhET simulation-assisted instruction was in the motivated level across all dimensions—intrinsic motivation, amotivation, extrinsic-career motivation, and social-extrinsic motivation—compared to those exposed to non-PhET instruction with a less motivated levels.

There was a significant difference in academic achievement between students exposed to PhET and those exposed to non-PhET instruction; thus, the null hypothesis ($H0_1$) stating that there is no significant difference in academic achievement is rejected.

There was a significant difference in motivation between students exposed to PhET and those exposed to non-PhET instruction; therefore, the null hypothesis ($H0_2$) stating that there is no significant difference in motivation is also rejected.

Recommendations

Based on the most significant findings corresponding to each specific objective of the study, the following recommendations are given:

For academic achievement, physics teachers are encouraged to integrate PhET simulations into electromagnetism instruction to support students' conceptual understanding, especially for abstract topics that are difficult to visualize through traditional methods alone.

For students' motivation, educators may design learning activities that combine PhET simulations with collaborative discussions, reflective tasks, and guided inquiry to further strengthen intrinsic and social–extrinsic motivation while clarifying learning goals to address amotivation.

For instructional practice, schools and higher education institutions, particularly those with limited laboratory facilities, are encouraged to adopt PhET simulations as a cost-effective and research-based alternative to enhance science instruction.

For curriculum developers and administrators, PhET simulation-assisted instruction may be formally integrated into physics curricula and professional development programs to promote innovative, technology-enhanced teaching strategies.

For future researchers, similar studies may be conducted using larger samples, different science topics, or longer intervention periods to further validate the effectiveness of PhET simulations and explore their impact on other learning outcomes such as critical thinking, problem-solving skills, and long-term retention.

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