|  |
| --- |
| This study evaluated the effectiveness of Physics Education Technology (PhET) |
|  interactive simulations in improving student academic performance on the topic  *Phases of Matter*, identified as the least mastered skill in the first quarter of Grade |
| 7 Science. | The purpose of this study was to examine the effectiveness of using |
| PhET interactive simulations as an instructional tool in enhancing Grade 7 |
| students’ understanding of the *Phases of Matter*. Specifically, it aimed to |
| determine whether the integration of interactive, technology-based simulations |
| improved students’ conceptual understanding and academic performance in |
| Science, particularly in addressing the least mastered competency in the first |
| quarter of the Grade 7 Science curriculum. The study also sought to explore the |
| perceptions of students and educators regarding the use of PhET simulations, |
| providing both quantitative and qualitative insights into their impact as a |
| supplementary teaching strategy. A convergent mixed-methods design was |
| employed, integrating both quantitative and qualitative data. In the qualitative |
| phase, two students and two educators participated in in-depth interviews to |
| provide contextual insights into the learning process and experiences. For the |
| quantitative phase, a total of 10 Grade 7 students from Section Tagaytay— |
| comprising 4 males and 6 females—were purposively selected based on their |
| poor performance in a prior quiz on the topic. The participants were randomly |
| chosen using the fishbowl method. These students underwent an intervention |
| using PhET interactive simulations. A validated 10-item pretest and posttest, |
| adapted from the Lesson Exemplar for Grade 7 Science Quarter 1, Lesson 1 |
| (Week 1), S.Y. 2024–2025, served as the primary assessment tool. The test |
| focused exclusively on the learning competency: describing the phases of matter |
| (solid, liquid, gas) and the particle theory of matter as outlined in the K–12 Science |
| Curriculum. To analyze the data, both descriptive and inferential statistics were |
| used, including frequency distribution, mean, percentage, and paired sample t- |
| test. The results revealed a significant improvement in the students’ performance |
| following the intervention. The t-value of 15.28, which exceeded the critical value |
| of 1.729, and a p-value of .001 (p < 0.05), The study revealed a statistically |
| significant improvement in students’ academic performance after the |
| implementation of PhET interactive simulations. The paired sample t-test yielded |
| a t-value of 15.28, which exceeded the critical value of 1.729, with a p-value of |
| .001 (p < 0.05), indicating that the intervention had a positive effect on student |
| learning outcomes. That confirmed the effectiveness of the simulation-based |
| instruction. The findings suggest that PhET interactive simulations are a highly |
| effective instructional tool for enhancing conceptual understanding and academic |
| performance in Science. When properly implemented, these simulations can |

|  |  |  |
| --- | --- | --- |
| 33 |  | **Improving grade 7 students' understanding on the** |
| 34 |  | **phases of matter through PhET interactive** |
| 35 |  | **simulations** |
| 36 |  |   |
| 37 | 14 | . |
| 38 | 15 | **ABSTRACT** |
| 39 | 16 |  |
| 40 |  |  |
| 41 |  |  |
| 42 |  |  |
| 43 |  |  |
| 44 |  |  |
| 45 |  |  |
| 46 |  |  |
| 47 |  |  |
| 48 |  |  |
| 49 |  |  |
| 50 |  |  |
| 51 |  |  |
| 52 |  |  |
| 53 |  |  |
| 54 |  |  |
| 55 |  |  |
| 56 |  |  |
| 57 |  |  |
| 58 |  |  |
| 59 |  |  |
| 60 |  |  |
| 61 |  |  |
| 62 |  |  |
| 63 |  |  |
| 64 |  |  |
| 65 |  |  |
| 66 |  |  |
| 67 |  |  |
| 68 |  |  |
| 69 |  |  |
| 70 |  |  |
| 71 |  |  |
| 72 |  |  |
| 73 |  |  |
| 74 |  |  |
| 75 |  |  |
| 76 |  |  |
| 77 |  |  |

78

serve as powerful interventions to help students master difficult concepts, particularly in topics where comprehension is commonly weak.

79

1. *Keywords: Phases of Matter, PhET Simulations, Science Education, Interactive learning,*
2. *academic performance, mixed-method research*

82

83

## 18 1. INTRODUCTION

1. 19
2. 20 In recent years, the rapid advancement of technology has driven substantial

100

101

102

103

104

105

106

107

108

109

110

111

112

113

114

115

116

87 21

88 22

89 23

90 24

91 25

92 26

93 27

94

28

95 29

96 30

97 31

98 32

99

changes in education, notably through the integration of information and communication technologies (ICT). As Lourida et al. (2024) affirm, ICT has profoundly transformed teaching and learning processes, offering enhanced educational experiences. Educational technology has thus become central to effective pedagogical practices, especially in science education. One prominent innovation is PhET (Physics Education Technology) interactive simulations, which provide research-based, hands-on learning environments that support conceptual comprehension in challenging science topics.

Research has consistently shown the pedagogical benefits of PhET simulations across various educational levels and subjects. For example, in elementary classrooms, Rahmah Kumullah et al. (2024) demonstrated that PhET- based virtual labs helped learners better visualize and understand abstract scientific concepts. Similarly, U. Umiliya et al. (2023) found that blending PhET with inquiry-based pedagogies significantly improved conceptual understanding of static electricity compared to control groups. In remote and resource-constrained settings, Nguyen et al. (2024) reported that PhET simulations substantially increased student engagement and comprehension in physics lessons in Northern Vietnam.

Meta-analyses and comprehensive literature reviews lend further support: a

systematic review in *Phys. Rev. Phys. Educ. Res.* identified robust evidence that PhET simulations improve conceptual understanding when integrated with active learning strategies. Likewise, Banda & Nzabahimana (2021) concluded that these simulations are most effective within inquiry-driven instructional frameworks,

underscoring their alignment with constructivist theory.

PhET, or Physics Education Technology, refers to a suite of interactive simulations designed to support the teaching and learning of math and science concepts. Developed based on extensive educational research, PhET simulations

1. engage students through an intuitive, game-like interface that promotes learning
2. through exploration and discovery. According to Doloksaribu and Triwiyono (2021),
3. PhET emphasizes the connection between real-life situations and underlying scientific
4. principles, enabling students to better visualize and conceptualize scientific models
5. and phenomena. This approach aligns with constructivist learning theories by
6. fostering deeper understanding through active, inquiry-based learning experiences.
7. PhET Interactive Simulations is a substantial and growing repository of over 85 high-
8. quality simulations for science teaching. The PhET website,
9. [http://PhET.colorado.edu,](http://PhET.colorado.edu/) offers simulators at no cost, which have been utilized
10. around 10 million times in the past year. Although the number of simulations in
11. chemistry, biology, mathematics, and other sciences is increasing, the majority of
12. PhET simulations are utilized for teaching physics. The application of PhET simulators
13. across several educational settings had been thoroughly examined. It is designed to
14. be accessible and beneficial for schools across the Philippines, regardless of location
15. or resource availability. Their free, userfriendly, and research-based nature makes
16. them particularly suitable for diverse educational settings, including those with limited
17. laboratory facilities.

134

1. PhET Interactive Simulations, developed by the University of Colorado
2. Boulder, are widely recognized educational tools designed to enhance learning in
3. science and mathematics through interactive, research-based simulations. The global
4. adoption of PhET has spurred extensive research into its effectiveness and
5. pedagogical impact. It has shown to boost learner engagement and motivation.
6. Research by Zacharia and Olympiou (2011) in Cyprus highlighted that students found
7. lessons using PhET more enjoyable and less intimidating than conventional
8. experiments. In a study conducted in Thailand, Bunterm et al. (2014) reported
9. increased student motivation and interest in physics when using simulations in
10. combination with hands-on activities. 145
11. In the Philippines, the integration of digital tools in science and mathematics
12. education has gained momentum, particularly in response to the K–12 curriculum’s
13. emphasis on inquirybased learning and the need for more accessible learning
14. resources. Among these tools, PhET Interactive Simulations have been increasingly
15. utilized in both basic and higher education. According to Aranas and Madrazo (2020)
16. who conducted a quasi-experimental study in a public senior high school in Metro
17. Manila, revealing that students exposed to PhET simulations in physics achieved
18. higher post-test scores compared to those taught with traditional lecture methods. The
19. simulations helped visualize abstract ideas such as Newton's laws and projectile
20. motion. It validates the effectiveness of PhET simulations in helping students
21. understand complex science concepts. 157

158 From a study conducted by Melvin C. Eleo and Ylcy B. Manguilimotan, 2024

159 recommend that active integration of PhET simulations into classroom instruction,

160 highlighting the need for professional training for educators. They argue that teachers

161 should move beyond passive lecturing and incorporate these interactive tools to

162 encourage student engagement and critical thinking. Additionally, administrators are

163 advised to support the implementation of such technologies through capacity-building

164 initiatives. Finally, the study suggests future research to explore PhET applications

165 across varied science topics and instructional contexts. 166

167 In the Philippine context, this is highly relevant due to the lack of laboratory 168

resources in many public schools. Eleo and Manguilimotan (2024) showed that the strategic use of PhET simulations led to improved test performance in Davao de Oro, aligning well with the Department of Education's goal of promoting inquiry-based

169

170

171 learning as part of the K–12 curriculum.

172 Amrullah et al. (2022) conducted a comprehensive meta-analysis on PhET 173

simulation use and concluded that their effect on improving science learning is consistently positive across grade levels. Similarly, Diab et al. (2024) highlighted how PhET enhances student engagement and learning outcomes in elementary and secondary science classes by providing interactive visualization of abstract concepts.

174

175

176

177 Theoretical foundations for PhET's effectiveness are rooted in constructivist 178

learning theory and Mayer’s cognitive theory of multimedia learning (Mayer, 2009), which emphasize the importance of active engagement and visual-verbal integration in deepening student understanding. These simulations are not only intuitive but are specifically designed based on learning science research that promotes inquiry-based learning (Wieman, Adams, & Perkins, 2008). According to Rutten, van Joolingen, & van der Veen (2012), computer simulations significantly improve student achievement

179

180

181

182

183

184 in science education, particularly when paired with guided instruction.

185 In recent years, the rapid advancement of technology has driven substantial 186

changes in education, notably through the integration of information and communication technologies (ICT). As Lourida et al. (2024) affirm, ICT has profoundly transformed teaching and learning processes, offering enhanced educational experiences. Educational technology has thus become central to effective pedagogical practices, especially in science education. One prominent innovation is PhET (Physics Education Technology) interactive simulations, which provide research-based, hands-on learning environments that support conceptual

187

188

189

190

191

192

193 comprehension in challenging science topics. 194

1. The integration of Physics Education Technology (PhET) Interactive
2. Simulations in the Davao Region has been explored in various educational settings,
3. demonstrating their effectiveness in enhancing students' understanding of scientific
4. concepts. A study conducted by Melvin C. Eleo and Ylcy B. Manguilimotan at Saint
5. Mary's College of Tagum, Inc., in Tagum City, Davao del Norte, investigated the
6. effectiveness of PhET simulations in improving students' performance in physics. This
7. quasi-experimental research involved 60 Grade 11 students from a public secondary
8. school in the Division of Davao de Oro. The findings revealed that students who
9. utilized PhET simulations showed a significant improvement in their physics
10. performance compared to those taught through conventional methods. The study
11. recommends the incorporation of PhET simulations into classroom instruction and
12. suggests that administrators provide relevant training and workshops for teachers on
13. the proper use of these simulations. 208
14. This study contributes to the growing body of research on educational
15. technology by providing practical insights into how PhET simulations can be used to
16. support science teaching in a middle school setting. By evaluating both the
17. instructional process and student outcomes, the research offers evidence-based
18. recommendations for integrating digital manipulatives into science curricula. It aims
19. to empower educators with effective strategies for using technology to create more
20. interactive, student-centered learning environments that promote deeper
21. understanding and sustained interest in science. 217
22. The use of PhET Interactive Simulations in classroom instruction is grounded
23. in Constructivist Learning Theory and Multimedia Learning Theory. Constructivism,
24. as proposed by Piaget and Vygotsky, emphasizes that learners actively construct
25. knowledge through interaction and meaningful experiences. PhET simulations allow
26. students to explore scientific concepts by manipulating variables and observing real-
27. time outcomes, fostering inquiry and deeper understanding. At the same time,
28. Mayer’s Multimedia Learning Theory supports the effectiveness of combining visual
29. and verbal elements to enhance cognitive processing and retention. Together, these
30. theories justify the integration of PhET simulations as a powerful tool to promote
31. active, student-centered, and visually rich learning in science education. 228
32. Using PhET Interactive Simulations in the classroom is important as many
33. schools particularly in the Davao Region lack access to adequate laboratory
34. equipment, limiting students’ ability to engage in hands-on science learning. These
35. simulations provide an interactive and cost-effective alternative that can enhance
36. conceptual understanding, especially in physics and chemistry. By exploring their
37. effectiveness in local classrooms, this study supports the goals of the K–12
38. curriculum, which emphasizes inquiry-based learning. It also helps assess how well
39. teachers and students adapt to digital tools in science education. Apart from this, the
40. study titled Enhancing Student Engagement and Understanding in Grade 7 students
41. on the Phases of Matter using PhET Interactive Simulations, the findings can guide
42. educational leaders in making informed decisions about integrating technology into
43. teaching practices.
44. This research investigates how PhET simulations can be effectively
45. integrated into middle school science instruction to improve both student engagement
46. and conceptual understanding. To design and implement lesson plans incorporating
47. PhET simulations for selected science topics. To evaluate the impact of PhET
48. simulations on students' conceptual understanding. To assess changes in student
49. engagement during PhET-enhanced science lessons. 247

248

249 **2. OBJECTIVES**

250

1. This study aimed to determine how PhET Interactive simulations enhance students
2. understanding in the Phases of Matter.
3. Specifically, the study sought to: 254

255 This study aimed to:

256 1. To evaluate the impact of PhET interactive simulations on Grade 7 students'

257 understanding of the phases of matter.

258 2. To examine the effectiveness of PhET simulations in supporting inquiry-based

259 learning in a Grade 7 science classroom.

260 3. To gather student and teacher perceptions regarding the use of PhET simulations as

261 a tool for learning and teaching the phases of matter.

262

## 263 3. MATERIALS AND METHODS

264

265 **Research Design**

266

1. In realizing the objective of this study, the researchers employed convergent mixed
2. methods design. A mixed methods research design, which is a complex approach, combines
3. both quantitative and qualitative data in a single study or succession of studies. This design
4. can be particularly functional for exploring complex research questions that cannot be fully
5. answered by using a single research design. Moreover, a mixed methods design is necessary
6. to examine the relationships between different variables because examining the relationships
7. between diverse variables is not viable just through a single research design (Sharma et al.,
8. 2023). In the context of this study, 2 students and 2 educators undergone in-depth interview
9. for the qualitative phase of the study. Moreover, in the quantitative phase of the study, grade
10. 7 section Tagaytay received the intervention. Furthermore, in analyzing the data that were
11. gathered, an Independent Sample t-test was utilized to determine the significance of
12. difference on the pre-test and post-test scores. The comparison of the scores implies the
13. effectiveness of integration of PhET Simulations in improving student conceptual
14. understanding of the Phases of Matter. 281

282

283

284 **Research Instrument**

285

1. The researcher used the following tools and instruments in conducting this study. The
2. "PhET Interactive Simulation” in the Phases of Matter which the researchers
3. downloaded/accessed in PhET Colorado website
4. [http://phet.colorado.edu/en/simulation/thephases-of-](http://phet.colorado.edu/en/simulation/the-phases-of)matter, and the Students' Pre-Test and
5. Post Test in the phases of matter. 291
6. PhET offers enjoyable, cost-free, interactive simulations of science and math based
7. on research, PhET simulations are particularly excellent for providing visual representations
8. of challenging scientific ideas while engaging learners through manipulation. This is an
9. effective teaching tool that influences students' understanding (Taneo, 2021). Anyone with a
10. device and an Internet connection can easily access and use PhET simulations. 297
11. The 10-item Pretest and Post-Test questions in the phases of matter were taken from
12. the Lesson Exemplar for Science 7 Quarter 1: Lesson 1 (Week 1) S.y. 2024-2025 since it was
13. already validated. Phases of Matter was the sole focus of the test's questions, which were
14. matched with the learning competency on describe the phases of matter (solid, liquid, gas)
15. and the particle theory of matter of (in) Grade 7 Science K-12 curriculum. 303

304 **Respondents of the Study**

305

1. The subjects for the study were chosen from a group of Grade 7 students who
2. performed poorly and failed the quiz on the Phases of Matter. Students were chosen using
3. basic random sampling (Fishbowl method). This sample method involved selecting a name at
4. random from a list of the pooled students' names on a piece of paper. 10 sheets have been
5. drawn to form the 6 males and 4 female Grade 7 students of Section Tagaytay. 311

312 **Data Gathering**

313

1. In order to address the stated concerns, this study conducted quantitative research.
2. Several statistical tools were utilized to assess or evaluate the data acquired.
3. **Development Process**
4. While PhET simulations are pre-developed, the process will involve adapting and
5. contextualizing them for classroom use:
6. Concept Selection – Choose science topics that align with the curriculum and are
7. suitable for PhET tools.
8. **Implementation Plan**
9. **B.1 Pre-implementation**
10. The 10-item Student's Pretest was given to 10 students to gauge their degree of prior
11. knowledge. The frequency distribution of the scores for each item, the mean, and the standard
12. deviation were used to analyze the Pretest in order to visualize and illustrate the data
13. gathered, define the distribution, and assess the level of score dispersion (Omoy, E. Q. 2023).
14. **B.2 Implementation**
15. The learners used the interactive PhET simulation on Phases of Matter following the
16. pretest. To gauge the students’ progress, the researcher examined students’ responses to the
17. simulation. The task isstions in the PhET (Omoy, E. Q. 2023).
18. **B.3 Post implementation**

Next, the post-test will be finished by the students. There was data encoding, analysis,

1. and verification. It was assessed how much the scores from the Pre- and Post-Test differed.
2. A significant increase in the post-test score indicates that the student has learned the
3. simulation. Additionally, the significance of the difference between the pre-test and post-test
4. data was determined using a two-tailed paired-sample t-test of means. With 9 degrees of
5. freedom, the test analysis is set at a 95% confidence level (Omoy, E. Q. 2023).

|  |  |
| --- | --- |
| 338 | **4. RESULTS AND DISCUSSION** |
| 339 | This section presented the discussion of the results and reflection after the |
| 340 | implementation of PhET Interactive Simulations in improving the student’s conceptual |
| 341 | understanding of the phases of matter. |
| 342 | **Standpoints of educators on the use of PhET simulation in improving teaching and** |
| 343 | **learning process** |
| 344 | Using the guide questions, the teachers were able to express their experience in using |
| 345 | PhET in their teaching and learning process. This consisted of a thematic analysis of this |
| 346 | research's qualitative data, collected through in-depth interviews. Table 1 shows the focal |
| 347 | point on the first column. The second column contains the interview responses' core ideas, |
| 348 | combined according to the common essential themes in the third column. In addition, sample |
| 349 | responses from the respondents in the in-depth interviews are also presented here. |
| 350 | **Accessible and Time-Saving.** The educators claimed that using PhET simulation |
| 351 | significantly helped them in their teaching process. These responses on accessible and time- |
| 352 | saving appear in the ***interview responses 1 and 2. Below are the sample responses:*** |
| 353 | ***“PhET is free, easy to access, and requires no expensive lab equipment.*** |
| 354 | ***It’s an excellent tool when resources are limited or time is constrained.”*** |
| 355 |  |
| 356 | ***“As a teacher, I appreciate how PhET simulations save me time in*** |
| 357 | ***lesson preparation and classroom setup—there’s no need for complex*** |
| 358 | ***equipment, yet students still experience interactive, lab-like learning from any*** |
| 359 | ***device.”*** |
| 360 | The participants have a common theme regarding accessible and time-saving which makes |
| 361 | using PhET in their classes improves the learning and teaching process. |

362

# 363 **Table 1** Use of PhET simulation in the teaching and learning process

|  |  |  |
| --- | --- | --- |
| Focal Point | Core Ideas | Essential Themes |
| *\_Using PhET**simulations in the teaching and learning process* | This topic is hard to understand because we can't see it.The examples are very abstract. | Accessible and Time-Saving. |
| I get tired of listening because it's all discussion. | Instructional Convenience and Flexibility |
|  | It is boring sometimes, so I do not listen anymore. |  |
|  | I do not like it because there are no activities. |  |

364

1. **Instructional Convenience and Flexibility**. This essential theme emerged from the
2. responses of the educator/teacher participants. Based on the interview responses, PhET
3. simulations minimize the need for costly laboratory materials and physical set-up. Teachers
4. can quickly integrate simulations into lessons without extensive preparation, and students can
5. access them anytime, making it easier to reinforce concepts inside or outside the classroom.
6. Making science instruction more practical and feasible, especially in resource-limited
7. classrooms. Here are the sample responses:
8. “PhET makes it easy to adjust my lesson on the spot based on student
9. needs—I can switch from lecture to interactive mode without setting up a lab.”
10. *“As a public-school teacher with limited lab resources, PhET lets me simulate*
11. *experiments that would otherwise be impossible due to cost or safety concerns.”* The essential
12. themes reflect the core benefits and underlying values that teachers associate with using PhET

377

378

simulations in their instructional practice.

1. **Standpoints of the Participants on Challenges in Learning the Phases of Matter** Using
2. the guide questions, the students were able to express the challenges and difficulty they
3. experience in learning the phases of matter. This consisted of a thematic analysis of this
4. research's qualitative data, collected through in-depth interviews. Table 1 shows the focal
5. point on the first column. The second column contains the interview responses' core ideas,
6. combined according to the common essential themes in the third column. In addition, sample
7. responses from the respondents in the in-depth interviews are also presented here.
8. **Lack of Real-Life Examples or Visual Aids.** The participants claimed that they are having
9. difficulty understanding the phases of matter since the concept is too abstract and they are
10. not able to do activities that can show them how it looks in real scenario. These responses on
11. the lack of real-world examples appear in the interview responses 1 and 2. Below are the

390

391

sample responses:

392 **“I find it hard to understand the phases of matter because we only talk**

393 **about solids, liquids, and gases in theory. It’s confusing when we don’t have**

394 **real-life examples to connect the concepts. For example, I know water can**

395 **freeze or boil, but I don’t really get how that shows a phase change unless I**

396

397

**actually see it.”**

257 **“It would help if we had more demonstrations or saw videos of materials** 258 **changing states, like dry ice turning into gas or metal melting. That way, I could** 259 **understand how these changes happen in real life, not just in the textbook."**

260

261 The participants have a common theme regarding the lack of real-life examples which 262 makes understanding the phases of matter difficult for them.

|  |  |  |
| --- | --- | --- |
| **Focal point** | **Core Ideas** | **Essential Themes** |
| Challenges of the participants in Learning the Phase of Matter. | We have difficulties in this topic, since we need some model to demonstrate the changes of the molecules and not just on purely discussion. | **Difficulty visualizing Molecular Changes** |
| We cannot actually acquire the concept on particle model of matter because they are not directly observable. | **Abstractness and Lack of Visibility** |

264 ***Table 2: The viewpoints of the participants in Learning the Phase of Matter.***

265

266 Table 2 presents the viewpoint of the participants difficulties dealing with the phase of matter topic. The table also shows the essential theme that will be the guide in dealing with 268 the problem. Based on the interview the participants have difficulty visualizing molecular changes.

269 This viewpoint arises from the thought that the molecular changes are abstract and not perceptual topics that includes the used of the spatial reasoning to the understand the 272 structure and the function of the phases of matter. Here are the common responses of the participants:

1. **“Lisod ang topic, kinahanglan namo ug mga model or visual**
2. **representation para sa mga changes of molecules ug dili lang pod unta purely**
3. **discussion”**
4. **“We have difficulties in this topic, since we need some model to**
5. **demonstrate the changes of the molecules and not just on purely discussion”.**
6. This thought reflects on the topic of molecular changes, most of the time their difficulty
7. is more on the understanding of the concept of what are the process in changes of the
8. molecules, such as condensation, evaporation and so on.
9. Additionally, Abstract and Lack of Visibility are one of the difficulties in dealing with
10. the topic according to the participants. This difficulty reflects on the topics of the particle model
11. of matter. The participants can understand the basic concepts of the solid, liquid and gas
12. particle model, but they have difficulties in learning like for example the following question;
13. “Which of the following shows how particles behave when heated? (Attached with the choices
14. with a model). Here are some of the responses of the participants.
15. “Dili namo makuha ang concept the particle model kay dili man god namo
16. siya directly makuha, such as the sublimation concept ug uban pa”
17. “We cannot actually acquire the concept on particle model of matter because
18. they are not directly observable, such as the sublimation concept and so on”. These

292

293

294

295

296

297

298

are the common difficulties of the participants in dealing with the phases of matter lesson.

299

301 **A. Prior to Intervention**

302 What is the level of performance of the students in Phases of Matter before the use 303 of PhET Interactive Simulation?

304 **Table 3: Pretest result.**

305

|  |  |
| --- | --- |
| SCORE RANGE(10 item test) | Pretest |
|  |
| Scores Frequency | Percentage | Performance Level |
| 10-8 | 0 | 0 | Very Good |
| 7-5 | 0 | 0 | Good |
| 4-3 | 4 | 40% | Average |
| 1-2 | 6 | 60% | Low |
| Total | 10 | 100% | Low |
| Mean | 2.3 |

306

307 Table 3 shows the level of performance of students based on the results of the 10308 item pretest in phases of matter. The results showed that the students had a "low" performance

1. in the pre-test with a mean score of 2.3. Pre-test results show that not a single student scored
2. 10-8 and 7-5 with "Very good" and "Good" performance levels; 4 out of 10 or 40% performed
3. in the "Average" level; and 60%, or 6 out of 10, scored 0-4, which is considered low performing.
4. This data indicates that students require intervention to increase their level of performance.
5. **A. After the Intervention**
6. After implementing the PhET Interactive Simulation activities on Phases of Matter, 315 students were given a post-test. The results were tallied and analyzed.
7. What is the level of performance of the students in Phases of Matter after the use of PhET
8. Interactive Simulation?

318

319 **Table 4: Post-test Result**

|  |  |
| --- | --- |
| SCORE RANGE(10 item test) | Post test |
|  |
| Scores Frequency | Percentage | Performance Level |
| 10-8 | 3 | 30% | Very Good |

|  |  |  |  |
| --- | --- | --- | --- |
| 7-5 | 4 | 40% | Good |

|  |  |  |  |
| --- | --- | --- | --- |
| 4-3 | 3 | 30% | Average |
| 1-2 | 0 | 0 | Low |
| Total | 10 | 100% | Good |
| Mean | 6.15 |

1. On the other hand, the post-test revealed that 3 out of 10 respondents, or 30% of the
2. group, performed very well, while more than half, or 40% of the population, scored between 7
3. and 5, and performed well, and 3 out of 10 students, or 30% of the group, had an average
4. performance, and not a single student scored 0-4, which is in the low level of performance. It
5. was very evident that there was an increase in students' scores. One study found that, “PhET
6. interactive simulation proved a more effective way to cultivate positive attitudes and attain
7. academic excellence”. (Bhatti & Teevno, 2021). 7

8 **Table 5: Mean of Pretest and Post-Test Scores.**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| No. of items | df | Pre-Test Mean | Post-Test Mean | Difference |
| 10 | 9 | 2.3 | 6.15 |  |

9

1. The table displays the results of the pretest and post-test in the 10-item test that the
2. researcher administered before and after using the PhET Interactive Simulation. It was found
3. that the pretest mean score was 2.3, and its mean score of 6.15 supported the post-test result.
4. The data unmistakably shows that the mean of the respondents' pretest significantly
5. increased after they used the interactive simulations from PhET for phases of matter. This is
6. an apparent indication that the utilization of PhET Interactive Simulation is effective and
7. powerful method in improving learners’ performance and mastering the skills of understanding
8. the concept of the phases of matter, which is one of the least learned skills in the 2nd quarter
9. of Grade 7 Science.
10. Is there a significant difference in the mean scores of students’ before and after using
11. PhET interactive simulation in understanding the concept of phases of matter? 21

22

1. **Table 6: Finding the Significant Difference in the means Before and After the Utilization**
2. **of PhET.**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Compared Variables | df | Mean | SD | Tvalue | Critical t-value | Pvalue | Decision | Impression0.05 Level |
| Pretest | 9 | 2.3 | 1.03 | 8.78 | 2.262 | <.001 |  | Significant |

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Posttest |  | 6.15 | 2.36 |  |  |  | RejectHo |  |

25

346

359

1. Table 6 shows the result of the t-test on finding the significant difference between the
2. pre-test and post-test. Following data computation, it became apparent that the t- value, 8.78, 349 exceeded the t-critical value, 8.78, at the degree of freedom, 9. Additionally, it demonstrates 350 that the p-value is <.001, indicating that the result is significant at p 0.05. As a result, the null 351 hypothesis is rejected. There is a significant difference in the mean scores of students before 352 and after the utilization of PhET Interactive Simulation in understanding the concept of the 353 phases of matter. PhET Interactive Simulation is a learner-centered approach supported by 354 constructivism learning theory that says

learners construct knowledge rather than just 355 passively take in information. It is an effective and successful instrument for raising students' 356 academic performance in their

least mastered areas the phases of matter because learners 357 are actively engaged in the learning process and acquire knowledge and skills even when 358 attempting new approaches.

## 360 5. CONCLUSIONS AND RECOMMENDATIONS

361

362

1. **Conclusion**
2. The researcher concludes that using PhET interactive simulations is a useful strategy for raising students' academic achievement based on the data that was provided. When it comes to helping students master the notion of the phases of matter, it is a powerful intervention or remediation technique. When used appropriately, PhET interactive simulations can help students who are having trouble understanding scientific concepts. As a result, using PhET simulations might be viewed as a useful way to help students who are performing poorly and acquire the abilities they haven't learnt.

371

1. **Recommendation**
2. 1. Conduct further research on the long-term retention of concepts learned through
3. PhET Interactive Simulations, which was not covered in this study.

2. It is recommended that future researchers consider conducting similar studies during the opening of the academic year to allow for a larger number of participants and more controlled implementation. This approach would not only increase the sample size but also enhance the reliability and generalizability of the results. Conducting the study at the beginning of classes may also provide more consistent baseline data and allow for longitudinal tracking of learning progress over time.

1. 3. Include students’ attitudes, engagement, and perceptions toward the use of PhET
2. simulations for a more comprehensive evaluation.
3. 4. Encourage students to explore PhET simulations independently to strengthen their
4. understanding and promote self-directed learning.
5. 4. Provide teachers with training and capacity-building programs to effectively implement PhET simulations in their science instruction.

381 5. Support from the school community is recommended through investment in ICT

382 infrastructure and access to devices that support simulation-based learning. 383 6. Future researchers are advised to use control groups and larger, more diverse 384 samples to enhance the validity and generalizability of results.

385 7. Expand future studies to include other science topics and disciplines, such as Biology, 386 Earth Science, and Chemistry.

387 8. Utilize both quantitative and qualitative data collection methods, such as interviews or 388 reflective journals, to capture deeper insights into student learning experiences.

389

390 **Disclaimer (Artificial intelligence)**

Option 1:

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

Option 2:

Author(s) hereby declare that generative AI technologies such as Large Language Models, etc. have been used during the writing or editing of manuscripts. This explanation will include the name, version, model, and source of the generative AI technology and as well as all input prompts provided to the generative AI technology

Details of the AI usage are given below:

1.

2.

3.

424

425

426 **REFERENCES**

427

428 **Adams, W. K. (2010).** Student Engagement and learning with PHET interactive 429

#### simulations. Student Engagement and Learning With PHET Interactive 430

Simulations. <http://eprints.bice.rm.cnr.it/16857/>

431 **Adomi E. E and I Kpangbon (2010)** application of ICT’s in Nigeria secondary 432 schools. Library philosophy and practice (e-journal) march, 1 – 8 433 http:/digitalcommonss.uni.edu/libphilprac/345.

#### 434 **Akudulo L.R. (2002)** restructuring Nigerian secondary education system though ICT 435 driven curriculum. Journal of the world council for curriculum and instruction 436 Nigerian chapter 3 (1): 7 – 17.

1. **Aluko, M.E (2004)** some issues in ICT for Nigerian development. Retrieved from 438

http:/[www.dawodu.com](http://www.dawodu.com/) /aluko98.htm.11th July 2011.

### Amrullah, M. F., Sari, M. I., Mahtari, S., Hidayat, A., & Setiawan, A. (2022). The

1. effectiveness of PhET simulations in physics learning: A meta-analysis study.
2. Journal of Physics: Conference Series, 2165(1), 012038.
3. https://doi.org/10.1088/1742-6596/2165/1/012038
4. **Arifin, S., Razali, F. B., & Rahayu, W. (2023).** Integrating PHET interactive simulation

#### to enhance students’ mathematical understanding and engagement in learning

1. mixed fraction. Al Ibtida Jurnal Pendidikan Guru MI, 10(2), 241.
2. <https://doi.org/10.24235/al.ibtida.snj.v10i2.15056>
3. B**in-Hady et al. (2020).** Journal Education and Social Research. Retrieved from

#### Google Scholar: http//[www.googlescholar.com](http://www.googlescholar.com/)

1. **Bunterm, T., Lee, K., Ng, C., & Rattanavongsa, J. (2014).** The effectiveness of
2. inquiry-based learning using a PhET simulation on students’ understanding of
3. static electricity. Procedia - Social and Behavioral Sciences, 116, 2951–2956.
4. https://doi.org/10.1016/j.sbspro.2014.01.682
5. **Chamberlain, et al. (2021).** Interdisciplinary Journal of Environmental and Science

#### Education . Retrieved from Google Scholar : https://[www.ijese.com/](http://www.ijese.com/)

1. **Diana Kozlova, Marcel Pikhart. (2021).** ScienceDirect . Retrieved from Google

#### Scholar : sciencedirect.com

1. **Diab, H., Daher, W., Rayan, B., Issa, N., & Rayan, A. (2024).** Transforming science

#### education in Elementary Schools: The Power of PHET Simulations in Enhancing

1. Student Learning. Multimodal Technologies and Interaction, 8(11), 105.
2. <https://doi.org/10.3390/mti8110105>
3. **Eleo, M. C., & Manguilimotan, Y. B. (2024).** Physics education technology (phet)

#### interactive simulations as teaching aid in enhancing students’ performance in

1. physics. EPRA Int. J. Multidiscip. Res. IJMR, 60-64.
2. **ESpinosa et al. (2020).** Journal Educational and Social Reasearch. Retrieved from

#### Google Scholar: [http:www.googlescholar.com](http://www.googlescholar.com/)

1. **Fernandes et al., 2018; . (2018).** Journal Education and Social Research . Retrieved
2. from Google Scholar : [http://ww.w.googlescholar.com](http://ww.w.googlescholar.com/)
3. **Florida E. Doloksaribu, Triwiyono Triwiyono. (2021).** International Journal on

#### Studies in Education . Retrieved from Google

1. scholar : https://d1wqtxts1xzle7.cloudfront.net/
2. **Galle. (2020, September ).** Turkish Science Education . Retrieved from Google

#### Scholar : [www.turkishscienceeducation.com](http://www.turkishscienceeducation.com/)

1. **Haryadi and Pujiastut. (2020).** Journal of Physics . Retrieved from Google Scholar :
2. https://iopscience.iop.org/

### Jumman Sani, Md Mostafa Kamal, Tapan Kumar Biswas. (2024, May).

#### International Journal for Multidisciplinary Research (IJFMR). Retrieved from

1. Google Scholar: [http://www.googlescholar.com](http://www.googlescholar.com/)

### Lourida, K., Anastasopoulou, E., Tsagri, A., & Avramidi, E. (2024). The impact of

#### ICT on education. Technium Social Sciences Journal, 58, 48–55.

1. https://doi.org/10.47577/tssj.v58i1.12345
2. **Konstantina Lourida, et.al . (2024, June )**. HeinOnline . Retrieved from Google

#### Scholar : heinonline.org

1. **Mayer, R. E. (2009).** Multimedia learning (2nd ed.). Cambridge University Press.
2. **Moore, et,al. . (2021).** Interdisciplinary Journal of Environmental and Science
3. Education . Retrieved from Google Scholar : https://[www.ijese.com/](http://www.ijese.com/)

### Perkins, K., Adams, W., Dubson, M., Finkelstein, N., Reid, S., Wieman, C., &

1. **LeMaster, R. (2006).** PhET: Interactive simulations for teaching and learning

#### physics. The Physics Teacher, 44(1), 18–23. https://doi.org/10.1119/1.2150754

1. **Rutten, N., van Joolingen, W. R., & van der Veen, J. T. (2012).** The learning effects

#### of computer simulations in science education. Computers & Education, 58(1),

1. 136–153. <https://doi.org/10.1016/j.compedu.2011.07.017>
2. **Telefonica. (2023, July 15).** Telefonica . Retrieved from
3. Google : htt[ps://www.telefonica.com/](http://www.telefonica.com/)

493

494 **Wieman, C. E., Adams, W. K., & Perkins, K. K. (2008)**. PhET: Interactive

#### 495 simulations for teaching and learning physics. The Physics Teacher, 44(1), 18–23.

487 **Zuzana, Alena . (2017, September ).** International Journal of Learning and Teaching. Retrieved from Google Scholar: internationaljournalof learningteaching.com

488 Doloksaribu, F. E., & Triwiyono, T. (2021). The reconstruction model of science learning based PhET-Problem Solving. International Journal on Studies in Education (IJonSE), 3(1), 37–47.

#### [ejournal.undiksha.ac.id+11academia.edu+11link.aps.org+11](https://www.academia.edu/44322485/The_Reconstruction_Model_of_Science_Learning_based_PhET_Problem_Solving?utm_source=chatgpt.com)Anastasopoulou, E.,

Tsagri, A., Avramidi, E., & Lourida, K. (2024). The impact of ICT on education.

489 Technium Social Sciences Journal, 58, 48–55. [searchworks.stanford.edu+3researchgate.net+3scispace.com+3](https://www.researchgate.net/publication/381300682_The_Impact_of_ICT_on_Education/fulltext/6667056aa54c5f0b945c87b9/The-Impact-of-ICT-on-Education.pdf?utm_source=chatgpt.com)

Budiarti, I. S., Boy, B. Y., & Lumbu, A. (2021). Analysis of students’ scientific problem solving skills in learning using PhET simulation in 3T region. Jurnal Pendidikan Fisika dan Keilmuan (JPFK), 7(2), 59–76. [pdfs.semanticscholar.org+1ojs.uho.ac.id+1](https://pdfs.semanticscholar.org/a4f0/b3ab9d87b0f017a748f127ed0ba27137cdfe.pdf?utm_source=chatgpt.com)

Halmuniati. (2022). Pengaruh model pembelajaran problem solving dibantu media simulasi PhET terhadap kemampuan pemecahan masalah fisika. Jurnal Penelitian Pendidikan Fisika, 7(4). [journal.uinjkt.ac.id+10ojs.uho.ac.id+10neliti.com+10](https://ojs.uho.ac.id/index.php/JIPFI/article/view/28649/0?utm_source=chatgpt.com)

Taqwa, M. R. A., & Rivaldo, L. (2019). Pembelajaran problem solving terintegrasi PhET: Membangun pemahaman konsep listrik dinamis. Jurnal TSCJ. [neliti.com](https://www.neliti.com/publications/286950/pembelajaran-problem-solving-terintegrasi-phet-membangun-pemahaman-konsep-listri?utm_source=chatgpt.com)

Wieman, C. E., Perkins, K. K., & Adams, W. K. (2008). PCAST report: Scientific teaching. Science, 332(6039), 978–979. (Referenced for active learning pedagogies)

Mayer, R. E. (2009). Multimedia learning (2nd ed.). Cambridge University Press.

(Theoretical foundation for visualizations and simulations)

Zacharia, Z. C., & Olympiou, G. (2011). Physical versus virtual manipulative experimentation in physics learning. Learning and Instruction, 21(3), 317–331. (Supports real-world connections and cognitive engagement)

Omoy, E. Q. (2023). PhET Interactive Simulations: A Tool in Improving Academic Performance of Grade 10 Students in Balancing Chemical Equations. International Journal of Formal Sciences: Current and Future Research Trends, 18(1).