EFFECTIVENESS OF ONLINE INTERACTIVE SIMULATION LABORATORY IN IMPROVING THE PERFORMANCE IN MOTION IN TWO DIMENSIONS OF GRADE 9 STUDENTS IN SAN JOSE ADVENTIST ACADEMY

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ABSTRACT

This study examined the effectiveness of online interactive simulations, specifically the CK-12-Physics Simulation, in enhancing physics education, with a particular focus on the challenging concept of motion in two dimensions. Recognizing the difficulties students encounter with this topic, as evidenced by PISA assessments, the researchers sought to determine if the simulation-based approach could outperform traditional teaching methods.

To investigate this, 40 ninth-grade students were divided into two groups: one exposed to interactive simulations and the other following a conventional curriculum. Both groups underwent five learning sessions tailored to their respective methods. Subsequently, all students completed a test on motion in two dimensions.

The findings were evident: the simulation group performed significantly higher post-test scores compared to their counterparts. This compelling evidence underscores the superior effectiveness of online interactive simulations in facilitating student comprehension and performance in the domain of motion in two dimensions. The study's results advocate for the integration of such technology into physics instruction to optimize learning outcomes.

Keywords: *conventional teaching, motion in two dimensions, online interactive simulation laboratory, physics education, science 9*

SDG: SDG 4: Quality Education

INTRODUCTION

A nation's progress is contingent on its educational system. Education paced with the advancement of technology is a hallmark of a developed nation. Technology is fundamentally linked with education in the field of science. Science is a central component within the curriculum as it advances the socio-scientific development of the society. Among the different branches of science, physics stands out due to its emphasis on analytical reasoning and problem-solving skills. It aims to explain the physical world through the application of mathematical analysis and conceptual understanding. However, despite its importance, physics is often perceived as one of the most challenging subjects in the curriculum (Sarabi & Gafoor, 2018).

The performance of Filipino students in science remains a pressing concern. In the 2022 Program for International Student Assessment (PISA), only 23% of 15-year-old Filipino students reached at least the minimum proficiency level in science, far below the average of 76%. The assessment focused on concepts such as motion and forces (e.g. velocity, friction) and action at a distance (e.g. magnetic, gravitational and electrostatic forces), which are very relevant in Physics. The recent exam, despite emphasizing mathematics and incorporating a creative thinking assessment, maintained consistency with the 2015 and 2018 frameworks. The statement implied that the Philippines, having come in third to last out of 81 participating countries, indicates severe deficiencies in learning (PISA, 2022; Marôco, 2024).

Traditional instructional approaches, which primarily rely on lectures and textbooks, often fail to address the diverse learning styles of students. These methods may also limit students' engagement and motivation to learn (Hannel & Cuevas, 2018). The integration of information and communication technologies (ICTs) in teaching science opens new possibilities for approaches. Subjects like physics, where abstract ideas cannot be demonstrated in a lab, blended and virtual learning tools make visualization and interactive experimentation possible (Abdulrahaman et al., 2020). Studies with the Physics Education Technology (PhET) simulations show improved concept understanding when used alternately with traditional methods (Rutten, 2014). Active learning id encouraged through these simulations and students are able to manipulate variables which leads to the observation of results and development of higher-order thinking skills (Gnesdilow, 2021; Mešić et al., 2021; Sullivan, 2017). However, existing research offers varying results regarding the overall effectiveness of simulation-based instruction, indicating the need for further empirical investigation.

This study aims to determine the effectiveness of online interactive simulations– specifically CK-12 Physics Simulation–in teaching motion in two dimensions to Grade 9 students at San Jose Adventist Academy. It explores whether this approach leads to better student performance compared to conventional methods.

METHODS

Study Design

This study employed a quasi-experimental design in assessing the efficacy of the CK-12 Physics Simulation on Grade 9 students' performance on Motion in Two Dimensions. Unlike true experimental designs, quasi-experiments work with pre-assigned groups, with the intent of establishing causal relationships between variables. This approach helped the researches to evaluate one group taught by traditional methods and another group taught using simulation-based teaching (Siedlecki, 2020).

This approach was selected because it is more realistic for educational settings where randomization is impossible, and some variables cannot be manipulated for ethical or practical reasons. Though the internal validity of this design may not be as strong as that of true experiments, the use of non-intrusive methods increases the likelihood of obtaining results that can be generalized to broader contexts.

In this case, it was possible to achieve the goal of determining if a notable difference in the performance of Grade 9 students at San Jose Adventist Academy subjected to conventional teaching methods versus those utilizing online interactive simulation laboratories tailored for grade 9 lessons.

Study Site

The study was conducted at San Jose Adventist Academy, San Jose, Occidental Mindoro, during the Academic Year 2023–2024. The school was chosen because it lacks a physical science laboratory and has limited equipment. The study aimed to assess whether online simulations like CK-12 Physics Simulations could enhance student understanding despite these limitations.

Unit of Analysis and Sampling

The unit of analysis for this study were Grade 9 students of San Jose Adventist Academy for the Academic Year 2023-2024, focusing on their performance in motion in two dimensions through online interactive simulation laboratories using CK-12 Physics Simulation.

The sampling units consisted of two specific sections of Grade 9 students taking the Science subject. The researchers employed a complete enumeration sampling technique, involving the entire population to eliminate sampling bias. A total of 40 participants were selected based on their relevance to the study as we studied motion in two dimensions during the fourth quarter of the academic year. Each setup involved 20 respondents from specified sections, included in the overall participant count.

Research Instrument

Parallel pre-tests and post-tests, adapted from the DepEd Science 9 module, assessed understanding of motion in two dimensions. The pre-test assessed baseline knowledge, while the post-test evaluated learning gains. A set of two formative quizzes were also prepared and administered to reinforce concepts and track learning progress across the instructional phase. Each quiz consisted of 15 items, tailored to match the students' performance and abilities observed during instructions. All instruments were validated by science teachers and modified according to their suggestions.

Data Collection Procedure

The principal granted permission prior to data collection from the school. Both groups were given a pre-test to assess their initial knowledge. The control group was given instruction the traditional way, while the experimental group used CK-12 Physics Simulations. Instruction was delivered over five learning sessions during the fourth quarter of the school year. Quizzes were administered after the second and fourth sessions. Two post-tests were given: one immediately after the intervention and another after a short interval to assess learning retention and consistency.

Ethical Considerations

Informed consent was obtained from all participants. Confidentiality was strictly maintained, and data were handled responsibly. The researchers upheld honesty, fairness, and proper acknowledgment of all sources throughout the study.

Data Processing and Analysis

Statistical tools were used to process and interpret the results. Descriptive statistics such as mean, frequency, standard deviation, and percentage were used to summarize and describe the performance data.

To compare the academic performance of the control and experimental groups, an independent samples t-test was employed. This statistical test determined whether there were significant differences between the mean scores of the two unrelated groups both before and after the intervention.

To measure within-group changes, a paired samples t-test was used. This test analyzed the differences between the pre-test and post-test scores of the same group to determine whether the observed improvements were statistically significant or could be attributed to chance.

These analyses enabled the researchers to draw valid conclusions regarding the effectiveness of the CK-12 Physics Interactive Simulation as a teaching tool in enhancing students' conceptual understanding of Motion in Two Dimensions.

RESULTS

Pre-Test Performance of Students

The pre-test showed that both groups similarly had low level of prior knowledge. The conventional method group had a mean of 5.55 (SD = 1.146), while the OISL group had 5.40 (SD = 0.995) [Table 1].

Table 1. Students' level of performance in motion in two dimensions before taught using conventional teaching methods and online interactive simulation laboratory as measured by the pre-test.

Pre-test	Mean	SD	Interpretation
Conventional teaching method	5.55	1.146	Did not meet expectations
Online interactive simulation laboratory	5.40	.995	Did not meet expectations

Legend: 0.00 – 7.99 – Did not meet expectations; 8.00 – 9.99 – Fairly Satisfactory; 10.00 – 11.99 – Satisfactory; 12.00 – 13.99 – Very Satisfactory; 14.00 – 15.00 – Outstanding

Difference in Pre-Test Performance of Students Between Two Dimensions

The independent samples t-test revealed no significant difference between the two groups' pre-test scores (p = 0.661) [Table 2].

Table 2. Independent samples t-test between the performance of the students in their pre-test.

	Mean Difference	t-value	Df	p-value	Interpretation
Pre-test (Control-Experimental)	.1500	.442	38	.661	Not Significant

Legend: p-value ≤ 0.05 – Significant

Post-Test Performance of Students

Post-test results showed that the OISL group scored higher (14.25, SD = 0.786) than the conventional group (11.50, SD = 1.100), indicating better performance with OISL [Table 3].

Table 3. Level of performance of the students in motion in two dimensions taught using conventional teaching method and online interactive simulation laboratory as measured by the post-test.

Post-test	Mean	SD	Interpretation
Conventional teaching method	11.50	1.100	Satisfactory
Online interactive simulation laboratory	14.25	0.786	Outstanding

Legend: 0.00 – 7.99 – Did not meet expectations; 8.00 – 9.99 – Fairly Satisfactory; 10.00 – 11.99 – Satisfactory; 12.00 – 13.99 – Very Satisfactory; 14.00 – 15.00 – Outstanding

Difference in Post-Test Performance of Students Between Two Dimensions

A paired sample t-test showed significant improvement in both groups from pre-test to post-test (t = 21.93, p = 0.000) [Table 4].

Table 4. Paired t-test between the performance of the students in the pre-test and post-test using conventional teaching method and online interactive simulation laboratory.

	Mean Difference	t-value	Df	p-value	Interpretation
Pre-test (Control-Experimental) - Post-test (Control-Experimental)	-7.400	21.93	39	0.000	Significant

Legend: p-value ≤ 0.05 – Significant

Difference Between Pre-Test and Post-Test in their OISL Performance

The OISL group also showed a significant improvement in their scores, with a mean difference of 9.825 (t = 13.603, p = 0.000) [Table 5].

Table 5. One-sample t-test between the performance of the students in the pre-test and post-test using online interactive simulation laboratory.

	Mean Difference	t-value	Df	p-value	Interpretation
Experimental (Pre-test - Post-test)	9.825	13.603	39	0.000	Significant

Legend: p-value ≤ 0.05 – Significant

Difference in Post-Test Performance of Students Between Two Dimensions

The independent samples t-test between the post-test results of both groups showed a significant difference (t = 9.094, p = 0.000), with OISL students outperforming those taught using the conventional method [Table 6].

Table 6. Independent samples t-test between the performance of the students in post-test using conventional teaching method and online interactive simulation laboratory.

	Mean Difference	t-value	Df	p-value	Interpretation
Post-test (Control-Experimental)	-2.75	9.094	38	0.000	Significant

Legend: p-value ≤ 0.05 – Significant

DISCUSSION

A study not that there were no significant differences in the pre-test score outcomes for instructional groups in teaching physics. Such an outcome is in line with studies which indicate that learners perceive the subject of physics to be challenging due to its abstract nature and high reliance on mathematical frameworks (Seifan et al., 2020; Akpinar, 2014; Karacop & Doymus, 2013). Understanding the gaps are well documented, especially in scalar and vector quantities, displacement, and acceleration (Handhika et al., 2019; Motlhabane, 2016; Defianti & Rohmi, 2021).

Post-test results showed significant improvement relative to the pre-test, particularly among students in the Online Interactive Simulation Laboratory (OISL) group. These students performed better than those in the conventional teaching group, suggesting that simulations enhance learning and retention. These results confirm the claims made by Aljuhani et al. (2018), who reported the effectiveness of simulation-based environments in promoting engagement and deeper understanding. Fallon (2019) further emphasized the role of simulations in fostering higher-order thinking and inquiry-based learning.

Within the OISL group, the paired samples t-test confirmed significant gains from pre- to post-test, affirming the effectiveness of simulation-based instruction. Students improved performance with innovative teaching strategies. Simulations appear particularly beneficial for subjects requiring abstract reasoning, like physics (Parno et al., 2020; Alqarni, 2021)

The value of simulation was underscored by an average increase of 9.825 in the OISL group, which a single-sample t-test validated, reflecting almost three standard deviations in the mean shift. According to Deriba et al., (2024), virtual experimentation can be a powerful tool for students to learn and master complex concepts. By providing safe, reproducible, and often gamified learning environments, virtual labs allow students to explore, experiment, and understand intricate ideas in a way that traditional methods might not allow. Akpinar (2014) noted the importance of animated and interactive educational materials in explaining abstract concepts in the study of physics.

Using an independent samples t-test, the comparative post-test analysis yielded OISL group results that were statistically significantly higher than the Control group results, indicating that students learn better in interactive technology-supported environments than the Control group results, indicating that students learn better in interactive technology-supported environments than through traditional lectures. These findings are supported in studies conducted by Chan et al. (2021), and Bautista and Boone (2015) which noted that student motivation, confidence, and achievement are enhanced by simulations. Balaji et al. (2020) also noted that students can safely learn from their mistakes because simulations replicate real lab environments.

It was concerned with one topic of physics within a certain context, which may not be broadly applicable. It also did not take into account student's attitude, engagement level, or retention over time.

Regardless of these limitations, the study supports the integration of online interactive simulations into science education, especially at the secondary level. These tools can enhance learning in conceptually challenging areas. Future research should examine the long-term impact of simulation-based instruction across different science subjects and explore its influence on motivation, critical thinking, and collaboration

CONCLUSION

This study showed that both students in the experimental group and in the control group demonstrated low performance in the pre-test indicating that they had little knowledge of the topic beforehand, prior to the lessons being taught. There was also improvement in the post test scores for both groups. However, students taught using the OISL performed better than those taught through the conventional method. This indicates that OISL is indeed more effective in promoting students' understanding and retention of the subject matter.

The interactive features of the simulation allowed students to explore the lesson more deeply and learn at their own pace, leading to better results. The significant improvement from pre-test to post-test in the OISL group supports the conclusion that virtual labs can improve student learning in science. This finding confirms that OISL helps students learn difficult concepts like projectile motion more easily and with greater interest. One limitation of this study is the small number of students and the short time of implementation. Future research can involve more students, different grade levels, or longer periods of instruction to get more reliable results.

Based on the findings, it is recommended that schools and teachers use virtual labs as part of regular science teaching. These tools can make lessons more engaging and help students understand complex topics. Teachers should be trained to use these technologies effectively, and schools should invest in making these tools available to support better learning for all students.

ACKNOWLEDGMENT

The researchers thank Almighty God, their adviser Jardene May G. Novio, faculty members, administrators, and students of San Jose Adventist Academy, and all who supported and guided them throughout this study

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