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PHYSICS EDUCATION TECHNOLOGY (PhET) SIMULATION AS AID IN INSTRUCTION IN LEARNING CHEMISTRY: AN EXPERIMENTAL APPROACH

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ABSTRACT

The objective of this study was to evaluate the influence of the inclusion of Physics Educational Technology (PhET) Simulations as an aid in instruction in learning chemistry to the Grade 10 learners at Sinobong National High School, a public secondary school in Agusan del Sur. A quantitative study involving pretest-posttest quasi-experimental design was employed to validate the proposed hypotheses. There were 80 participants randomly assigned to the control and experimental groups. The instruments used for data collection were a validated 50-item pre-test/post-test adapted from the Grade 10 Teachers' Guide unified test in the K to 12 science curricula used by the secondary schools. In addition, the mean score and t-test statistical analysis were used to analyze the given data. The results showed a substantial difference between the experimental and control groups' post-test scores. The data support the claim that PhET Simulation significantly influences students' academic attainment compared to a traditional teaching strategy. The researcher suggested that teachers should involve Phet Simulation in their classroom instructions and learning process, and administrators should provide more professional development, workshops, and training to abreast the technological advancement of Phet in chemistry learning.

KEYWORDS: *MAED, Teaching Science, PhET Simulation, traditional teaching strategy, academic attainment*

I. INTRODUCTION

The inadequate acquisition of science processing skills among students has become increasingly apparent in the widespread failure of students in public examinations (Cecila et al., 2020; Celikler, 2020). Chemistry is essential to every aspect of existence. It is the study of the qualities and content of matter, including its chemical reactions, structure, and related modifications (Nkiko, 2021). For most students, the insufficiently valuable exposure provided during chemistry instruction contributes to students' subpar performance. As a result, scholars have persistently pursued the quest for pedagogical approaches that can effectively address this practical limitation (Nkemakolam et al., 2018).

The University of Colorado Boulder developed a nonprofit, open educational resource called Physics Education Technology (PhET) simulations. This project aims to enhance the pedagogical approach worldwide through freely accessible simulations (Banda & Nzabahimana, 2021). This platform enables students to engage in scientific exploration, develop conceptual understanding, establish connections to real-world scenarios, perceive science as enjoyable, and take ownership of the learning experience (Banda & Nzabahimana, 2022).

In the Philippines, there is an increasing demand for technology, and it is exceedingly difficult for teachers to attract students' attention when lessons are not computer-related applications. Sometimes, students must easily engage well in classroom conversations, leading to low academic achievement. The 21st Century Teacher should be adaptable to the changing industry (Paje et al., 2021).

In rural areas, the researcher courageously undertook quasi-experimental research with Grade 10 students of Sinobong National High School. This study could be a reference point for science teachers in developing quality education and suggests an opportunity for future studies to explore the potential benefits and effectiveness of integrating these simulations into the chemistry curriculum for Grade 10 students, thus the urgency to conduct the study.

II. OBJECTIVES

This study aimed to determine that Physics Education Technology (PhET) simulation as an aid in Instruction in learning chemistry affects the academic performance of Grade 10 students. More specifically, this study aimed:

1. To describe the level of performance of Grade 10 students in science before using Phet simulation as aided Instruction in learning chemistry.
2. To describe the level of performance of Grade 10 students in science after using Phet simulation as aided Instruction in learning chemistry.
3. To find if there is a significant difference in pre-test and post-test scores of the controlled group (taught in the traditional method).

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4. To assess the significant difference in pre-test and post-test scores of
5. the experimental group (taught using PhET simulation as computer-aided Instruction).
6. To ascertain the significant difference in the pre-test scores of the controlled and experimental groups.
7. To determine the significant difference in the post-test scores of the controlled and experimental groups.

III. METHODOLOGY

In this study, the quasi-experimental was used pre-tests and post-tests to compare the characteristics of the groups. The respondents of this study were the Grade 10 learners of the school year 2022-2023 of Sinobong National High School in the Municipality of Veruela, Agusan del Sur. The researcher randomly selected two sections (control group and experimental group) each consisting of 40 students. To determine the level of the performance of the sections a pretest was administered to assess participants before treatment to see if there were influences on students' performance. The results of the mean scores that there is no significant difference, suggesting that the level of performance in both in control group and the experimental group were at the same baseline.

The treatment used for the experimental group was PhET simulation as an intervention. During the delivery of lessons, the students are subjected to utilizing a computer laboratory for hands-on experiences. On the other hand, in the control group, a traditional method of teaching was used while the teacher refrained from any use of computer-aided instruction. However, a Self-Learning Module and Learning Activity were utilized for conventional teaching methods. Each of the groups was required to complete four teaching hours a week for three weeks consecutive to cover two learning competencies.

After administering the treatment, the researchers conducted a post-test to measure the attributes or characteristics of participants assessed in both experimental and control groups. A 50-item test questionnaire was adopted and modified from the Pretest/Post-test section of the teacher's guide and unified test used by the science teachers in the K–12 curriculum. The researchers carefully identified and selected each question which was validated using a table of specifications of test items that cover a representative and balanced range of content and cognitive skills from a particular topic.

The Mean score was used to determine the achievement for Pretest and Post-test. Likewise, the t-test was used for the independent sample to determine whether there were significant differences in the performance in the pretest and post-test between the experimental and control groups.

IV. RESULTS

Table 1. Level of Pre-test Scores in Science of the Control Group and the Experimental Group

Pre-test	Mean Score	SD	Description
Controlled Group	9.90	4.04	Very low
Experimental Group	9.00	4.13	Very low

Table 2. Level of Post-test Scores in Science of the Control Group and the Experimental Group

Post-test	Mean Score	SD	Description
Control Group	29.71	7.08	Low
Experimental Group	33.29	6.88	Moderate

Table 3. Significance of the Difference Between the Pre-test and the Post-test Scores in Science of the Control Group

Control Group	Mean Score	SD	t-value	Probability Level	Decision @ α = 0.05
Pre-test	9.90	4.04	24.33	0.001	Rejected
Post-test	29.71	7.08			

Table 4. Significance of the Difference Between the Pre-test and Post-test Scores in Science of the Experimental Group

Control Group	Mean Score	SD	t-value	Probability Level	Decision @ α = 0.05
Pre-test	*9.00*	*4.13*	*30.74*	*0.001*	*Rejected*
Post-test	*33.29*	*6.88*			

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Table 5. Significance of the Difference in the Pre-test Scores in Science Between the Control Group and the Experimental Group

Pre-test	Mean Score	SD	t-value	Probability Level	Decision @ α = 0.05
Controlled Group	9.90	4.04	1.00	0.320	Not Rejected
Experimental Group	9.00	4.13			

Table 6. *Significance of the Difference in the Post-test Scores in Science Between the Control Group and the Experimental Group*

Pre-test	Mean Score	SD	t-value	Probability Level	Decision @ α = 0.05
Controlled Group	29.71	7.08	2.33	0.023	Rejected
Experimental Group	33.29	6.88			

V. DISCUSSION

Table 1 shows the pre-test results for the control and experimental groups. The control group's mean score in the pre-test is 9.90, with a standard deviation of 4.04 and a descriptive equivalent of very low. Similarly, the experimental group posted a very low descriptive equivalent, with a mean score of 9.90 and a standard deviation of 4.13. The results indicate that neither group's chemistry development was observed before using the Phet simulation.

This study's finding is justified by the fact that Chemistry is a discipline that implies a very complex set of knowledge that learners may sometimes find hard to cope with. These results corroborate the idea of Bryne (2020) pointed out that students frequently encountered challenges in middle school when studying chemistry.

Table 2 shows the results of the post-test of the control group and the experimental group. The control group obtained a mean score of 29.71 with a standard deviation of 7.08, indicating low achievement. The mean score obtained by the experimental group is 33.29, with a standard deviation of 6.88, which can also be described as moderate achievement. The results indicate that after using Phet simulation as a medium of instruction, the control and experimental groups' development in chemistry was observed to be low and moderate, respectively.

The results imply that the PhET simulation as a medium of instruction successfully improved the respondents' development in chemistry. This finding is parallel to Byrne's (2020) idea that PhET simulations have provided various benefits for students and teachers. The results consonance with the study of Nuraida et al., (2021) revealed the primary attribute of these resources was to promote independent exploration of physical phenomena among students.

Table 3 shows the difference between the control group's pre-test and post-test scores in science. The group obtained a mean score of 9.90 with a standard deviation of 4.04 in the pre-test. A mean score of 29.71 and a standard deviation of 7.08 are posted in the post-test. The t-test revealed that a t-value of 24.33 was obtained. The obtained probability level is 0.001, which is less than 0.05. This means there is a significant difference between the pre-test and post-test scores of the control group.

The findings corroborate the idea of Cayvaz et al., (2020), who posited that although most nations shifted the focus of their science curricula from the teacher to the student as the primary participant in the learning process, the level of scientific proficiency among middle school learners remains variable. The results are similar to the idea of Permatasari et al. (2022) suggested that understanding abstract chemistry concepts must be facilitated by incorporating diverse representations within the chemistry pedagogy and utilization of multiple representations.

Table 4 shows the difference between the experimental group's pre-test and post-test scores in science. The group posted a mean score of 9.00 with a standard deviation of 4.13 in the conducted test before the treatment was given. The group's mean score in the post-test is 33.29, with a standard deviation of 6.88. These results obtained a t-value of 30.74. Tested at a 0.05 significance level, the 0.001 probability level signifies that the null hypothesis is rejected.

These results parallel the conclusions of Brown et al. (2021), who concluded that computer simulations were a valuable resource for students as they facilitated establishing relationships, interpreting information, and establishing connections between various representations of a given object. The findings consonance with those of Prima et al. (2018), using PhET as a technological medium to facilitate the acquisition of scientific knowledge.

Table 5 shows the difference in the science pre-test scores between the control and experimental groups. In the pre-test, the control group posted a mean score of 9.90 and a standard deviation of 4.04. The experimental group also took the same pre-test, with a mean score of 9.00 and a standard deviation of 4.13. These results give a t-value of 1.00. The obtained probability level is 0.320. Since the obtained probability level is more significant than 0.05, the null hypothesis that there is

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no difference in the pre-test scores in science between the control and experimental groups is not rejected.

The results corroborate the study of Cecilia et al., (2020) mentioned a pressing need for a paradigm shift in how science was conveyed to students. Science subject is concerned with knowledge of the matter, it should be taught via something other than the lecture technique but by using actual items acquired from the environment.

Table 6 shows the difference in the science post-test scores between the control and experimental groups. The control group (taught in the traditional method) posted a mean score of 29.71 with a standard deviation of 7.08. Meanwhile, the experimental group obtained a mean score of 33.29 with a standard deviation of 6.88. The computed t-value for these results is 2.33. With a probability level of 0.023, the null hypothesis that there is no significant difference between the post-test scores of the control group and the experimental groups' post-test scores is rejected.

The results resonate with the idea of Salame & Makki (2021) that PhET computer simulations have been widely used in science education to improve the curriculum. The findings are parallel to the idea of Bahtiar et al., 2022 Considering 21st-century learners were digital and freethinkers, the education standards emphasizing creative and critical problem-solving and decision-making prepared students to solve complex problems in a competitive and technology-intensive world. Parallel to the findings of Yuliati et al. (2018), PhET simulation is deemed significant in enhancing students' comprehension and enthusiasm toward studying as inferred from the issues.

VI. CONCLUSION

Based on the results of the study, the following conclusions are drawn:

1. The level of performance of Grade 10 students in science before using Phet simulation as aided instruction in learning chemistry is very low.
2. The level of performance of Grade 10 students in science after using Phet simulation as aided instruction in learning chemistry is moderate.
3. There is a significant difference between the pre-test and post-test scores of the control group.
4. There is a significant difference between the pre-test and post-test scores of the experimental group.
5. There is no significant difference in the pre-test scores of the controlled and experimental groups.
6. There is a significant difference in the post-test scores of the controlled and experimental groups.

VII. RECOMMENDATIONS

After profound consideration and considering the possible implications of the study's findings and conclusion, the researcher made several recommendations for achieving the optimum level of performance among Grade 10 students in Chemistry.

1. PhET simulations may include lesson planning to offer a dynamic tool for teachers to create well-structured lesson plans that align with the curriculum and include a variety of teaching strategies, such as lectures, hands-on experiments, group discussions, and multimedia presentations.
2. Teachers may promote active learning strategies like problem-solving exercises, case studies, and laboratory experiments using PhET simulations. Encourage students to engage in discussions, pose questions, and establish connections between theoretical concepts and real-life examples.
3. Teachers may utilize visual aids, such as diagrams, charts, and models, to simplify complex concepts and make them more accessible to students. Incorporating technology tools like PhET interactive simulations, virtual labs, and educational websites to supplement classroom teaching can provide additional resources for self-study.
4. Teachers can use these PhET simulations as a foundation for additional activities such as science fairs, where students can demonstrate their findings, or as part of a field trip, where virtual experiments can complement real-world observations.
5. Teachers may continually update their knowledge and teaching strategies through professional development programs, workshops, and networking with other educators. Staying abreast of new developments in the field of chemistry will enhance their instructional skills and enable them to provide the best learning experiences for students.

VII. COMPLIANCE WITH ETHICAL STANDARDS

The researcher followed ethical standards in conducting this study. The researcher also ensured that the respondents' participation in this study was voluntary. Likewise, the decisions about participation in this research were made from an informed position. It was made sure that this study adhered to the ethical standards outlined, including informed consent, risk of harm, anonymity, and confidentiality.

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