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Integration of Phet Interactive Simulations in Online Synchronous and Asynchronous Teaching of Science: It's Impact on Learners' Science Process Skills

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ABSTRACT

The rife of technology nowadays hugely influences the way various disciplines are taught and learned in the classroom, and Science is no exemption to that. Cognizant of this, the present study aimed to investigate the impact of integrating the PhET simulations through online synchronous and asynchronous teaching of science on the learner's science process skills. A total of 60 Grade 8 learners of Sto. Niño National High School were purposively chosen according to their learning abilities and were randomly grouped into two: the online synchronous group and asynchronous group. Applying the two-group pre-test and post-test design model, the study utilized a validated test questionnaire along with a validated self-made survey questionnaire. Obtained post-test achievement results have revealed the positive effect of integrating PhET simulation in online synchronous and asynchronous teaching of Grade 8 Science in distance learning. Furthermore, no significant difference was deduced between the two teaching methods with a P-value of .057 which signifies the two teaching methods' viability in the teaching of Science integrated with PhET simulation. Moreover, this study concludes that PhET simulation improves the learners' science process skills as perceived by the learners. The learners' agreement rate of both groups is high in the statement items in the perceptual questionnaire. Thereby, the study highly recommends the integration of PhET simulation in the teaching of Science to make teaching and learning more engaging, interactive and effective in this era of massive technological advancement.

KEYWORDS: *Asynchronous Science Teaching, Distance Learning, Online Synchronous Science Teaching, PhET Simulations, Science Process Skills*

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1. THE PROBLEM AND ITS SETTING

Introduction

PhET simulation is undoubtedly one of the most accessible and effective tools in teaching Science today. It offers opportunities for the learners to be engaged in the learning activities and allows them to perform the simulation exercises in their most convenient space (Salame & Makki, 2021), especially now that face-to-face classes have been temporarily halted owing to the COVID-19 pandemic. One of the most successful solutions for satisfying the needs of today's learners in a blended learning setting is integrated learning using computer simulations (Dwi Sulisworo, sn.d.). The introduction of ICT into education has hastened the development of instructional pedagogies that are crucial to learners' academic achievement (Fadi & Aoude, 2015). Hence, this study explores the viability of integrating PhET simulation in online synchronous and asynchronous teaching of Science.

The PhET simulation is an efficient tool for learners in the Physics discipline to strengthen their critical thinking skills (D Sulisworo et al., 2019; Gottschalk, 2018). Puspita Sari and Kuntjoro (2018), Haryadi and Pujiastuti (2020), and Taibu et al. (2021) affirmed in their studies that PhET simulation contributes successfully to the development of learners' science

processes, knowledge, and skills in Physics. They agreed that ICT-assisted teaching gadgets, resources, and models could improve learners' academic performance significantly.

Astutik and Prahani (2018) discovered that when Collaborative Creativity Learning was paired with PhET simulations, Junior High School learners in Indonesia significantly improved their Scientific Creativity. In addition, Manao et al. (2021) and Prima et al. (2018) found out that PhET boosted learners' enthusiasm to participate in class by allowing them to investigate abstract concepts eagerly. Although PhET simulations were originally made according to the Physics education concepts, surveys with learners, and class observations (Özcan et al., 2020), it must be put into account that PhET is not exclusively for physics anymore; it has penetrated other fields like chemistry and biology (Taibu et al., 2021). However, there are still few studies conducted on the effective use of PhET simulation in other science fields like Chemistry to bring out the inclusive effect of using PhET simulation.

The foregoing studies only concentrated on the effectiveness of PhET simulation in science teaching in the classroom. Now, in distance learning, PhET is commonly employed through synchronous online teaching. Although PhET is proven to be an effective tool in teaching Physics, there are no studies yet that support its effectiveness in improving the science process skills of the learners in Chemistry in distance learning in the Philippines, and more specifically in the school under study where many students fared dismally in the said subject as evident on the mean percentage score (MPS) in the last two school years. Furthermore, since the online teaching and learning process is challenged by affecting factors such as the availability of gadgets of the learners, the time schedules of the teacher and the learners in dealing with synchronous online classes, the learning styles of the learners in coping up the distance learning modalities, and the slow internet connection, the teacher needs to be more flexible, creative, and adaptive in delivering the lessons in the distance learning.

Based on the preceding arguments, the result of this study would be extremely beneficial to the learners in grasping Chemistry ideas in distance learning, as it is based on the principle that teaching science is only effective when learners participate in interactive activities such as simulations. Moreover, this intervention could be a strong potential to improve the perennial low achievement scores of the Grade 8 learners in Chemistry with an average of 67.34 MPS. Furthermore, despite the distance form of education, PhET simulation can be a solid exercise to be implemented into learning modules or activity sheets for learners to enjoy flexible, engaging learning. In this context, the researcher will integrate the use of PhET simulations in order to assess the effective strategies in employing PhET and to determine its effect on the learners' science process skills and academic performance in Sto. Niño National High School, Sto. Niño, San Agustin, Surigao del Sur in distance learning.

Theoretical Framework

This study is founded on the following theories: John Dewey's Inquiry-based Theory, Lara Kathleen Smetana and Randy L. Bell's Computer Simulation Theory, and Greg Kearsley and Ben Shneiderman's Engagement Theory.

This study is instituted on the **Inquiry-based Learning Theory,** also known as learning by doing, by John Dewey (1910). The core of inquiry-based learning is a self-directed exploration that exercises freedom for learners to take more responsibility for their learning (Yunus & Pammu, 2015).

One of the characteristics observed in Inquiry-based learning is by employing investigative processes such as measuring, classifying, predicting, inferring, experimenting, drawing conclusions, and generalizations.

Corpuz and Salandanan (2007), in their book Principles of Teaching 1, enumerated the outcomes of inquiry-based learning: improves initiative and critical thinking skills; builds up the confidence to discover more; independent inquiries develop their sense of responsibility in managing their learning; sharpens learners' intellectual capabilities; concepts and facts that learners discovered themselves are stored in their permanent learning, and; students are effectively learned by manipulating and carefully examining natural objects.

However, realia is not always available in the classroom. Thus, alternatives like computer simulations are employed to facilitate the inquiry approach to learning.

According to Smetana & Bell (2012), **Computer Simulations Theory** has a significant potential to improve teaching and learning methods that enable teachers to bring even the most abstract topics to the students and incorporate seemingly unrealistic or unattainable events into the daily teaching instructions. Collaboration with computer simulations resulted in demonstrable advances in achievement, demonstrating that computer simulations had more significant benefits than traditional methods.

Users can use simulations to record their observations and engage with representations of events that would otherwise be invisible. As indicated by Kearsley & Shneiderman (1998) in their **Engagement Theory**, which is a framework for Technology-based Teaching and Learning, learners become more active and involved in the teaching and learning process as a result of this. The basic concept of engagement theory is that learners should be profoundly immersed in the teaching-learning process by participating in activities that are relevant to them. Although such interaction would be impossible without using technology, it is believed that technology has the undoubted potential to enable involvement in ways that would be difficult to achieve otherwise. As a result, engagement theory is a theoretical underpinning for technology-assisted learning. Forming influential collaborative groups that work on demanding activities that are important to the learners outside of the classroom is also central to engagement theory.

Despite being derived in part from theoretical frameworks for learning, it shares many similarities with many other frameworks. It is, for example, entirely congruent with constructivist techniques because of its emphasis on purposeful learning. It can be grouped with contextual learning theories because it emphasizes student collaboration. These theories are significant to the present study since they support the uses and functions of PhET interactive simulation as a teaching tool in Science.

The primary goal of this study is to see how adding PhET interactive simulations into online synchronous and asynchronous instruction of Grade 8 Science in distance learning affects the learners' science process skills via distance learning.

Conceptual Framework

Learning Science is more effective when combined with interactive learning activities like computer simulations, which allow students to explore and discover independently, allowing them to participate actively in the teaching and learning process.

In this study, the main goal is to determine the impact of integrating PhET Simulations in online synchronous and asynchronous teaching of Grade 8 Science on the learners' science process skills in the new normal. The schematic diagram of the study is presented in figure 1.

As shown on the first box, the core of the study is the integration of PhET simulation in the existing learning activity sheets (LAS) for Grade 8 Science. Learning activity sheets have been the primary material used in the Department of Education during this time of pandemic where education is delivered through distance learning. LAS is a self-directed instructional material aimed at guiding learners in accomplishing activities at their own pace and time using contextualized resources in the community. This material is based on the Most Essential Learning Competencies (MELC) issued by DepEd Central Office. In the context of this study, the researcher added an additional element in the material which is the integration of PhET interactive simulations to make distance learning more engaging and interactive sans face-to-face instruction. Through student manipulation, PhET simulations aid students in understanding hard to grasp concepts in science by creating visual representations.

Moreover, the study explores the viability of incorporating PhET simulations in two distance learning delivery modes dominant in the Department of Education namely, synchronous and asynchronous teaching. In this study, as an online instruction, both synchronous and asynchronous distance teaching and learning are aided by the internet. Asynchronous teaching used google drive as platform where all materials are uploaded and downloaded from. This allows flexible time in teaching and learning process. On the other hand, synchronous teaching made use of google meet to conduct classes and whereby teachers and students directly interact virtually. The study further endeavored to find out whether or not there is significant difference on the performance of the students employing these two modalities.

By integrating PhET simulations in the teaching of science, this research also foraged how this interactive simulation affects the science process skills of the students. These skills include observing, communicating, classifying, inferring, measuring and predicting. These are among the thinking skills which teachers need to develop among students as they study and investigate the world of science. By doing so, all these boil down to the ultimate goal of improving the academic performance of learners in science equipped with the paramount skills in scientific investigation through the use of modern technology such as PhET interactive simulations as relevant and meaningful platform.

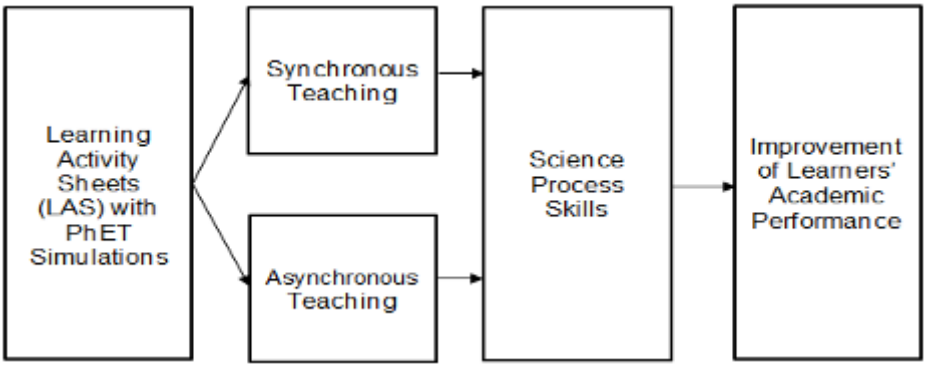

Figure 1 Schematic Diagram of the Study

Statement of the Problem

The study aimed to determine the effect of integrating PhET Simulations in Online Synchronous and Asynchronous teaching of Grade 8 Science in the new normal. Specifically, it sought to answer the following:

1. What is the pre-test and post-test achievement of learners exposed to online synchronous science teaching and asynchronous science teaching incorporating PhET interactive simulations?
2. Is there a significant difference between the learners' exposed to online synchronous and asynchronous teaching of Science using PhET interactive simulations?
3. What is the level of application of the science process skills in PhET interactive simulations as perceived by the learners?
4. What are the challenges encountered by the learners in integrating PhET simulations in online synchronous and asynchronous teaching science?

Hypothesis

To answer objectively the problem number 3, hypothesis was formulated to guide the researcher on whether to negate or accept the findings and are to be tested at a 0.05 level of significance:

H_{o1}: There is no significant difference between the learners' achievement exposed to online synchronous and asynchronous teaching of Science using PhET interactive simulations.

Scope and Limitation of the Study

The study aimed to determine the impact of integrating PHET Interactive Simulations in Online Synchronous and Asynchronous teaching science to the science process skills of grade 8 learners of Sto. Niño National High School in distance learning modalities.

This study was conducted at Sto. Niño National High School Grade 8 learners in the third quarter of the School Year 2021-2022. Among the total enrollment of 193, only 60 learners were considered the subjects of the study. The basis for choosing the respondents was their grades in Science in the second quarter of this School Year (2021-2022). The 60 subjects were divided into two, Group A and Group B. The Online Synchronous Teaching Group was group A while the Asynchronous Teaching Group was group B. The content standards, as reflected in the Most Essential Learning Competencies (MELC), discussed the particle nature of matter as basis for explaining properties, physical changes, and structure of substances and mixtures, and the identity of a substance according to its atomic structure.

Significance of the Study

The results of the study are deemed significant to the following individuals/groups:

School Heads. The findings could aid them in developing and delivering meaningful in-service training for Teachers. Teachers will be encouraged and educated to use PhET simulations in this way.

Science Teachers. This research is beneficial to them. Teachers can utilize this as an alternative if laboratories are unavailable and if the activities or experiments demand expensive, risky, or difficult-to-find items. It could also be one of the additional possibilities in their instructional tactics for improving the teaching and learning process. Furthermore, this research addresses teachers' concerns and may demand the Department of Education to push for greater ICT integration in the classroom.

Learners. They stand to gain the most from this research. This will stimulate their interest in the subject and encourage them to participate in the educational process. Learners are aloowed to participate in the thinking process, which aids in developing cognitive skills. Furthermore, learners are encouraged to use ICT in their studies and practice self-learning. As a result, they may be able to increase their academic achievement in the topic.

Future Researchers. Other researchers interested in simulations and ICT-based teaching instructions may find this valuable work as a reference. They may utilize the outcomes of this study as a foundation for future research on the same subject.

Definition of Terms

In order to understand some of the terms used in the study, the following are operationally/conceptually defined:

Distance Learning Modality. It refers to a learning delivery method in which the teacher and the learners are geographically remote from each other during instruction. It is the learning modality used in the study to restraint the spread the COVID19 pandemic.

New Normal Education System. This refers to the educational milieu during the COVID-19 pandemic and post-pandemic time where education shifted to dominantly distance learning.

Online Asynchronous Teaching. It is a form of online learning which is not limited by time and place. This study will be aided by Google drive for uploading and downloading the materials. The teacher and the learners have flexible time in the teaching and learning process.

Online Synchronous Teaching. It is live, real-time, scheduled, and facilitated online teaching. In this study, it will be aided by a Google Meet Application where a teacher can interact with the learners virtually.

PhET Simulations. PhET simulations are interactive simulations of science and math concepts created by the University of Colorado Boulder. It is the subject to be tested in the study, its effectiveness in improving the science process skills and the academic achievement of the learners if used as a medium of instruction in teaching Science in the distance mode of learning.

Science Process Skills. It refers to the following six actions, in no particular order: observation, communication, classification, measurement, inference, and prediction. These skills promote the scientific creativity, attitudes towards science, and achievements in science of the learners. This is the goal of this study to improve by integrating PhET simulations in two different approaches: online synchronous and asynchronous.

Academic Performance. Refers to the scores gained by the learners in pre-test and post-test after the identified topics were discussed.

2. REVIEW OF RELATED LITERATURE AND STUDIES

This chapter presents a review of related literature and studies from which the study is anchored. It focuses on the effectiveness of PhET simulations in teaching science in general and the findings of researchers on various related studies which are considered to be relevant to the present study.

Related Literature

Foreign

Physics Education Technology (PhET) simulations are computer-aided free online interactive simulations originated in Colorado Boulder University in the year 2002. It was initially created based on observations made in class, conversations with learners, and research on physics ideas. It is available for free because of the ongoing assistance of people from around the world who help to fund the project's progress. PhET is no longer limited to physics; it has spread to other STEM fields such as biology, chemistry, and mathematics. Through demonstrations, visuals, and visualizations, this is an excellent and effective alternative in traditional laboratories for developing fundamental scientific abilities. Learners are allowed to participate in a game-like yet courageous environment in this simulation. Many of the simulations in PhET are appropriate and applicable to learners. As a result, PhET simulations are frequently utilized in education and are preferred by teachers in the classroom. (Özcan et al., 2020).

According to surveys, teachers' top learning goals for using simulations are to help students visualize phenomena, improve conceptual knowledge, engage them in discovery and inquiry, and encourage enjoyment and engagement. In-class activities, virtual laboratories, presentations, worksheets, and homework are just a few examples of how PhET simulations might be used. As a result, PhET simulation empowers teachers by providing a versatile resource that can benefit a wide range of learners across several learning areas and in various ways. The usage of PhET simulations is already having an impact on STEM teaching and learning around the world, according to the numbers. According to the figures, PhET simulations are already impacting STEM teaching and learning around the world, with over 120 million simulations used annually across 200 nations and counting. Currently, with the COVID 19 epidemic raging, the utilization of PhET simulations is skyrocketing. STEM fields are inspired by curiosity about the world's wonder and energy to solve complex challenges, resulting in active undertakings. Finally, a growing number of academics worldwide are undertaking studies on PhET simulations in their local contexts, which is significant evidence of PhET simulations' potential for actual global effect. (Perkins, 2020)

Local

PhET simulation was created for and tested with high school and college learners. However, it became an

educational entertainment for learners in grade schools to even graduate school (Garcia, 2021). This generates free-to-use interactive math and science simulations. Simulations in Philippine education intended to provide an intuitive game-like environment where learners could learn via exploration and discovery. Because simulations are employed in other fields of study outside Physics, the acronym PhET (Physics Education Technology) is unnecessarily restrictive. Despite this, the PhET researchers decided to keep the acronym because it is well-known. The PhET is a free online or download-only interactive simulation in physics, biology, chemistry, earth science, and arithmetic on research.

Computer simulations have different effects on learners based on their academic position and skills, according to research. Learners were given an open-learning environment in which they could improve their understanding of physical phenomena and laws by testing hypotheses; improve their scientific understanding of the relationship between physical concepts, events, and variables by isolating and manipulating parameters; and use various visual illustrations such as animations, pictures, graphs, and numerical figures presentations to help them understand the material. Learners demonstrate their understanding of the physical world and apply an investigative technique to scenarios that are nearly impossible to achieve in science laboratory activities due to their complexity and technical difficulty, lack of resources or time, or because the subject occurs too quickly to be understood by simply observing them in the real-world environment. (Garcia, 2021).

Related Studies

Foreign

Salame and Makki, (2021) evaluate the impact of PhET simulations on learners' interest in learning in their study. In the United States, PhET simulations are used by K12 and college learners in all 50 states, resulting in 45 million runs per year. During the spring and autumn semesters of 2020, they conducted their research at City College of New York. The goal of the study design and paradigm is to examine learners ' impressions of the influence of PhET simulations on their learning and attitudes, as well as to determine PhET's most beneficial aspects. PhET simulations considerably helped learners better understand the concepts of the subject matter, the lecture became smoother and more enjoyable, and the issues addressed made much sense to the learners, according to the findings of their study.

Furthermore, learners agreed that using PhET simulations is simple and enjoyable (Taibu et. al., 2021). It offers new learning chances as an alternative to typical laboratory settings, and it helps learners improve their scientific abilities and academic achievement. The researchers concluded that PhET simulations had a remarkable impact on the learners' attitude toward learning science: learners enhanced clear understanding of the physics concepts because of the various tools available in the PhET simulations, and; understanding complex topics, including the abstract concepts, were made possible for the learners (Puspita Sani & Kuntjoro, 2018). Finally, the findings of this study back up the assertion that general chemistry laboratories need to be upgraded and expanded to accommodate new technology and be offered to learners in the most convenient manner possible.

According to Sulisworo et al. (2019), a study conducted at Ahmad Dahlan University in Indonesia looked into a hypothetical deductive technique helped by PhET simulations on tenth-grade learners' critical thinking skills. The Critical Thinking Skills were measured using non-routine issues, and the results show that PhET simulations can considerably increase CTS.

According to the study's findings, most pupils fared better in the physics course. PhET simulations, as a technique for implementing a hypothetical deductive strategy to improve learners' CTS, had a significant influence on the learners because, according to feedback, they are interesting, entertaining, and simple to use (Astutik & Prahani, 2018). The learners' favorable responses to using PhET simulations to improve their CTS provide teachers the confidence to employ ICT-based activities like PhET in their lectures (Yusuf & Widyaningsih, 2019). The significant contribution of PhET simulation in applying the hypothetical deductive strategy to enhance the CTS of the students, has unlocked opportunities for the learners and the teachers to explore more the technology-supported activities (Thohari et al., 2019). However, if both the teachers and the learners have poor technology literacy, using PhET simulations may be difficult. As a result, it is recommended that before using the application in the classroom, teachers ensure that they have mastered the use of simulations Taibu et al. (2021).

Özcan et al. (2020) found that PhET simulation is the most feasible way of teaching global warming. During the study, it was discovered that the PhET simulation was simple to use. the learners were intrigued to try it at home, that the learners had no problem using the program, and that the PhET simulation made the discussion more enjoyable. The study's findings revealed that PhET simulation helped learners learn greenhouse effect ideas in a statistically

significant way. The study's findings also revealed that simulation methods, such as PhET, are pretty beneficial to the course. Finally, the researchers reiterate that simulations contribute significantly to the development of learning by elevating the teaching approach. It may also be deduced that interactive techniques have a beneficial impact on the teaching and learning process because of their easy-to-use features and capacity to manipulate the outcome, resulting in quick feedback.

The data results indicated that the usage of PhET simulation is successful in the discussion of the Solar System lesson, according to Prima et al. (2018). The learners' reactions to the usage of PhET simulation as a teaching tool in the learning progression are overwhelmingly positive. When they used the PhET simulation to learn about the Solar System, they were excited, entertained, and amazed because they were able to explore the abstract concepts of the subject matter on their own. As a result, they were able to easily answer the problem questions from the worksheet provided to them. PhET simulation is a medium that encourages collaboration. As a result, learners will be more engaged in the teaching and learning process. The higher the academic accomplishment in studying the Solar System, the greater the learner's enthusiasm and interest.

Local

Batuyong and Antonio (2018) studied the impact of PhET simulation on learners' performance and learning experiences in electromagnetism. Based on the data gathered, the generated PhET simulations are incredibly significant in learning outcomes, guidance characteristics, and assessment. They further looked at the impact of PhET simulation on learners' electromagnetic performance and learning experiences. The created PhET simulations are highly significant in learning outcomes, guidance qualities, and assessment, based on the data acquired. The findings and positive feedback from the learners reveal that the produced PhET simulations are valuable. As a result, they are recommended for use in classrooms to help learners understand physical sciencie concepts.

According to Taneo and Moleño (2021) findings, the astonishing difference between the pre-test and post-test outcomes of learners utilizing the PhET interactive simulation tool as a teaching strategy. The PhET simulation approach, according to the data, can significantly increase learners' academic performance in Physics. Based on the findings and conclusions of the study, the researchers recommended adopting PhET interactive simulation to improve learners' learning capacities in Physics.

Mallari (2020) found that while conducting the activities in the class discussion, the learners were very enthusiastic, extremely interested, and entertained while also being challenged. The findings concluded that incorporating a PhET interactive simulation-based teaching strategy improves the performance of grade 7 learners in science; PhET simulation-based activities such as computer-aided instruction encourage learners to be engaged and participate in class, and; the use of PhET simulation-based activities saves time for teachers and learners in science laboratory experiments.

According to Marces and Caballes (2019), the experimental group those who utilized PhET simulation performed better than the control group (who used actual laboratory activities). As a result, the following conclusions were drawn: the PhET interactive simulation is effective as an additional learning option because it caters to learning competencies in the K-12 curriculum; the PhET simulation is beneficial to the academic improvement of grade 10 learners in Physics; the interactive simulation can be a substitute for topics with insufficient or available instructional materials (Linog et al., 2013). Based on the findings, the following suggestions were made; science teachers must use PhET simulation for the identified topics with no available instruments in order to be more effective; curriculum designers and science teachers must develop additional interactive simulations like PhET that align with the learning competencies under the K-12 program; a relevant study that covers other topics with the use of PhET simulation; and a relevant study that covers other topics with the use of PhET simulation.

The study conducted by Constante et al., (n.d.) showed that eighth-grade learners subjected in the study who were commonly female achieved an impressive, very satisfactory performance in seventh-grade Physics. The findings of the study revealed that the control group and experimental group had a remarkable improvement in mean scores from pre-test to post-test. Nevertheless, the experimental group tallied a higher mean difference of 12.21 than to control group, which only tallied a mean difference of 9.06. As to the performance level in the post-test of eight grade learners, the findings showed that most of the experimental group had a better performance (48.5%) level after being exposed to Interactive Computer Simulation Strategy. While on the other hand, most of the learners in the control group achieved an average performance (51.15) level once exposed to Traditional Teaching Strategy, which is comparatively lower than the experimental group.

Generally, the results strongly recommend that science teachers especially who do not specializing in physics, shall consider the use of Interactive Simulation in teaching physics (Taneo & Moleño, 2021).

Synthesis

Several studies have been conducted to test the effect of the use of PhET simulations to improve the academic performance of the learners in the science subject. The common findings among the related studies revealed that PhET simulations is an effective tool to trigger the interest of the learners to participate in the class and involve them in the discussion, allowing them to learn by themselves because of the easy-to-use features of the simulation, thus, the significant increase of post-test MPS.

Studies have proven that PhET simulations can help enhance learning independence and necessary skills of the learners like critical thinking skills. Moreover, PhET simulations is an influential media used in teaching strategies like hypothetical deductive strategy, collaborative creativity learning, and inquiry-based learning. However, among the fields of science, Physics is the most focus of the past studies. Other fields like Chemistry are less concentrated. In fact, no studies on the use of PhET simulations in improving the science process skills of the learners have been conducted in the Philippines.

The preceding studies were only focused on the synchronous teaching of science using PhET simulations in the classroom or computer laboratory setting, where a teacher has instruction to the learners. Furthermore, no studies on the use of PhET simulations in improving the science process skills of the learners in Chemistry in the distance learning have been conducted in the Philippines. Since online teaching is challenged with external factors such as the availability of gadgets for the learners, the time schedules of the teacher and the learners in dealing with synchronous online classes, the learning styles of the learners in coping with the distance learning modalities, and the slow internet connection, the teacher needs to be flexible and creative.

With this, the researcher has caught his interest in studying the integration of PhET simulations in the online synchronous and asynchronous teaching of Chemistry. This is to discover the effective strategies in employing PhET simulation in distance learning that will benefit the teacher and the learners in surpassing the challenges mentioned above. Furthermore, the researcher desired to explore other applications of PhET simulations in improving the different skills necessary for mastering science, one of those is the science process skills. Hence, an improvement in the academic performance of the learners will be achieved. Moreover, this study will help to widen the scope of the effectiveness of PhET simulations in different modalities and in other areas of science for it to be more inclusive.

3. RESEARCH METHODOLOGY

This chapter discusses how the experimental study was conducted. It includes research design, research setting, respondents and sampling procedure, instrumentation, data gathering procedures, and statistical treatment that was employed in the completion of the study.

Research Design

This study used the quasi-experimental design to determine the effect of integrating PhET interactive simulations in online synchronous and asynchronous teaching of Grade 8 Science in the new normal. In this design, two groups of learners were involved: online synchronous and asynchronous teaching. The pre-test and post-test were given to both groups.

Research Locale

This study was conducted in Sto. Niño National High School in the third quarter of the School Year 2021-2022. The school is located in Barangay Sto. Niño, San Agustin, Surigao del Sur as shown on Figure 2.

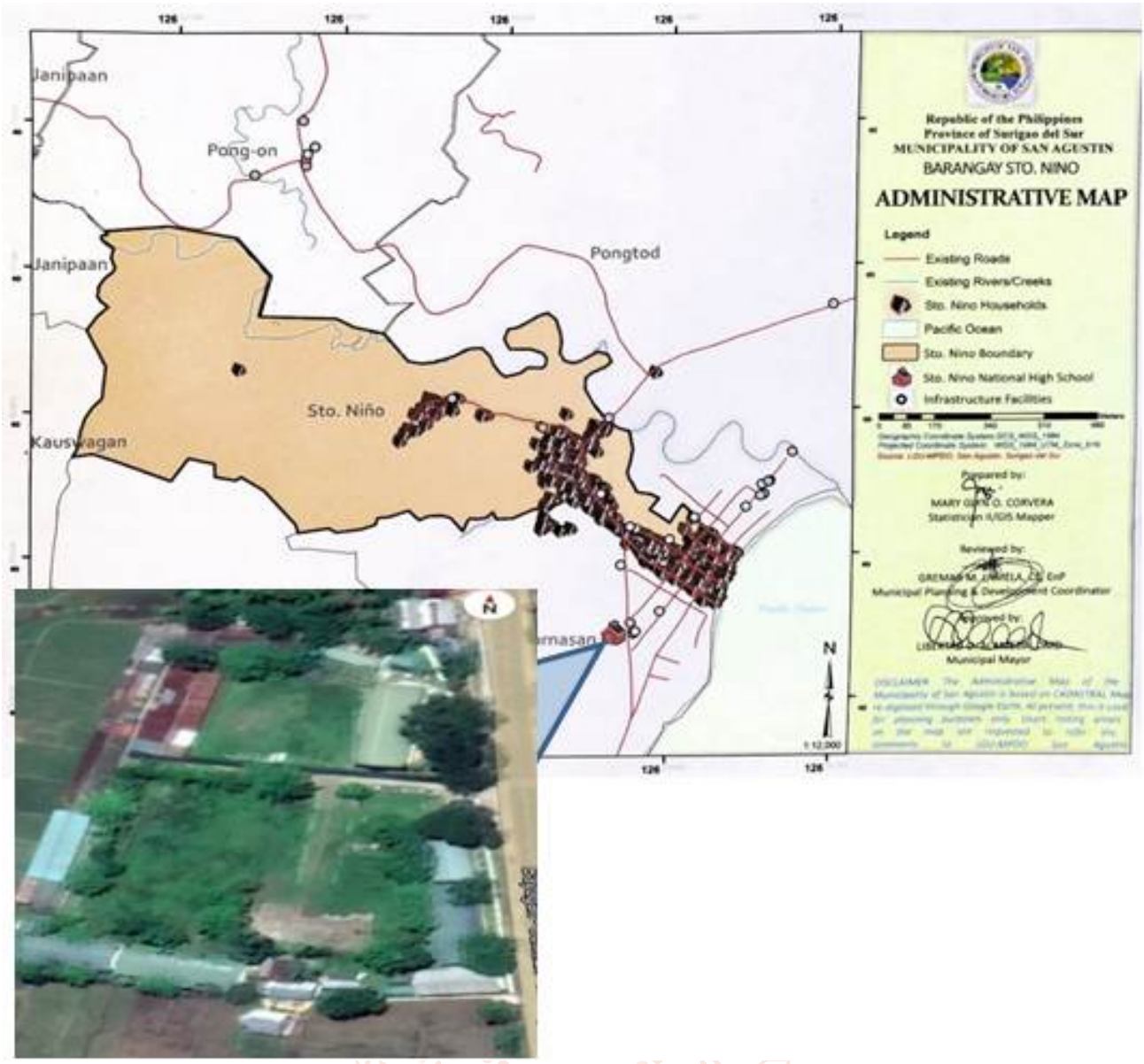

Figure 2 Map of the Study Area

Sto. Niño National High School is the largest secondary school in the San Agustin District, with 816 learners in Junior High School, and 459 learners in Senior High School. The setting of this study was the Grade 8 learners.

Participants of the Study

The subjects of the study were the Grade 8 learners enrolled in Sto. Niño National High School SY 2021-2022. Grade 8 level comprises 8 sections, 1 class is under Science, Technology, and Engineering (STE) program, while the seven classes are under the Basic Education Curriculum (BEC). The total enrollment in grade 8 level is 193, 104 males and 89 females. Out of this number, only 60 were considered the subjects of the study. The 30 subjects in each group were chosen according to their grades in Science in the second quarter of this school year (2021-2022) to ensure that the two groups are comparable. Moreover, the researcher requested the Grade 8 Science teacher to facilitate to conduct the study.

Sampling Procedure

Data in both groups are comparable when students have the same capacity (in this case, academic performance). This makes data more valid and reliable. Following the determination of each learner's ratings per section, the researchers selected 60 learners as the subject of the study research. They are the learners who scored 85 percent and above were chosen as the study's subjects. To guarantee that the respondents are comparable, since learners from section Mendel under Science, Technology, and Engineering (STE) are more advanced when it comes to learning abilities compared the other seven sections under Basic Education Curriculum (BEC), the class was divided into two groups, with the remaining number needed for each group coming from section Courage who received 85 percent and above ratings. The researcher divided the students into two groups using the fishbowl random sample approach. Group A was subjected to online synchronous science instruction using PhET interactive simulations, while Group B was subjected to online asynchronous science teaching.

In identifying the learners' Science grade groupings, the researcher used the School Form 9 or the Progress Report Card of the students in the second grading. The scale on Table 1 was adopted in grouping the students.

Table 1 Distribution of Respondents

Science Grades	Description	Synchronous Teaching Group	Asynchronous Teaching Group
90% and above	Outstanding	13	13
85% - 89%	Very Satisfactory	17	17
80% - 84%	Satisfactory		
75% - 79%	Fairly Satisfactory		
60% - 74%	Failed		
Total		**30**	**30**

After the respondents were randomly grouped, the next stage was to identify the learners who did not have gadgets to provide them the tablets from the school, issued by the DepEd Central Office under the custody of the ICT coordinator. The researcher requested the ICT coordinator on the release of the tablets for the identified no-gadgets learners.

The next stage was the conduct of the two-day orientation and workshop on the proper handling of the PhET simulations, Google Meet (for synchronous teaching), and Google Drive (for asynchronous teaching) to the Grade 8 Science teacher and the research participant learners via face-to-face on February 10-11, 2022. The first day was for the synchronous teaching group, and the second day was for the asynchronous teaching group. This was to make sure that both the teacher and the learners were knowledgeable and equipped with the tools to be used in the study.

Research Instrument

To obtain the data necessary for the study, the researcher utilized three instruments. The first one is the Unified Test Questionnaire in Science 8 in the Region of Caraga. This questionnaire was validated by experts from the different parts of the region. It has also been subjected to reliability test.

Another instrument used was a survey questionnaire to find out the level of application of science process skills of the students in the integration of PhET simulation, while another survey questionnaire was distributed to survey the challenges encountered by the users during the actual simulations. Both of these questionnaires underwent validation and reliability test.

Data Gathering Procedure

The pre-test was given to both the synchronous and asynchronous teaching groups to ensure that they were similar in terms of science competence. Based on the prior discussion, this test will also determine the students' knowledge level of the studied skills and concepts.

The researcher conducted classes on The Particles of Matter and Atoms for both groups. The discussion focused on the competencies stipulated in the Most Essential Learning Competencies (MELC) guide. The duration of this study was started from February 14, 2022 to March 25, 2022.

After all of the topics had been addressed, both the online synchronous and asynchronous teaching groups were given the post-test to assess their learning. The exact tests were given in both types of instruction, and it was multiple choices. Presented on Table 2 is the procedure for the conduct of online synchronous teaching and asynchronous teaching.

Table 2. Flow on the Conduct of Online Synchronous and Asynchronous Teaching of Grade 8 Science with the Integration of the PhET Interactive Simulations

Teaching Approach	Procedure
Online Synchronous Teaching Grade 8 Science with the Integration of PhET Interactive Simulations	➢ Conduct online class via Google Meet (Premium account). ➢ Create a Breakout Rooms for PhET simulation group activity. ➢ Send the link of the PhET Simulation activity to the chat box. ➢ Direct the learners to proceed to the Breakout Room assigned to their group. ➢ Allow each group to perform the simulation and answer the Activity Sheets. ➢ After the group activities, instruct the learners to go back to the main meeting room for the final announcements. ➢ Require the learners to submit the activity sheets together with their modules on Friday. Learners will be provided with a hard copy of activity sheets upon the distribution of the modules every Monday. ➢ Online Synchronous class is scheduled on Tuesday. The session will last 2 hours.
Online Asynchronous Teaching Grade 8 Science with the Integration of PhET Interactive Simulations	➢ The google drive will serve as the access of the teacher and the learners in uploading and downloading the video lessons and PhET simulation links. ➢ In the Google Drive, create folders for the video lessons downloaded from the YouTube and for the links of PhET simulation activities. ➢ Download video lessons from the YouTube and upload it to the Google Drive together with the links for PhET simulation activities. ➢ Share the links to the learners. ➢ Instruct the learners to watch the downloaded lesson and perform the simulations afterwards. They will be given the option whether to watch directly from the link or download first before watching. ➢ Learners have the option to perform the simulation either offline or online. ➢ Require the learners to submit activity sheets every Friday. Learners will be provided with a hard copy of activity sheets upon the distribution of the modules every Monday.

Statistical Treatment

To analyze the data obtained in this study, the statistical tools were employed:

Mean. This was used to:

1. Analyze the pre-test and post-test achievement of learners exposed to online synchronous Science teaching incorporating PhET interactive simulations.
2. Analyze the pre-test and post-test achievement of learners exposed to online asynchronous Science teaching incorporating PhET interactive simulations.
3. Determine the level of application of science process skills and the challenges encountered in PhET simulations.

T-Test. It was applied in determining the significant difference between the learners' achievement exposed to online synchronous and asynchronous teaching of Science using PhET interactive simulations.

4. PRESENTATION, ANALYSIS, AND INTERPRETATION OF DATA

This chapter presents, analyzes, and interprets the data based on the problems and hypothesis of the study.

Pre-test and Post-test Achievement of Learners

Table 3 presents the learners' achievement scores both from the two teaching methods along with their mean gained scores in the two administered tests. As gleaned from the table, pre-test results reveal poor achievement in all level of learners of both groups. In the synchronous group, outstanding learners got 18.9 while very satisfactory learners got 15.9 mean score. In the asynchronous group, outstanding learners got 19.4 while very satisfactory learners got 15.8 mean score. By the standards of the Department of Education, all these scores are considered 'failed'.

Table 3 Learners' Achievement in Pre-test and Post-test

Learning Ability	SYNCHRONOUS GROUP					ASYNCHRONOUS GROUP				
	Pre-test		Post-test		Mean Gained Score	Pre-test		Post-test		Mean Gained Score
	Mean	SD	Mean	SD		Mean	SD	Mean	SD	
Outstanding Learners	18.9	1.656	36.3	1.377	17.4	19.4	1.387	35.6	1.044	16.2
Very Satisfactory Learners	15.9	1.676	31.1	2.045	15.1	15.8	1.921	28.2	2.278	12.5

For the post-test results, it can be inferred that the achievement scores of the learners in two groups dramatically increased compared to their pre-test mean score. Between the two groups, synchronous group had tallied higher post-test mean scores of 36.3 for the outstanding learners and 31.1 for the very satisfactory learners. The achievement of students in the synchronous group may be attributed to the feature of this method which affords students to collaborate, help each other and learn together during the instructional process. Learning at the same time provides the opportunity for students to have a more knowledgeable other such as their teacher or academically-excellent students to give them scaffold during the learning process which immensely aid in better understanding Science concepts. In the context of the study, the synchronous method allowed collaboration among the learners via groupings activity on breakout rooms which supports the claim of Prima et al. (2018) that PhET simulations is an effective medium that encourages collaboration, hence, better understanding to the concepts of the subject matter (Salame & Makki, 2021).

On the other hand, the asynchronous group got 35.6 and only 28.2 mean scores respectively. It can be observed that outstanding learners from the asynchronous group also recorded high mean score of 35.6, closer with the synchronous group with 36.3. This can be attributed to the ability of the outstanding learners of both groups to learn independently. In contrast, the post-test achievement of the very satisfactory learners from the asynchronous group is lower with only 28.2 mean score compared to the 31.1 mean score from the synchronous group. Based on the DepEd Order No. 31, S. of 2015, also known as the Policy Guidelines on Classroom Assessment for the K-12 Basic Education Program, the equivalent Percentage Score of 28.2 is 70.5 which is lower to the standard percentage of 75.

This result supports the findings of Yunzal & Casinillo (2020), that employing PhET simulations individually failed to significantly increase the learners' scores, even if learners exhibited interest in manipulating with the simulation activities. It can be inferred that very satisfactory learners, if not reinforced by an explanation or elaboration from the teacher or from the fast-learner classmates, could hardly grasp the Science concepts.

Test of Significant Difference between Learners' Achievement

The statistical results gleaned in table 4 failed to reject the null hypothesis. There is no significant difference between the achievement of the learners exposed to online synchronous and asynchronous teaching of Science using PhET interactive simulations.

Table 4. Significant Difference Between the Achievement of the Learners Exposed to Online Synchronous and Asynchronous Teaching of Science Using PhET Interactive Simulation

Groups	Mean	SD	df	t	P-value	Interpretation
Asynchronous Synchronous	31.4 33.3	4.141 3.177	58	-1.994	0.57	Not Significant

This concludes that PhET simulations, regardless of its method of application can be a potential tool for inquiry-based learning (Puspita Sari & Kuntjoro, 2018). The results also provide evidence to the theory of constructivism that learner-centered approach is presumed to be an effective way for the students to learn better because they are required to explore and discover by themselves (Batuyong & Antonio, 2018).

This can be concluded further, that teachers can vary the methods in integrating PhET simulations, either synchronous or asynchronous. However, asynchronous method must be done by group for collaborative learning in order for the dependent learners to be mentored by the fast learners. This is a very positive outcome, since online synchronous teaching can be challenged by various factors.

Level of Application of the Science Process Skills in PhET Interactive Simulations

The table 5 presents the level of application of science process skills in using PhET simulations as perceived by the learners. In a 5-point Likert scale, where 1 indicates the 'strongly disagree', while 5 is the 'strongly agree', both groups agreed that PhET simulations activities help them enhance their science process skills.

Table 5 Level of Application of the Science Process Skills in PhET Interactive Simulations as Perceived by the Learners

SCIENCE PROCESS SKILLS	SYNCHRONOUS GROUP		ASYNCHRONOUS GROUP	
Statements	Mean	SD	Mean	SD
I – OBSERVING				
1. Assists me to easily identify the changes in the simulation once I move the sliders.	4.7	0.450	4.6	0.490
2. Strengthens my focus on recognizing what the animated models represent because the activities are fun and engaging.	4.7	0.446	4.6	0.490
Average	**4.7**	**0.454**	**4.6**	**0.486**
II – MEASURING				
1. Helps me in measuring the quantities by changing the units, and the magnitude of the variables.	4.6	0.490	4.5	0.507
2. Helps me estimate the required magnitude of variables necessary in the given activity.	4.6	0.498	4.5	0.507
Average	**4.6**	**0.490**	**4.5**	**0.504**
III – COMMUNICATING				
1. Offers convenient means of answering the activity worksheets because the questions are anchored on the simulation activities that I performed.	4.4	0.504	4.3	0.466
2. Helps me formulate an explanation in answering the questions because I understand the concept of the topic.	4.5	0.507	4.4	0.490
Average	**4.5**	**0.504**	**4.3**	**0.475**
IV – CLASSIFYING				
1. Helps me perform the activity systematically because the sliders are easy to manipulate. 2. Helps me improve in classifying the variables because of the clear representations of the models.	4.5 0.507 4.6 0.504		4.4 0.498 4.4 0.504	
Average	**4.6**	**0.502**	**4.4**	**0.497**
V – PREDICTING				
1. Assists me in forming an understanding of the potential outcomes while moving the sliders.	4.5	0.507	4.3	0.450
2. Activates my curiosity which leads me in formulating my predictions.	4.6	0.504	4.4	0.490
Average	4.5	**0.504**	**4.3**	**0.469**
VI – INFERRING				
1. Helps me obtain factual information because it exhibits actions that are beyond what I can do or see in real life situations.	4.6	0.498	4.5	0.507
2. Presents relevant and appropriate models, allowing me to infer about why a particular result occurred.	4.6	0.504	4.5	0.507
AVERAGE	**4.6**	**0.497**	**4.5**	**0.503**

The group of students that has a higher agreement rate in the statement items in the administered perceptual questionnaire is the online synchronous group learners with an average mean of 4.58 of the combined skills compared to the asynchronous group learners with an average mean of 4.43. Moreover, it is notable that all skills have almost the same mean in both groups. It can be inferred that learners of both groups have applied the six fundamental science process skills in using PhET simulations. These support the claim of Yusuf and Widyaningsih (2019) that employing PhET simulations can develop the learners to cooperate in the teaching and learning process which triggers their creative thinking skills and also agrees to the findings of (Astutik & Prahani, 2018) that Junior High School learners have increased their higher order thinking skills by performing PhET simulations. These skills are integrated with one another, since these are the essential skills that learners need to master for the holistic learning to happen in Science subjects. Furthermore, among the six science process skills, observation skill has the highest agreement rate with a mean of 4.7 in the synchronous and 4.6 in the asynchronous group. This is a positive outcome since observation is the first step among the six process skills. The learners' ability to make a good observation is critical for the improvement of the other science process skills (Maison et al., 2019).

Generally, the positive responses of the two (2) groups of learners confirmed the findings of Ramadhan (2017) cited by Taibu et al. (2021) that using simulation-based ICT tools improve learners' creativity, problem solving skills, higher order thinking skills, and science process skills as simulations like PhET trigger the inquisitiveness of the learners that leads them to discover and explore on their own.

Challenges Encountered by the Learners in Using PhET Simulation

Table 6 presents the challenges encountered in integrating PhET simulations in online synchronous and asynchronous teaching. In a 5-point Likert scale, where one (1) is the 'strongly disagree', while five (5) is the 'strongly agree', it is shown that learners of both methods did not encounter problems in manipulating the PhET simulations which confirms the findings in the study of Taibu et al. (2021) and Salame & Makki (2021) that learners agreed that PhET simulation is easy to use allowing them to enjoy learning the science abstract topics because of its interesting and engaging features. Thus, the participants in their studies encourage the use of PhET simulation in learning Science.

The positive outcome of this survey is the result of the orientation and workshop conducted on the proper handling of PhET simulations and other media to be used prior to the implementation of the study as a proactive measure to the conclusion of Sulisworo et al. (2019) that the use of PhET simulations in teaching will encounter problems if the teachers and learners do not have knowledge in technological literacy.

Table 6 Challenges Encountered by the Learners in Using PhET Simulations

CHALLENGES ENCOUNTERED	SYNCHRONOUS GROUP		ASYNCHRONOUS GROUP	
Statements	Mean	SD	Mean	SD
1. I cannot perform the simulation activity correctly.	1.2	0.430	1.8	0.568
2. I have the difficulty in understanding the representations in the simulation.	1.2	0.407	1.7	0.596
3. I have the difficulty in searching the simulation activity on the website.	1.1	0.305	1.2	0.430
4. I got confused about what to move in the sliders.	1.2	0.346	1.9	0.346
5. I cannot finish performing the activity because I don't understand the whole simulation.	1.0	0.000	1.8	0.407
6. I cannot open the simulation because of the low internet connection in our area.	2.4	0.814	2.4	0.809
7. I cannot concentrate on performing the simulation because of the internet interruptions.	2.0	0.556	1.7	0.466
8. I have the difficulty in performing the simulation activity using a cellphone or tablet.	1.0	0.000	1.2	0.430
9. I cannot perform the simulation without the assistance of my teacher or classmates.	1.8	0.568	1.8	0.568
10. I am not comfortable using PhET simulation in distance learning.	1.0	0.000	1.4	0.490
Average	**1.4**	**0.630**	**1.7**	**0.610**

Hence, there were no problems encountered in searching and using PhET simulation throughout the conduct of the study for the two methods of teaching. Surprisingly, the participants in this study did not encounter major problems in the internet connection as shown in indicator six from the table while performing the PhET simulation activities. However, this problem is still possible to arise since internet connection can be challenging sometimes.

Generally, all learners from both methods were able to handle correctly the simulations and were able to finish performing the simulations themselves.

5. SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

This chapter presents the summary of findings gleaned from the data gathered, the conclusions and recommendations formulated through analysis to fill the gaps of knowledge and determine the impact of integrating PhET interactive simulations through online synchronous and asynchronous teaching grade 8 science in the science process skills of the learners.

Summary of Findings

Regardless of their learning abilities, all students have low prior knowledge on the topics based on their achievements in the administered pre-test. On the other hand, it can be inferred from the post-test achievements of students after integrating PhET simulations in the online synchronous and asynchronous teaching made improvement to all learners of the two proficiency levels; however, its significant increase is more notable and more pronounced to the learners in the online synchronous group with mean score of 35.6 for the outstanding learners while 31.1 for the very satisfactory learners. This can be attributed through the collaboration of the learners in the online synchronous teaching via groupings on breakout rooms compared with asynchronous teaching where each learner had to perform the activities by themselves. However, outstanding learners from asynchronous group have tallied high post-test scores of 35.6, closer with synchronous group. This is an indication that these learners can learn independently. In contrast, the very satisfactory learners from the asynchronous group got lower mean score with only 28.2 mean score compared to the synchronous group with 31.1 mean score. Thus, they failed to meet the DepEd's standard.

Generally, because of high mean scores of the outstanding learners from the asynchronous group, there is no significant difference on the post-test achievement between two teaching methods, with P-value of .057, hence, the nulled hypothesis is accepted.

Further, students approved the statements in the perceptual questionnaire that there is an application of science process skills in using PhET simulations. Based on the table presented, learners agreed that PhET simulations enhance their science process skills because of its creative and engaging features.

The two groups of learners have expressed their perception on the application of science process skills in using PhET simulations in the distance learning wherein they agreed that activities in PhET simulations developed their science process skills.

Moreover, the group of learners agreed that they did not encounter problems in using PhET simulations.

Conclusions

Drawn from the findings of this study, the following conclusions are noted:

Integrating PhET simulations in online synchronous and asynchronous teaching of grade 8 science is proven effective to improve the academic performance of the learners through their post-test results. However, very satisfactory learners from the asynchronous group did not meet the DepEd's standard, hence, these learners could hardly learn independently, although enjoyed in playing the simulations. Therefore, asynchronous method must be done by group so that the outstanding learners who can learn independently can guide and tutor the dependent learners in grasping the Science concepts. Through this collaborative learning can be exercised which is proven effective based on the findings from the preceding studies.

Furthermore, because of the high scores of the outstanding learners in asynchronous group, the total post-test results between two teaching methods are closer with each other with P-value of .057; hence, no significant difference is deduced.

It is also proven in this study that PhET simulations have the impact on the learners' science process skills as perceived by the learners was notable that learners of two groups, after performing the simulations, agreed the statements in the perceptual questionnaire that PhET simulations develop their science process skills.

Finally, there were no problems encountered by the learners in both groups in using PhET simulations. This can be inferred that PhET simulation is easy to use aside from its fun and engaging features.

Recommendations

Based from the drawn findings and conclusions of the study, the following recommendations are formulated:

Teachers are strongly encouraged to integrate PhET simulations in their teaching methodologies for the

learners to be more engaged in learning abstract concepts in Chemistry subjects. This study proves that integrating PhET simulations in asynchronous teaching exhibited potential to be as effective as synchronous teaching which was widely used in the preceding studies. Therefore, the application of the asynchronous method in integrating PhET simulations is suggested if the hampering factors in conducting the synchronous teaching like the challenging internet connectivity, power interruptions, and the conflict schedules between the teachers and the learners may arise. However, integrating PhET simulations in asynchronous method must be done by group not individually, since it is proven from this study that dependent learners could hardly grasp the Chemistry concepts by themselves, even though they don't encounter problems in manipulating the simulation activities. It is also recommended to minimize the activities or workloads of the learners in the distance learning because it may cause exhaustion to them that may lead to poor academic performance.

Since the Philippine education in the new normal limits the contact time of the learners in the face-to-face classes owing COVID19, teachers need to rise to the occasion and design a variety of creative and effective approaches and strategies for the students to enjoy the opportunity in learning despite the recent circumstances. Hence, future researchers are encouraged to conduct a study that merges the asynchronous and synchronous class sessions in improving the science process skills of the learners. This may help in maximizing the effect of PhET simulations in the limited-in-person classes in the blended learning arrangements. Furthermore, to strengthen the perception of the learners of this study, a self-made test questionnaire which is anchored to the science process skills is highly encouraged to test the effectiveness of PhET simulations in improving the science process skills of the learners. Moreover, trainings and workshops on the proper handling of PhET simulations is highly recommended to equip the learners in manipulating the variables in the simulation activities.

Lastly, the outcome of this research strengthens the preceding studies, hence, Information Technology experts are highly encouraged to add more simulation activities to cover other topics not only in the Chemistry subject, but including other fields of Science.

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