

The Effect of Using PhET in Changing Malaysian Students' Attitude to Learning Physics in a Full Virtual Environment

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ABSTRACT

This study investigated the effect of physics inquiry learning using PhET Interactive Simulation on form four students' attitudes toward physics in a fully virtual environment during the COVID-19 pandemic in Malaysia. This quantitative study employed the Quasi-Experimental Design by administering the Attitude Toward Physics Lesson Scale (ATPLS). Fifty-nine form four students from a rural school located in Selangor, Malaysia, participated in this study. The control group ($n_1 = 25$) was taught in the standard thematic order as the usual teaching approach by the teacher during online lessons. In eight lessons, students only watched videos related to laboratory experiments that covered Gravitational Force, Newton's Laws, and Gas Laws. Meanwhile, the experimental group ($n_2 = 34$) used the PhET Interactive Simulations as a treatment to explore the same topics. All test results underwent a normality test, homogeneity test, and hypothesis evaluation. The data in this study were analyzed using Multivariate Analysis of Covariance (MANCOVA) and Analysis of Covariance (ANCOVA). Findings revealed that PhET Interactive Simulation negatively impacts students' attitudes towards physics inquiry learning during the full virtual online lessons. Further study is expected to pair PhET Interactive Simulation with other e-learning tools or platforms to provide better instant feedback and enhance students' attitudes in physics inquiry learning.

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INTRODUCTION

Future jobs will depend on an excellent grasp of the Science, Technology, Engineering, and Mathematics (STEM) subjects as the

request for professional skills that bridge the gap between people and machines increases. As predicted, by 2025, 85 million employments may be uprooted by expanding computerization. In contrast, a few 97 million new fields may develop to be more adjusted to the new workforce section between people and machines. According to the Employment Statistics First Quarter 2021, 55.5% of job vacancies were algorithms (World Economic Forum, 2020). In Malaysia, the government launched the National Fourth Industrial Revolution (4IR) Policy to assist in leveraging innovation and ethical use of technologies for the country's strategic socio-economic transformation (Economic Planning Unit, 2021). Along with the aspirations, the Secondary School Curriculum Standards were enacted to ensure the syllabus is comparable to meet the needs of the STEM professional workforce in the future (Ministry of Education Malaysia, 2013).

The need for workforces in related STEM fields is crucial in Malaysia. As the Academy of Sciences Malaysia predicted, one million workforces are required by 2020 to be involved in the science and technology field. The top critical occupations include support and service comprising technicians, scientists, engineers, digital IT professionals such as prominent data scientists, and content creators who will remain in demand in coming years. In addition in the semi-skilled category and 23.5% were in the skilled category (Department of Statistics Malaysia, 2021). This situation may worsen as current studies show a declining interest

among students in science subjects (Markus et al., 2021; Ministry of Education Malaysia, 2019). As cutting-edge educators, teachers have to explore new and exciting teaching approaches to capture the interest of students who are digital natives as well as change their attitude and behavior in learning science in general and physics in particular (Shahroom & Hussin, 2018).

Background and Overview

According to Rutten et al. (2012), compared with textbooks, chalk, and talk lessons, a learning environment with computer simulations can foster students systematically explore hypothetical situations. Various computer simulations are available to assist in teaching and learning physics. For instance, Sari et al. (2019) used an Interactive Physics simulation program to perform force-motion experiments in a virtual laboratory (VL) compared to the computer-based laboratory (CBL). Similarly, Gusmida and Islami (2017) utilized augmented reality technology to develop a learning media for physics, specifically the kinetic theory of gas. Finally, Ben et al. (2021) studied the effect of using PhET Interactive Simulation among rural and urban students in learning electrical resistance and Ohm's Law. With the help of PhET Simulation, the students can observe natural events in physics that cannot be seen directly, and learners are allowed to manipulate initial conditions directly as well as immediately see the impact (Sari et al., 2017). Therefore, the effect of using PhET in teaching physics has been proven

as a fully-fledged teaching tool (Akhigbe & Ogufere, 2019; Faour & Ayoubi, 2018; Yusuf & Widyaningsih, 2019). However, all these studies were conducted in a face-to-face classroom teaching mode.

Problem Statement and Rationale

As the COVID-19 pandemic surged in the middle of March 2020, many countries, including Malaysia, had to stop their citizens' daily routine activities, such as going out to work or attending school. Educational institutions are one of the sectors that were severely affected by the pandemic. In order to ensure students are not left out of mainstream education, traditional face-to-face teaching has entirely been shifted to a virtual learning environment. The sudden shift to an entirely virtual learning environment has become a significant challenge to teachers and students (Chu et al., 2021). Most teachers have no previous online teaching experience, nor are they familiar with the digital applications to deliver their online lessons effectively (Tan, 2020). The nation gets worried when a report shows students' declining interest in online lessons occurs after studying from home (Mohd Azman, 2021).

In addition, even though lately the Malaysia education system has been revised to move from a teacher-centered approach to a student-centered approach, some teachers still neglected to adapt to the new approach as their primary concern was to deliver all the content on time and prepare their students for final examination (Jing &

Saleh, 2020). This teaching approach has dramatically impacted students' learning attitudes (Fatimah & Santiana, 2017). Hence, there is a need to examine the effect of an alternative strategy in building a desirable attitude and capturing students' enthusiasm toward learning physics rather than using the lecture method (Qaiser et al., 2017).

Aim of Study

Most studies have investigated the effects of implementing PhET on students' attitudes in face-to-face teaching mode (Demeku, 2019; Faour & Ayoubi, 2018; Mahulae et al., 2017). Based on this research gap, the study aims to investigate the effect of physics inquiry learning using PhET Interactive Simulation on Form Four students' attitudes toward physics in a full virtual learning environment. As some teachers struggle to find a suitable way to captivate students and arouse their curiosity in learning physics, thus this study aims to provide a positive example of implementing inquiry learning using the PhET Interactive Simulation. Hence, such simulation encourages students to learn physics with meaningful learning opportunities provided in this educational process (Wardani et al., 2017). The aforementioned claims led to the formulation of the following research question: Is there a significant statistical difference between the post-test mean scores of the control group and experimental group's attitudes toward physics, after controlling for the pre-test score?

Research Question

The research question sounds as “Is there any statically significant difference between the control and experimental group’s attitude toward physics lesson post-test mean scores after controlling the pre-test score?”

Literature Review

Students’ Attitude Towards Physics Learning. Based on a review of past literature, students often faced difficulties relating the physics content and real-world applications, causing a lack of confidence in learning physics. This situation may worsen when students keep facing failure in mastering the physics content. Similarly, students may be able to define the terms such as kinetic molecular theory, but when they need to apply it in solving problems, they reveal their misunderstanding. Hence, examining students’ attitudes toward physics learning is crucial since it is challenging to understand, yet it is complicated to find solutions to physics-related problems (Veloo et al., 2015). Such an attitude like persistence to learn complicated physics solutions is crucial as it could influence students’ attitudes toward physics learning and improve learning achievement (Kurniawan et al., 2019).

Past literature concerning the physics learning environment showed a relationship between the learning environment and students’ attitudes toward physics (Gardner, 1975; Hacıeminoglu, 2016; Rutjens et al., 2018). Further investigation also proved that students’ negative attitudes toward physics were related to a traditional approach used

in the physics classroom. In other words, inquiry physics instruction could foster students’ positive feelings (Hacıeminoglu, 2016). Contrary to this, when students were provided with loads of scientific information directly, they would have a more negative attitude toward physics (Oh & Yager, 2004).

The Rationale for Choosing PhET Interactive Simulation. PhET (previously known as Physics Education Technology) Interactive Simulations are now widely used to teach physics and chemistry (Sarı et al., 2019; Wieman et al., 2010). This free online simulation (<https://phet.colorado.edu/>) is animated, interactive, and engaging for students to learn through exploration. These simulations (abbreviated as sims) have connected real-life applications and physics by visualizing the concept. Additionally, simulations were explicitly designed to support students in constructing a robust conceptual understanding of physics through exploration (Sitindaon et al., 2017).

In recent years, foreign educators have integrated computers into the physics classroom to tap the benefits of using the PhET Interactive Simulations in an inquiry learning environment. For example, Safarati (2017) found that students’ science process skills taught by the scientific inquiry model using the PhET are better than students taught by direct instruction. At the same time, Sitindaon et al. (2017) explained that guided inquiry learning using PhET influences students’ problem-solving skills and critical thinking in physics learning. PhET could also conduct simulation

laboratory activities in electric circuits and wave motion to enhance students' learning attitude (Demeku, 2019; Faour & Ayoubi, 2018). However, Malaysian secondary school teachers have been relatively slow in implementing PhET Interactive Simulation to enhance students' attitudes in the physics learning environment.

Approaches to Teach Physics Topics.

Eventually, this study covers the topics of Gravitational Force, Newton's Laws, and Gas Laws. According to the Standard Secondary School Curriculum, these topics are among the compulsory contents of the Form Four physics syllabus. Students learned about which variable affects the Gravitational Force between two bodies, the application of free-fall situation with three types of Newton's Laws, and determining the relationship between pressure, temperature, and volume of gas in terms of the behavior of gas molecules based on Gas Laws. Past researchers have addressed that secondary school students face more difficulty in physics topics such as forces, movement, as well as pressure due to their abstract and complex concepts (Fidan & Tuncel, 2019). The findings of a study conducted by Kane et al. (2016) have demonstrated that 14% of their respondents have many misconceptions about the 'pressure and kinetic energy of gas'. Furthermore, the forces associated with Newton's Laws of Motion included its microscopic aspects, such as speed, collisions, and pressure gas, that increase the difficulties.

Various literature shows that educators use different approaches to teach these topics in the physics discipline (Fidan & Tuncel, 2019; Gusmida & Islami, 2017; Tobaja et al., 2017). Tobaja et al. (2017), for example, found that using the jigsaw technique in mapping radioactivity concepts could help students learn meaningfully with the lesser effort needed. On the other hand, Fidan and Tuncel (2019) suggested that integrating augmented reality into problem-based learning in Newton's Laws could lead to positive learning emotions.

However, these approaches may not be suited to the current local environment situation where students have faced challenges such as lack of access to internet facilities, poor communications with peers and teachers, as well as delaying feedback from their teachers in this virtual learning environment (Bestiantono et al., 2020; Tan, 2020). In this case, using PhET Interactive Simulation during virtual physics lessons can be an alternative way, as it can be downloaded for free and is user-friendly.

According to Yuliati et al. (2018), learning with PhET simulations can make the invisible appear and provide multiple representations (macroscopic, microscopic, graphics) of an abstract concept. Hence, using this media will provide the students with the opportunity to visualize the abstract concept of physics. Nevertheless, such simulations that emphasize the connections between real-life phenomena and physics have a researchable viewpoint if PhET Interactive Simulation effectively changes students' attitudes and behavior in learning

physics (Pucholt, 2021). While it is essential for students to conduct actual laboratory hands-on activities and understand the physics concepts (Fouad et al., 2018), PhET simulations fulfill the needs when schools are closed down. Thus, this shows that the study on implementing PhET to learn Gravitational Force, Newton's Laws, and Gas Laws during the full virtual environment is essential.

Relationship Between Attitude, Belief, and Interest in Physics Learning.

Attitude is an affinity to supply learned, consistent, positive, or adverse reactions to a question, such as a subject or a lesson (Syahril et al., 2019). While physics is challenging to understand due to its abstract or complex structure, students' attitudes toward physics learning may be negatively affected (Fidan & Tuncel, 2019). Nevertheless, students' attitudes toward learning physics and beliefs are influenced by their intention to study physics, confidence level, teachers' characters, interactive learning environment, and other factors (Astalini et al., 2018; Sheldrake et al., 2019).

The feelings, beliefs, and interests about physics also contribute to students' attitudes toward physics learning (Jufrida et al., 2019). In other words, students' attitude toward physics learning is influenced by their feelings, beliefs, or interest in physics. According to Crouch et al. (2018), "interest" refers to positive feelings toward something that can lead to the desire to continue seeking knowledge and learning. However, interest differs from the attitude of learning

as liking can be a proxy for attitude; it is not an adequate marker of interest (Crouch et al., 2018).

Hypothesis

H1: There is a significant difference between the control and experimental groups' attitudes toward the physics lesson post-test mean scores after controlling for the pre-test score.

MATERIALS AND METHODS

Sample of the Study

In this study, Quasi-Experimental designs were employed (Creswell & Creswell, 2018). This design was employed because the sample cannot be randomly assigned, and researchers want to investigate the cause-and-effect relationship. In addition, the non-equivalent group pre-test and post-test design were applied in this study because the number of students in the three classes differed. A total of 59 Form Four students from a secondary school in a rural area in Selangor, Malaysia, participated in this study. The respondents were selected from the same school to ensure that comparing the students' and both groups' result was legitimate. They were separated into the control group ($n_1=25$) and the treatment group ($n_2=34$). Both groups' average age is 16 years old and has the comparable ability to access the internet and comparable learning physics experience. Their science background are similar, as 61% obtained a credit (at least grade C and above) for the PT3 science examination. In comparison, 88% obtained credit for

the PT3 mathematics examination. Table 1 demonstrates the comparable learning physics experience between the control and treatment groups.

Table 1

Comparable learning Physics experience between the control group and treatment group

Control Group	Treatment Group
Students were engaged with their relevant background knowledge based on different themes during online lessons.	Students used PhET Interactive Simulation as a tool to explore different themes in the fully virtual environment.
Students watched videos related to the topics before solving problems.	Students conduct experiment activities via PhET Interactive Simulation before solving problems.

Instrumentation: Attitude Toward Physics Lesson Scale (ATPLS)

The Attitude Toward Physics Lesson Scale (ATPLS) was adapted from Cheung's (2009) Attitude Toward Chemistry Lessons

Scale (ATCLS). This self-administered survey questionnaire has 12 items covering cognition, affective, and behavior components in measuring students' attitudes toward physics lessons (Table 2).

Table 2

Categorization of attitude toward Physics lessons scale items

Construct	Item
Liking for physics theory lessons	I like physics more than any other subject. Physics lessons are interesting. Physics is one of my favorite subjects.
Liking for physics laboratory work	I like to do physics experiments. When I am working in the physics lab, I feel I am doing something important. Doing physics experiments with PhET is fun.
Evaluative beliefs about school physics	Physics are useful for solving everyday problems. People must understand physics because it affects their lives. Physics is one of the most important subjects for people to study.
Behavioral tendencies to learn physics	I am willing to spend more time reading about physics. I like trying to solve new problems in physics. If I had a chance, I would do a project in physics.

ATPLS was categorized based on four construct: liking for physics theory lessons, liking for physics laboratory work, evaluative beliefs about school physics, and behavioral tendencies to learn physics. A six-point rating scale labeled as strongly

disagree, disagree, slightly disagree, slightly agree, agree, and strongly agree was applied to measure respondents' degree of attitude. Beglar and Nemoto (2014) suggested that most Likert scales should be made up of six points, which excluded the *neutral* or middle category (e.g., *not sure*) to avoid statistical problems in that analyses of rating scales as they do not fit statistical models well. The ATPLS is recommended to measure students' attitudes overall and how dynamically they conceptualize "attitude to physics lessons" as a student's affective response toward physics, cognitive response, and behavioral tendencies to learning physics in school (Cheung, 2009).

Validity and Reliability

Since the ATPLS was adopted from the instrument based in the Hong Kong context, validity and reliability tests need to be carried out to ensure it is suitable for the Malaysian context. The items were validated by two experts from the National STEM Center. In order to ensure that students understood the language used in the items, two English teachers were invited to validate the questionnaire from the language perspective. Before the actual study, a pilot test was conducted to establish the content validity of scores on ATPLS. Forty Form Four students from nearby schools with similar backgrounds to actual study participants were invited to participate in the pilot study. The Cronbach's Alpha value obtained from the pilot study is 0.94, and the items in the questionnaire are appropriate to be administered in the Malaysian context (Creswell & Creswell, 2018).

Research Procedures

Prior to the study, all students' attitudes toward physics were measured using ATPLS. The control group was taught in the standard thematic order, where the teacher started with students' strengths and engaged them with their relevant background knowledge based on different themes during online lessons. The teaching and learning for the control group were conducted as usual without any interference or changes to its original setting. In eight lessons, students in the control group only watched videos related to laboratory experiments that covered Gravitational Force, Newton's Laws, and Gas Laws.

Meanwhile, the treatment group used the PhET Interactive Simulation to explore the same topics with the teacher's guidance during the full virtual environment. For example, one of the lessons applied Gravity Force Lab from the PhET simulations to explore Newton's Universal Law of Gravitation (Figure 1).

Students could manipulate few variables, such as masses, force values, distance, and regular size, to explore the consequences of each change. While students were involved actively with their mental and physical involvement during this exploration phase, they could establish relationships, observe patterns, identify variables, and question events.

Using the results obtained from the PhET, students determined two variables affecting the gravitational force between two bodies. Then, students explained the relationship between these variables and

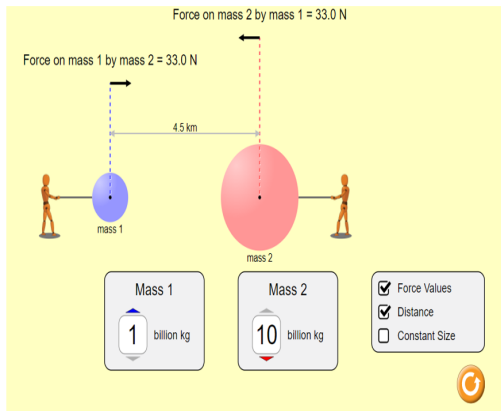


Figure 1. A screenshot of the Gravity Force Lab simulation interface.

gravitational force. In addition, students used PhET to elaborate further on the applications of gravitational force in daily life (e.g., students predicted the condition to gain minimum gravitational force between two bodies). At this moment, students corrected their remaining misconceptions and generalized the concepts in a broader context. Finally, students completed the evaluation activity at the lesson's end.

In this way, the treatment group students used their computers or handphones to work with the PhET Interactive Simulation and a worksheet to guide them during the physics online lessons. Thus, the teacher facilitated and guided them to explore as well as solve their individual and group tasks. Therefore, the treatment group students were actively engaged with the online lessons and could monitor their understanding as concurred with the literature (Arafah et al., 2020). After both groups had completed all their online learning lessons, a post-test was conducted to measure their attitude again using the ATPLS. Although both groups used

different methods, they were comparable as the purpose of this study is to study the effect of using PhET compared to a more conventional method for the same teaching content as well as the same duration of time (Karpudewan & Mohd Ali Khan, 2017; Pucholt, 2021).

Due to the COVID-19 pandemic, all the control and experimental groups were conducted entirely via a virtual platform. During this period, no physical or face-to-face interaction between teacher-students and students-students. Hence, the teaching and learning activities are solely based on virtual interaction.

Data Analysis

The data obtained from the ATPLS questionnaire were analyzed using SPSS version 16.0. Descriptive statistics were used to report mean and standard variation for the score for each construct in ATPSL. Meanwhile, inferential statistics such as MANCOVA and ANCOVA were employed to determine the difference between the control and experimental groups and rule out the effect of PhET in enhancing students' attitudes toward physics learning.

RESULTS

To meet the assumptions for the application of MANCOVA and ANCOVA, the pre-test and post-test scores were found to be normally distributed based on Kolmogorov-Smirnov tests. Another assumption that has been met is the homogeneity of regression with significant results $F(4, 53) = 3.366, p < 0.05, \text{Wilks' } \Lambda = 0.797$, partial

$\eta^2 = 0.203$. Meanwhile, the last assumption of equal variances between the two groups in the data was tested using Levene's Test of Equality of Error Variance. This result indicated that the p -value between the treatment interaction and pre-test with post-test for all four constructs under students' attitudes toward physics was greater than 0.05 (see Table 3).

Table 3
Summary of the F and P -value for Levene's test of equality of error variance

Construct	F	P
Liking for a physics theory lesson	1.85	0.18
Liking for physics laboratory work	0.01	0.94
Evaluative belief about school physics	2.39	0.13
Behavioral tendencies to learn physics	1.00	0.32

Table 4 presents a deduction in the post-test mean values in all four constructs in the ATPLS. Surprisingly, the results show that the treatment group has lower post-test mean scores than the control group. As such, it can be postulated that PhET Interactive Simulation has a limited impact on the treatment group students to obtain a higher score in the post-test.

Table 4
Descriptive statistics for all the four constructs included in attitude toward Physics lessons

Construct	Group									
	Control					Treatment				
	Pre-Test	SD	Post-Test	SD	Diff	Pre-Test	SD	Post-Test	SD	Diff
Liking for a physics theory lesson	4.61	0.88	4.31	0.92	-0.30	4.03	0.94	3.82	0.99	-0.21
Liking for physics laboratory work	4.90	0.77	4.52	1.15	-0.38	4.58	1.04	4.29	0.99	-0.29
Evaluative belief about school physics	4.96	0.69	5.04	0.64	-0.08	4.48	0.81	4.28	0.90	-0.20
Behavioral tendencies to learn physics	4.43	0.91	4.24	0.83	-0.19	3.96	0.80	3.75	0.92	-0.21

The MANCOVA analysis was conducted to analyze the significant difference in attitude toward physics lesson post-test mean score between the control and treatment groups after controlling the pre-test score. The results are summarized in Table 5.

Table 5

Results obtained from Wilks' Lambda test

Effect	Wilks' Lambda	F	Hypothesis df	Error df	Sig.	η^2
Intercept	0.448	16.304 ^b	4.000	53.000	0.000*	0.552
Pre-Test	0.844	2.453 ^b	4.000	53.000	0.057	0.156
Treatment	0.797	3.366 ^b	4.000	53.000	0.016*	0.203

Hence, the hypothesis is rejected, with results showing significant differences before and after implementing PhET Interactive Simulation during full virtual learning. However, this result suggests that the PhET Interactive Simulation implemented in the school context leads to a more negative attitude among students than regular teaching during the virtual lesson.

Due to the significant result obtained from Wilks' Lambda test, the ANCOVA analysis result was obtained from Tests Between-Subjects Effects. Test of Between

Subjects Effects for three constructs shows a significant effect of the independent variable on the dependent variable (liking for physics theory lessons, evaluative belief about school physics, and behavioral tendencies to learn physics). The test result shows that the post-test score for these three constructs is significant, with $p < 0.05$. However, one construct (liking for physics laboratory work) is non-significant with $p > 0.05$. The summary of results obtained from Tests Between-Subjects Effects is presented in Table 6.

Table 6

Summary of tests of between-subject effects

Construct	Sum of Squares	Mean Square	F	Sig.	η_p^2
Liking for Physics theory lesson	5.886	5.886	6.882	0.011*	0.109
Liking for Physics laboratory work	1.480	1.480	1.332	0.253	0.023
Evaluative belief about school Physics	6.889	6.889	10.529	0.002*	0.158
Behavioral tendencies to learn Physics	4.600	4.600	5.962	0.018*	0.096

DISCUSSION

The research revealed that PhET Interactive Simulation negatively impacts students' attitudes toward physics inquiry learning during the full virtual online lessons. Surprisingly the finding does not concur with the resulting yield by Wardani et al. (2017), as PhET Interactive Simulation has no significant direct influence over students' attitudes toward physics. Students have declined interest in learning physics after implementing the PhET Interactive Simulation during the full virtual learning lessons. One logical explanation could be the influence of physical distance that caused students' anxiety during the COVID-19 pandemic, as reported by Ardan et al. (2020), where more than 90% of their respondents were feeling depressed, fearful or worried that they would be exposed to COVID-19 and less able to concentrate in their study. The situation could be worsened if the student is from a disadvantaged family background (Putra et al., 2020).

Students face challenges and difficulties with limited online facilities and less supervision and guidance than with face-to-face study (Tan, 2020). According to Hamid et al. (2020), many students (64.3%) perceived fully online learning during COVID-19 as less effective than face-to-face learning. The study further elaborated that various factors, such as limited space for interaction between students and teachers, the readiness of students, as well as limited resources, have decreased students' interest in attending their online classes. This statement is aligned with Bali and Liu

(2018) that students' perceptions of face-to-face learning were higher than online learning in terms of social presence, social interaction, and satisfaction. The rationality goes that when previous research on the effect of PhET Interactive Simulation, which was conducted either face-to-face or a mix between online and face-to-face (Pucholt, 2021; Sitindaon et al., 2017; Yusuf & Widyaningsih, 2019), could be successful but less effective when it is conducted in a fully virtual environment.

In addition, a post-intervention interview was carried out to rule out further the reasons for declining attitudes among students in physics learning. A few students reported limited teacher support when lessons were entirely conducted in a virtual learning environment. Other reasons are that students were likely addicted to online games, causing them to lose interest in studying. Some worked part-time jobs to reduce family financial burdens during this COVID-19 pandemic. However, there were no complaints regarding using PhET Interactive Simulations during their online Physics lessons.

CONCLUSION

Summary and Significance of Study

This study examined the effect of physics inquiry learning using PhET Interactive Simulation on students' attitudes toward physics. Many studies have been conducted to determine the effects and advantages of implementing PhET Interactive Simulation in physics teaching. However, very few have been done in a fully virtual learning

environment where students and teachers faced more challenges and obstacles than before during this COVID-19. It came to light in this study that students' attitude toward physics is declining, although the implementation of PhET Interactive Simulation was proven to increase the students' positive attitude toward physics in previous studies (Demeku, 2019; Veloo et al., 2015). Nevertheless, the outcomes of the study notified that the PhET might not be suitable to be applied during the entire virtual environment to enhance students' attitudes in physics lessons; thus, further study is recommended toward this viewpoint.

Limitation and Suggestions

The researchers conducted this study online as the current COVID-19 pandemic did not allow the researcher to conduct a face-to-face study. Therefore, it might affect the study results. Some students did not turn up during the online lessons due to personal matters, technical issues, school training lessons, and extraneous influences. These extraneous influences or unessential impacts from outside, such as the uncertainty of the COVID-19 pandemic progression, cause unstable emotions among students, especially when they cannot carry out daily activities such as going to school (Ardan et al., 2020).

Therefore, the study recommends that the teachers pair PhET Interactive Simulation with other e-learning tools or platforms to provide better instant feedback and guidance to students in online learning.

The outcome of this study shall alarm all educators that although an approach may be practical during regular school lessons, it may not be the same as conducting in a fully virtual environment.

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