

Learning Media PhET Laboratory to Improve Understanding of Mathematical Concepts: Classroom Action Research

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Abstract: The use of technology in the context of education has become an urgent need to improve the effectiveness of learning in primary schools. The study aims to evaluate the impact of PhET (Physics Education Technology) media use on the understanding of mathematical concepts in the SDS YMI Tani Makmur District. This research method is class action research with the aim of improving the understanding of mathematical concepts. The study was conducted in two cycles. In Cycle I, only 15 pupils understood the material, and the test results were 53.58%. For pupils who did not understand the material, there were 13 pupils with a percentage of 46.42%. In Cycle II, there were 26 pupils that did understand the materials, and the test results of the pupils were 92.85%, and for students who didn't understand the matter, there were 2 pupils and 7.1%. By using PhET, not only did it make the content of the fragment more interesting and real, but it also actively involved students in thinking creatively and producing learning conclusions on the fragmented material. The findings of this study suggest that the PhET medium can enhance the student's understanding of mathematical ideas by providing solutions to enhance understanding.

Keywords: *Instructional media; Virtual laboratory; PhET simulation*

1. INTRODUCTION

Mathematical learning is one of the branches of science that touches on many aspects of everyday life. Mathematical punctuation can be applied to many real-world problems. "Participants require mathematical exposure to develop the ability to think logically, analytically, systematically, critically, creatively, and cooperatively." Therefore, mastery of mathematics is very important. Elementary school mathematics curricula tend to focus on strengthening basic concepts and developing them to prepare students to face more advanced topics in primary and upper secondary school. The author presents some formula problems, as mentioned earlier. (Fatmawati & Kurniawan, 2017).

The results of direct observations of SDS YMI Tani Makmur Rengat West District saw and observed students of Classes 3a and 3b in mathematical learning, where some students did not understand the concept that was just explained by their educators about fragmentation. But the most surprising fact is that there are still a lot of third-grade students who have difficulty mastering basic arithmetic skills such as multiplication and division.

When viewed from a learning perspective, media is a powerful tool for maximizing the effectiveness of the learning environment. Because his physical presence can inject new energy into the class. Students' attention, interests, ideas, and emotions can be involved in learning activities through the use of all resources (including people, objects, and the physical environment) that can be used to communicate or channel messages, considered a form of learning media (Nurfadhillah, 2021).

Virtual laboratories replicate difficult and expensive research and replace it with software to avoid potentially harmful setups (Mahanta & Sarma, 2012). Virtual laboratories using multimedia in the classroom can transform difficult-to-understand ideas into more tangible and visual representations (Bétrancourt & Tversky, 2000). Students are better able to store and apply the knowledge gained through visualization because it allows student-to-student and student-to-educator communication and reactions. One virtual laboratory that is easily accessible for free is PhET. The convenience of having this app available on Android and online (at <https://phet.colorado.edu/in/>) makes it more accessible to students.

PhET (Physics Education Technology) consists of simulation media developed by the University of Colorado and packed with interactive physics, biology, and chemistry assignments that can be used both in class and at home. The characteristics of PhET simulations include the use of constructivist and interactive methodologies, feedback, and an atmosphere that encourages technological innovation (Iwan Umboh & Dwi Putri Umacina, 2020). Educators can do more than just use video conferencing for online discussions and teaching. The PhET program is just one of several virtual tools available to educators to use to enhance student

learning. The Android Play Store hosts a free version of this software, which can be downloaded from the website (Adam et al., 2020).

According to Rahayu (Gilang Fahrudhin et al., 2018) to have a strong conceptual understanding, one must be able to classify events and actions according to a set of clearly definable mathematical characteristics. According to Sanjaya, having a strong understanding of a subject requires not only a thorough understanding of the core ideas but also the ability to articulate those ideas clearly, interpret data, and apply those ideas in new contexts (Batubara, 2017).

Understanding concepts, according to Karunia in Achmad Gilang, is a skill related to understanding the basic principles of mathematics; Conceptual understanding is more valuable than rote memorization (Gilang Fahrudhin et al., 2018). According to the journal of the Ministry of National Education, Nila Kesumawati found that understanding ideas is one of the abilities or levels of mathematical performance anticipated in mathematics education. One way to achieve conceptual understanding in mathematics is to demonstrate that you understand the concepts being studied. Another way is to explain the relationship between concepts. Lastly, when solving problems, make sure to apply concepts or algorithms flexibly, accurately, efficiently, and precisely (Arifah & Aziz Saefudin, 2017). Therefore, avoid giving the wrong advice or instructions to children. If you do not direct or guide students successfully, they will learn the wrong things and apply the wrong things to their work.

Understanding requires time spent reflecting and learning. Because, as the saying goes, learning and thinking are important steps towards understanding. Ahmad Susanto added two statements by saying, "Understanding comes from the word understand, which means a lot of knowledge, opinion, flowing, really understanding" in the Big Indonesian Dictionary. One interpretation of "understanding" is "the process of understanding" or "the act of understanding." When we talk about students' "comprehension," we mean their ability to understand the material presented in class (Ahmad, 2016).

Students' inability to understand mathematical concepts can be traced back to the fact that traditional classroom models continue to dominate mathematics education. They take things at face value and don't bother to research the topics or resources they learn about on their own. Everything from providing definitions and formulas, looking for formulas, proving propositions, and answering example questions is done by the teacher, while students only copy their work and follow their directions in learning (Agustina et al., 2018).

Based on these problems, the researcher took action in classroom learning using PhET media. The aim is to (1) increase the conceptual understanding of grade 3 students at SDS YMI Tani Makmur in learning mathematics regarding fractions and (2) find out what factors influence PhET media so that they can increase their understanding of the mathematical concepts regarding fractions.

2. METHODS

This research uses classroom action research (PTK), which is a series of processes consisting of four stages: preparation, action, observation, and reflection. This research was conducted using this research style. According to (Mustafa, 2020), classroom action research (CAR) is a part of action research that has its own characteristics. PTK has an important and strategic role in efforts to improve the quality of educational practices and programs as a whole (Abdillah, 2021). According to Dave Ebbut, quoted from Hopkins (1993:45): Through action research, a group of participants regularly examines how they can improve educational practice through their own practical actions and reflection on the results of those actions. This type of research is conducted by groups of people rather than by individuals (Hanifah, 2014).

The research approach used in this research is an example of classroom action research. Investigations like this were carried out in the third grade of SDS YMI TANI MAKMUR, which is located in West Rengat sub-district, Indragiri Hulu district, in Riau province. This classroom action research was carried out with the aim of improving educational practices currently in circulation. According to Kilpatrick et al. (Lestari and Yudhanegara), stated in Intan Triasuci, conceptual understanding is an ability related to understanding mathematical ideas comprehensively and functionally. This is what the understanding indicator shows. Examples of things that demonstrate understanding of mathematical principles include (Apriliani, 2018).

This classroom action research was carried out in two cycles. In each cycle, an evaluation of the data collection techniques in this research was carried out by giving two formative tests at the end of each cycle. The test carried out is in the form of a mathematics test on fractions, which consists of several questions. Other data collection techniques were also obtained by interviewing students and observing field notes to see how learning activities using PhET media were carried out in class, and then the data was analyzed. For mathematics test score data on fraction material, data analysis tables for cycle I and cycle II tests and tables were used. percentage

of student completion. Scores are processed by looking for the average value and percentage of students to see which students are successful in each cycle.

The qualitative analysis technique uses a coding process, interview results, observation results, grouping interview results, and observations to find themes to provide an overview of how the PhET method can improve students' understanding of fractions in mathematics subjects.

This research method regularly measures the effectiveness of using PhET virtual laboratory media in learning fraction material in elementary schools, as well as increasing understanding of mathematics learning concepts.

3. RESULTS

1.1 PhET (Physics Education Technology) media can improve understanding of mathematical concepts about fractions at SDS YMI Tani Makmur, West Rengat District.

In cycle I, only 15 students understood the content, and the test results showed a completeness of 53.58%. The remaining 13 students had a percentage of 46.42% who did not understand the topic. Even though the results of students' understanding and tests are still below the minimum completeness criteria set at >75%, students' teaching and learning abilities are influenced by reviewing the understanding and results of cycle I tests in mathematics learning. This occurs regardless of how well students understand the material or how they perform on assessments.

This assessment was caused by several things, including ineffective instructor activities, less innovative methods, students who did not participate in class, and many students who did not pay attention to their educators when teaching. Even though at the first meeting the percentage score was 53.58%, it was still far from meeting all the criteria for the fractional exam. When compared with the minimum completeness criterion, which is greater than 70%, these findings are still below the threshold. The lack of participation of teachers and students in lectures is one of the reasons why students' learning capacity is still far from the required threshold for completion. Therefore, considering that the research objectives of cycle I have not been achieved with the results of cycle I research, the researcher wishes to continue this research in cycle II.

In cycle II, there were 26 students who understood the material, 92.85% of students completed the test results, and 2 students who did not understand the material had a percentage of 7.1%. The increase in students' mathematical understanding and test scores shows that the application of PhET media has a significant impact on students' mathematics teaching and learning processes.

The findings of cycle II showed an increase in students' understanding, test results, and observation results of students' and instructors' activities. Apart from that, this result is higher than the minimum completeness criterion, namely 75%. Efforts made to develop students' knowledge of mathematical concepts can be said to be effective if they result in increased understanding scores and test results that are higher than the minimum standard of 75% of class 3B students in fraction material. This shows that the desired goal has been achieved. Table 1 below shows the data analysis presentation for each cycle.

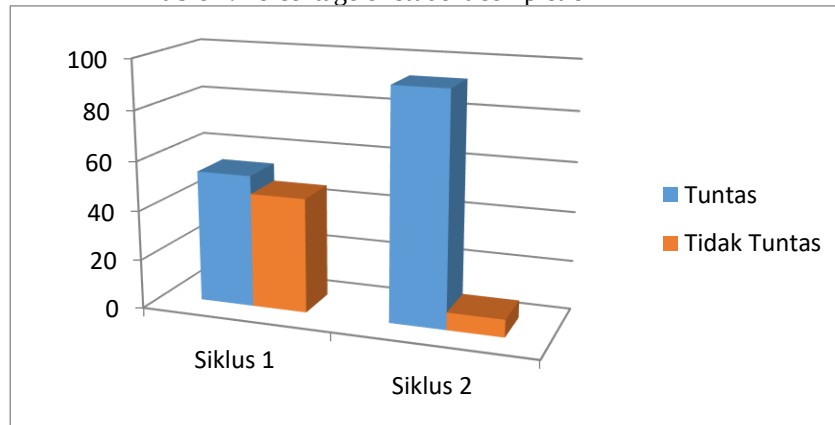
Table 1. Analysis of cycle I and cycle II test data

No	Parameter	Cycle I	Cycle II
1	The number of students	28	28
2	Average	67.14	89.82
3	Maximum Value	90	100
4	Minimum Value	40	60

Based on table 2, it is known that the average value of cycle I is 67.14 with the lowest value of 40, and after learning using PhET media in cycle II, the class average is 89.82 with the lowest value of 60.

So it can be concluded that learning using PhET media can improve the concept of mathematical understanding of fraction materials.

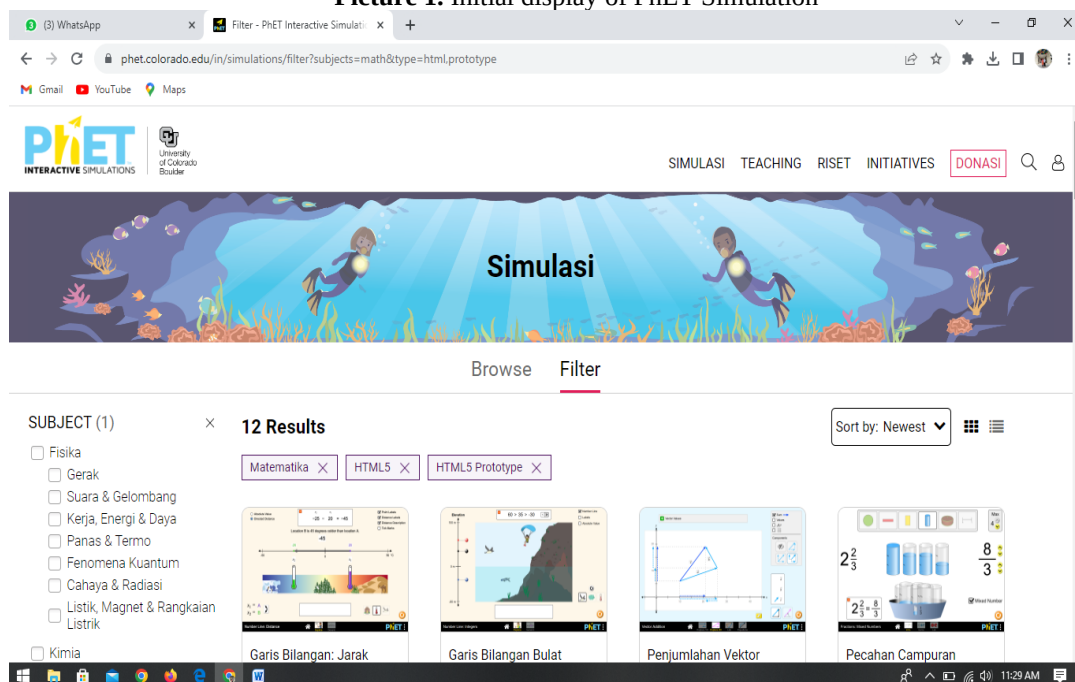
Results of students' complete understanding of mathematical concepts: Cycle I completed 53.58%, Cycle II completed 46.42%, and Cycle II completed 92.85%. Incomplete 7.1%.

Table 2. Percentage of student completion

By using this PhET media and the results obtained in cycle II show that the results have greatly improved, far above the average. By using interesting media and varied methods, mathematics lessons for fractions become very interesting and look real and are liked by students.

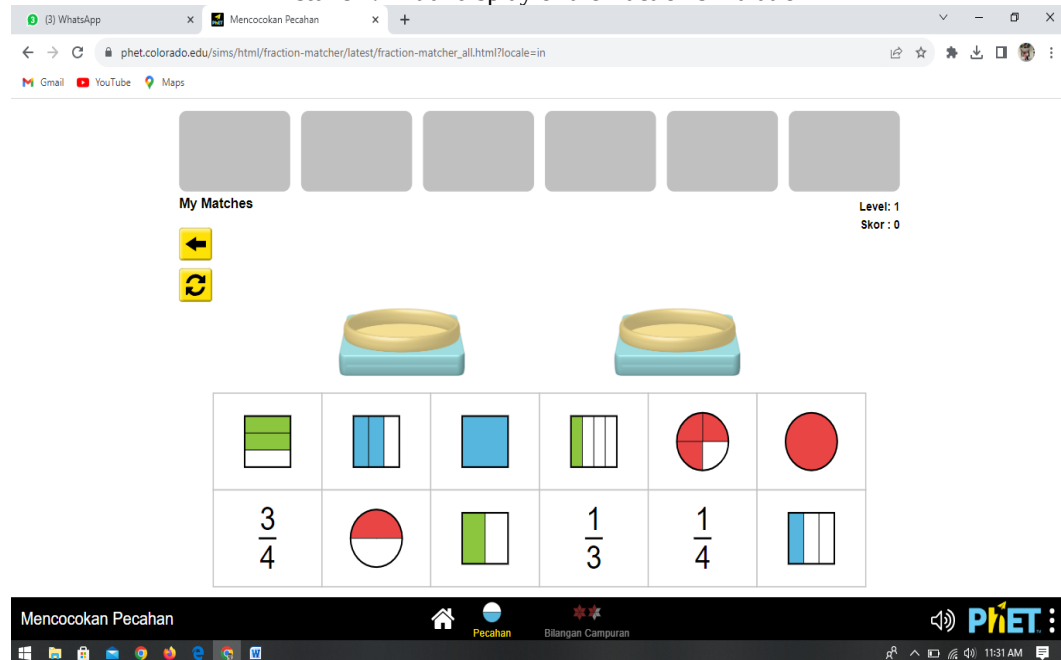
In cycle I, the research implementation project was held in two meetings and at each meeting there was one item. Apart from that, in the process of carrying out research in cycle I, students work on questions at the second meeting to find out the findings of cycle I. Make sure the activities carried out include planning, implementation, observation and reflection during the implementation of cycle I which started on October 31, 2023 and will be completed on November 9, 2023. Research in cycle I begins on October 31, 2023 and continues until November 9, 2023.

During the implementation of the second cycle of research, two meetings were held and each meeting had one content. Students only work on questions to find out the findings of cycle II at the second meeting of the cycle research they carry out for cycle II. The researcher carried out actions throughout the implementation of cycle II which consisted of planning, implementation, observation, or observation and reflection. Research in cycle II begins on November 9 2023.

Picture 1. Initial display of PhET Simulation

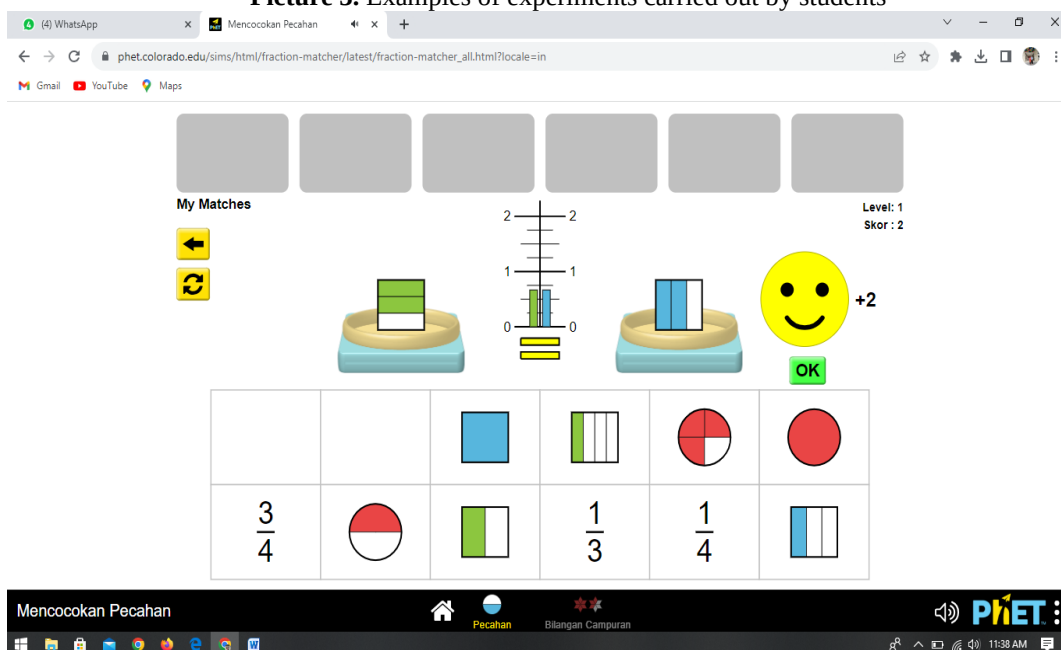
Before researchers use PhET media, the first step: Before starting to ask questions to students, the teacher must give them about ten to twenty minutes to freely use the PhET Simulation. To ensure that students have access to simulation applications when needed, we will simulate the situation. After that, the children began to try with the objects that were right in front of them. Those who have never experienced simulation will try using this media for the first time.

Picture 2. Initial display of the fraction simulation



Students can find out that there are various kinds of colorful shapes, numbers, and other tools by looking at the picture in Picture 2 below. This image is shown below. They can start by clicking on the image, which is one of the options immediately available to them on the image of the fraction in the selection and matching it, then seeing the correct answer. As before, first-year students can observe the transformation taking place, but they may not fully understand its significance.

Picture 3. Examples of experiments carried out by students



Picture 3. Is a practice question that can be done by students. They were able to experiment with the fragments displayed on the screen and match the fragments they found. They will be able to see the image at the bottom of the page as they try to match the fractions, and they will start matching them as they do so. Through this procedure, they were able to recognize that the image located next to the fraction was a representation of the fraction. Students develop a stronger interest in the material, and their level of curiosity increases, when the teaching and learning process is enjoyable. This can be seen from the results obtained in cycle II which are much improved compared to the teaching and learning process carried out in cycle I. (move the picture to the results) (for discussion, add the results from previous research and compare them with the results we examined, for comparison, see below. recording)

3.2 The advantages of using PhET (Physics Education Technology) media which can improve grades and understanding of mathematical concepts about fractions at SDS YMI Tani Makmur, West Rengat District.

From research conducted involving a total of 28 class 3B students at SDS YMI Tani Makmur. During the research period, there was a marked improvement in understanding the fraction material. During the initial stages, teachers experience difficulties in teaching students effectively. Apart from that, students also seem to have difficulty understanding the concept of fractions at the beginning of learning. Based on empirical findings reported by students, it appears that a state of confusion occurs among students when faced with new problems, which indicates a lack of understanding or proficiency in their knowledge and abilities.

This research started on 31 October 2023 and 09 November 2023. This research was carried out in two stages; If the goal is not achieved after the initial two stages, the process moves to the second stage. Two meetings form each cycle, and student ability tests will be carried out at both meetings. Each meeting lasts one and a half hours, divided into one-hour increments.

Picture 4. Implementation of research cycle II of SDS YMI Tani Makmur



Students and educators use PhET media in the teaching and learning process, where this media is the solution offered. Researchers create a Learning Implementation Plan (RPP) which educators use to carry out the teaching and learning process. From the interviews conducted at the end of the meeting, it was found that students made it easier to understand the concept of fractions. Some of the advantages of PhET media are:

- 1) Increase the efficiency of mathematics learning
- 2) Increase the level of conceptual understanding in fraction material.
- 3) Learning becomes fun
- 4) There are many simulations presented as games
- 5) Students also become enthusiastic during learning

From the results of interviews conducted with all students who expressed their joy in participating in the learning process using PhET media; they felt the fraction material was easier to understand and the learning experience became more interesting.

With the results obtained from cycle II, researchers conducted interviews with several students and the students' responses were very enthusiastic and liked mathematics lessons regarding fractions. The students were very happy and delighted with fractions using PhET media.

4. DISCUSSION

Mathematics is a topic that is still considered challenging by most students in educational institutions. On the other hand, mathematics is considered important due to the fact that it serves as a more accurate predictor of

whether a child will continue in conventional school or not than a child's emotional and social skills. Apart from that, there has been a fairly rapid expansion in the use of mathematics in various fields of work in this technological era. Investigation of the ways students perceive mathematics is the basis for providing intervention by researchers in the form of research and by educators in the form of selecting techniques and methods for teaching and learning mathematics to students in the school environment.

Learning mathematics is a very boring subject for some children. To change mathematics lessons to make them more fun and enjoyable, researchers use interesting and fun media so that students become motivated in mathematics lessons. For this reason, researchers deliberately took fraction material in mathematics lessons in grade 3. If children already like the lesson, then the material provided will be more fun and memorable. There were several children who the researchers interviewed regarding the fraction material, and the children's answers said that the fraction material was very difficult and hard to understand. To make students understand about fraction material and make students like mathematics lessons, researchers made changes in providing material using PhET media and methods that are very interesting, innovative and fun in accordance with developments in the world of education in the 21st century. Because the use of PhET media makes students also enthusiastic about PhET media so that learning is not boring because the simulation is presented in the form of an interesting game so that students can learn while having fun (Nurul Hikma, La Ili, 2023).

In other research, results were obtained that the use of virtual laboratory media could increase mastery of concepts in Animal Tissue Structure material during the Pandemic season (Asnita Wati, 2021). Meanwhile, this research focuses more on fractional material using the PhET virtual laboratory media. The same thing was done by (Nana, 2020) in implementing the PhET virtual laboratory-based Problem Based Learning (PBL) model in physics learning as an innovation to improve conceptual understanding in high school students. Even though they differ in methods and materials, the use of PhET media has been proven to increase students' understanding of concepts.

On research (Fatmawati & Kurniawan, 2017) It was found that there was an increase in students' understanding of mathematical concepts in mathematics learning through the application of RAKTEPEL (Rainbow Egg Shelf) media. From this research, the same results were obtained that students' understanding of mathematical concepts had increased. It's just that this committee is more focused on fractional material and the use of PhET virtual laboratory media.

5. CONCLUSIONS AND RECOMMENDATIONS

In this research, there was an increase in understanding of mathematical concepts in fraction material at SDS YMI Tani Makmur. Mastery of concepts in cycle 1 was 53.57% and in cycle 2 was 92.85%. After two cycles of using the PhET app for learning, students had positive reactions, according to the data. These two results show that students' conceptual understanding increased after using the PhET simulation on fractions.

The findings from PTK can also be used by educators to utilize PhET media in the classroom. To increase students' learning motivation, learning materials may be made to appear more interesting. Educational materials developed using the PhET method have great potential, especially for disseminating mathematical knowledge. As a suggestion, teachers can use PhET media to support the learning process accompanied by appropriate facilities and infrastructure, depending on the lesson and content to be taught.

Students who do not have smartphones should not be a barrier to participating in simulation activities, therefore the researcher suggests that future researchers pay more attention to this problem and find a solution. Schools that do not have a complete laboratory but have a computer laboratory can use it to carry out PhET simulations.

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