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The Use of Phet Interactive Simulation Software in Physics Learning

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Abstract: Physics learning is a discipline that requires in-depth understanding and a strong grasp of concepts. The use of technology in physics learning has become very essential, such as in the use of PhET interactive simulation software. This article aims to explore literature studies regarding the use of PhET software in the context of physics learning and its positive impact on students' abilities. The literature review method was carried out by searching for articles and journals related to the use of PhET in physics learning. The study results show that the use of PhET in physics learning can increase students' understanding of physics concepts and motivate them to study physics. Strategies for using PhET in physics learning include using it as a tool in explaining physics concepts, creating virtual experiments by students, and preparing virtual experiment reports. This article is an effective and efficient alternative for increasing students' understanding of PhET in physics learning.

Keywords: PhET Simulation; Physics Learning; Virtual Laboratory.

Introduction

In the current era of Industry 4.0, the development of information and communication technology is taking place very quickly, resulting in changes in people's mindsets in seeking and obtaining information (Susilawati et al., 2023). In recent decades, the educational field has undergone major changes, with a focus on interactive and constructivist learning. According to (Nurjannah et al., 2021) physics is one of the natural sciences studied in high school which requires problem-solving abilities and generic science skills in its application. Physics learning has a very important role in improving the quality of a nation. Physics learning is aimed at the goal that students can develop intellectual, critical, logical, and scientific thinking skills and be able to understand concepts and solve problems, especially those related to everyday life. (Wiravanjava, 2017) states that the ability to think critically is very important to develop science and knowledge and make students superior human beings, namely intelligent, critical, and creative people. The ability to think critically will also have an impact on solving problems and opening insight into the learning provided so that it will also have an impact on student learning outcomes. To achieve this goal, teachers must be skilled in choosing suitable models and media that will be applied in the classroom (Zulkifli et al., 2022).

Physics is a science that studies events consisting of scientific processes, products, and attitudes that are cyclic, interconnected and shows how these natural phenomena are measured through observation and research (Masita et al., 2020). The 2016 Minister of Education and Culture Regulation states that physics is a subject that is still classified as a science that can develop analytical, inductive, and deductive thinking skills in the process of solving problems related to natural phenomena, both quantitatively and qualitatively and can increase knowledge, skills and an attitude of self-confidence (Tullah et al., 2022).

Until now, science lessons, especially physics, still have little place in the hearts of students. Physics is

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considered a difficult and unpleasant subject. Teachers also use various ways to overcome this so that physics subjects are more fun and enjoyable, and they are motivated to learn physics. (Simbolon, D.H et al., 2023). One of the important problems in learning physics is the low quality of learning at various levels of education. The quality of the physics learning process and outcomes is determined by many factors, one of which is the availability of laboratory facilities in schools. Laboratory activities or experiments are important things to do in physics learning because through experiments aspects of products, processes, and students' attitudes can develop.

Physics is a science subject that is not popular with most students. Because they consider physics subjects to be difficult subjects. Apart from theory, physics material also includes material that must be completed using calculations related to mathematics. To be able to understand physics material, a simulation is needed, because if you explain physics material by just imagining then understanding the concepts of the physics material will be difficult for students to accept. Therefore, an effective learning system is needed so that students can absorb the material presented (Badriyah, 2023).

According to (Hidayati et al. 2020) they emphasize the progress of digitalization in current learning media. They hope to use technology to improve students' critical thinking skills and creativity. PhET early learning allows for a more active and exploratory learning experience, supporting this approach. The rapid development of technology has had a significant impact on many fields, including education. According to (Aprilia et al, 2022), technological advances can be beneficial for the learning process, as long as they are used in the right way to achieve learning goals. In situations like this, educators must have the ability to adapt to technology in the learning process. One effort to overcome the imperfections of Physics learning is through the use of technology and information and computers which can be used to support the implementation of Physics practicum, both for understanding concepts, collecting data, presenting, and processing data, (Elisa et al., 2017). The way students learn has changed due to advances in technology. Physics learning simulations are one example of how technology can help learning.

Many students struggle to understand abstract physics concepts. Student-centered physics learning is becoming more important, according to recent research, so traditional approaches are no longer considered relevant. As a result, teachers need to use visualization as a way to help students understand physics material, especially quantum physics material. So apart from using the right learning model, the choice of learning media is also considered. One of the interactive learning media is PhET (Physics Education Technology) simulation media. This PhET software contains physics animations that are abstract or cannot be seen by the open eye, such as tools and materials used in elasticity material (Nurulhidayah et al., 2020).

PhET is a systematic computer program that is responsive to developments in learning technology developed by the University of Colorado in Boulder, America to provide virtual laboratory-based science teaching and learning simulations that make things easier for educators because they can be used for classroom learning (Nafrianti et al., 2017).

By offering more concrete and interactive visualizations, PhET Simulation can help address these issues. Learning physics is often considered difficult and uninteresting for students. However, PhET simulations can make students more interested in studying physics. Based on the results and discussion of research by (Defianti et al., 2021) students who carry out PhET simulation-based virtual practicum with guided question modules improve their understanding of the material. PhET is the choice of many teachers in implementing virtual physics practicums because it has free access and an easy-to-use user interface. PhET's flexibility also makes it a portable simulation, because it can be accessed using various devices. PhET provides interactive animation-based simulations of various learning materials in Physics, Chemistry, Biology, Mathematics, and Earth Sciences, allowing students to interact and explore their understanding of the material studied through these simulations (Muzana & Lubis, 2021).

In PhET there are theoretical and experimental simulations that actively involve users. Users can manipulate activities related to the experiment. So apart from being able to build concepts, PhET can also be used to develop science process skills (Ekawati et al., 2015.) PhET contains material simulations that are explained in theory and experiments that actively involve users. Users can manipulate activities related to the experiment (Alam et al., 2021).

This PhET simulation media was developed to help students understand physics concepts visually, namely using dynamic graphics that can explicitly bring to life the visual and conceptual models used by expert physicists (Rizaldi et al., 2020). Apart from that, PhET is the choice of many teachers in carrying out virtual physics practicums because it has free access and an easy-to-use User Interface. PhET's flexibility also makes it a portable simulation, because it can be accessed using various devices. PhET provides interactive animation-based simulations of various learning materials in Physics, Chemistry, Biology, Mathematics, and Earth Sciences, allowing students to interact and explore their

understanding of the material studied through these simulations (Verdian et al., 2021).

Previous literature studies on the use of PhET simulators in physics learning can be used to assess the success, difficulty, and advantages of previous research. For example, research conducted by Fencl (as mentioned by (Khaerunnisak, 2018) found that PhET simulations have more benefits than Weaknesses. PhET Simulation can help students get better learning outcomes and serve as an alternative to physical activity in the laboratory. Students can understand physics concepts better through visual and interactive experiences with PhET.

Intended to make physics learning more engaging and interactive, PhET simulations are designed to be engaging and accessible to all students. In addition, through its animation, this simulation provides useful feedback to students (Sujanem et al., 2022). This research aims to evaluate whether the use of this simulation can increase students' desire to learn physics and increase their involvement in the learning process.

Technology is considered very important for the curriculum, especially in the digital era. This study ensures that PhET simulations are in line with curriculum trends and needs (Banda & Nzabahimana, 2021). The reviewed studies show that PhET simulations can significantly improve students' conceptual understanding of physics and can be used in a variety of learning environments. PhET simulations are undoubtedly one of the most accessible and effective in teaching Science offering opportunities for students to become involved in learning activities and allowing them to perform simulation exercises as fully as possible in a comfortable space (Layson, 2022).

This research aims to find obstacles and difficulties that may arise when implementing PhET simulations in physics learning and find ways to solve them. Studies looking at the use of technology in physics learning show progress in education. This research will have a major impact on students' understanding of the benefits and potential of PhET Simulation in improving the quality of physics education because we hope to change the way students perceive and understand physics. In the future, this can serve as a basis for improving education.

In line with research conducted by (Sari & Lutfi, 2013) it is stated that PhET virtual media can train process skills to achieve cognitive product results and positive responses from students by using LKS as a support for PhET Virtual media. Teachers can use PhET simulations to make it easier to explain lesson material to students. Teachers can use certain simulations to explain abstract learning material so that it is easier to understand. This simulation can prove things that are difficult to see from practicums carried out in real laboratories, this PhET simulation can be used online or offline, and the design of the image shapes and colors in the PhET simulation is very interesting because it is directly adjusted to the basic color of the material and is by the original form or tool during practicum in the real laboratory (Arifin et al., 2022).

Method

This literature research method is used to search for literature about the use of PhET software in physics learning. Online databases such as Sinta Kemdikbud (accreditation 2), Elsevier, ERIC, and Scimagojr were used to search. “PhET”, “interactive simulation”, “physics education”, “student education”, and “learning strategies” were the keywords used. Selected articles and journals must discuss the use of PhET software in physics learning and have been published within the last five years. To make it easier for readers to understand the flow of the research, the author displays the research pestle. We can see the flow of this research below (Figure 1).

Figure 1. Research Flow

Result and Discussion

Introduction to PhET Software

It is important to use additional applications to meet student proficiency standards in the form of trial simulation software. One of the virtual laboratory simulators used in physics learning that is commonly used in physics learning is the PHET (Physical Education and Technology) simulation. The PHET simulation application was created by the University of Colorado USA. PHET Simulation users can carry out simulations anytime and anywhere using a computer or cellphone because they can be connected via an internet

network or without an internet network which is used for some physics materials. Students who use PHET simulations when studying can be more comfortable and not get bored and tired quickly so that students' learning outcomes can improve (Nisak, 2023).

PhET Interactive Simulations is an interactive simulation software that offers interactive simulations for a variety of physics, chemistry, biology, and mathematics concepts. The goal of this simulation is to allow students to conduct virtual experiments and see physics concepts firsthand. PhET simulations emphasize the relationship between real-life phenomena and the underlying science, support interactive and constructivist approaches, provide feedback, and provide a creative workplace (Prihatiningtyas et al., 2013). PhET simulations are designed to support physics learning. It is engaging and accessible for students, and the animations provide feedback to students (Sujanem et al., 2022).

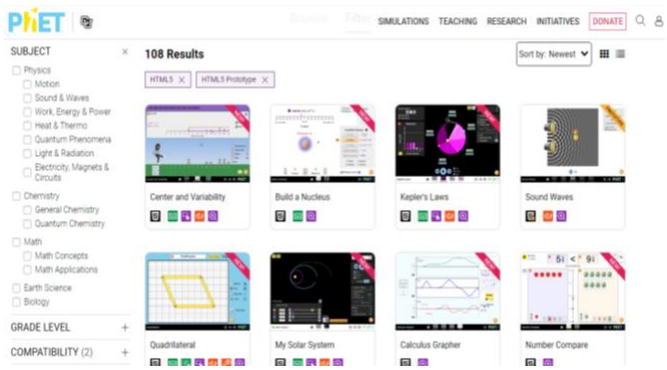

Figure 2. PhET main view

Characteristics of PhET Interactive Simulations: Interactive simulations allow students to manipulate variables and see the results directly; Simulations that are easy to use and can be accessed online; Simulation that can be adapted to learning needs; Simulations that help students understand physics concepts more easily and interestingly. (Abdjul et al., 2022) said that one of the advantages of the PhET simulation is that it has an attractive appearance which makes students interested in using it.

Use of PhET Software in Physics Lessons: Many studies show that using PhET software in physics lessons can help students understand physics concepts better. A study conducted by Hake (Mahardika et al., 2022) found that students who used PhET software in physics lessons understood physics concepts better than students who did not use the device. The use of PhET provides higher learning outcomes compared to other media, such as PowerPoint media (Muna et al., 2023).

The Phet simulation was developed to help students achieve three learning objectives, namely: a.) To connect procedural knowledge in the form of physics formulas and the original reality; b.) To help students develop procedural knowledge and skills so they not only learn how to perform experimental procedures but also when those procedures can be applied; c.) to help students understand the application of their knowledge in the real world (Muzana & Astuti, 2017).

The advantages and disadvantages of this PheT simulation according to Khoiriyah (2015) PheT was developed using the following design principles: a) encourages scientific inquiry, b) provides interactivity, c) makes the invisible visible, d) displays visual mental models, e) displays some representation (e.g., object motion, graphs, numbers, etc.), f) uses real-world connections, g) provides the user with implicit guidance in exploration; and h) create simulations that are flexible and can be used in a variety of educational situations. The weaknesses of PheT simulation as a learning medium are; a) access to implementation in this learning must use a computer, b) success in learning depends on student independence in following the lesson, c) students feel bored if they don't understand how to use computers (Yani & Tawil, 2019).

(Budiarti & Lumbu, 2021) say that PhET is an interactive simulation with a research-based approach, which connects real-life phenomena with the underlying science to increase student understanding and interest. This allows teachers to do this using PhET as a virtual laboratory in learning activities or teaching and learning activities (KBM).

(Jannah et al., 2021) conducted research comparing student performance in scientific and digital literacy activities using a virtual laboratory. They use a PhET simulation and an electronic workbench. Both groups carried out practical work in a virtual laboratory. A more thorough and accurate experience in carrying out practicum procedures and understanding scientific content is made possible by practicum with an electronic workbench, while PhET simulations enable a more thorough, accurate, and thorough understanding of the practicum material. These two virtual laboratory applications can help reduce the anxiety that often arises during actual practicums.

In addition, the use of the PhET program in physics learning has been proven to increase students' self-efficacy and their mathematical representation abilities. Analysis shows that students' self-efficacy is in the quite high category, and their mathematical representation abilities increase during the learning process (Rahmawati et al., 2020) In addition, by using PhET animation media, learning becomes more interesting for students. The use of this media also helps students develop constructivist thinking patterns and allows them to learn while playing with simulations, which helps them see physical concepts (Farid et al., 2018).

The PhET simulation media can make students interested and enthusiastic (increasing learning motivation) in the learning process and provide students with an understanding of abstract concepts. There are exciting activities in the learning process, which also causes the PhET simulation media to become an alternative media that presents interesting images in the learning process (Samitra et al., 2023). PhET Interactive Simulations make physics easier to understand and engaging for students. They can manipulate variables and see the results directly, which increases their understanding of physics.

Project-based learning allows students to relate what they know from classroom lessons to real-world situations. In situations like these, it is important to monitor how students complete projects to ensure they remain focused and engaged in their assignments. Praise and feedback given to each group of students can increase student motivation and show appreciation for the results of their work. According to (Hadi et al., 2023) evaluating the experiences experienced by students during the project creation process also helps in understanding and responding to what they learn.

As shown by (Saregar, 2016), PhET interactive simulations in learning photoelectric effect material using a scientific approach and LKM media can increase student learning motivation. An interesting and easy-to-use simulation can increase students' interest in physics.

Research by (Aprilia et al., 2022) found that the application of physical education technology (PhET) in physical education can improve students' physical learning outcomes. This is because interactive PhET simulations engage students in learning activities that require strong cognitive skills. In addition, PhET's interactive simulations help students improve their problem-solving abilities and creative thinking abilities.

As shown by (Panggabean et al., 2023) the use of PhET requires careful preparation. This research found an increase in student understanding of concepts by using the POE2WE model with the help of the PhET virtual lab android application. However, several challenges hinder this research. For example, students face problems accessing applications due to limited memory or internet packages. Therefore, it is very important to use PhET in physics learning to prepare and solve technical problems.

Research conducted by (Azhar et al., 2023) found that students' science processing abilities can be improved effectively by using the guided discovery learning model assisted by the virtual PhET lab. The research results showed that the experimental class that used this model had better processing capabilities compared to the control class. Moreover, the results of statistical analysis show that this difference is very significant.

A study conducted by (Susilawati et al., 2021) found that using PhET in virtual laboratory practicums can improve students' conceptual understanding of digital literacy and laboratory skills. The results show that students' experience in carrying out practical procedures is more accurate and thorough, which shows the benefits of using PhET.

A study conducted by (Hali et al., 2023) found that PhET simulations helped students learn better. This shows that the use of problem-based learning tools in problem-based learning can produce positive results.

The results of this research show that Virtual Lab Phet is very suitable for use in basic physics practical activities. The PhET virtual lab has a very attractive appearance consisting of several animations so that it can create interaction between real events and computer simulations. The features contained in the PhET Virtual lab are interactive and visual, capable of creating effective learning thereby increasing understanding of abstract physics concepts. It is hoped that the Virtual PhET lab can be applied to other materials within the scope of physics (Diraya et al., 2021).

According to research conducted (Sunni, 2014) problem-solving strategies with the help of PhET improve students' mastery of physical concepts as well as their critical thinking abilities. As shown by these various studies, the application of PhET in physics learning has significant positive effects. PhET can improve students' understanding of physics concepts, science process skills, thinking skills, and their motivation to learn. Therefore, PhET is an effective tool to help students understand physics concepts and acquire necessary science skills. The use of PhET software in physics learning has a significant positive effect. Students see physical concepts firsthand and conduct virtual experiments through PhET's interactive simulations.

In line with research conducted by (Nurhayati et al., 2014), learning is more interesting using PhET simulations because students can use PhET software animation media which can also provide learning and playing experiences.

Figure 3. Force and Motion in the PhET Application

According to (Lamanepa et al., 2020) learning is more interesting using PhET simulations because students can use PhET software animation media which can also provide learning and playing experiences. Students want physics lessons should be made in the form of games or simulations that make them fun to learn. Meanwhile, the physics teacher as the assistant in this activity hopes that this simulation activity should always be given in subsequent activities. This simulation training also provides enlightenment for physics teachers in teaching physics to students in class. PhET as an interactive medium has a positive impact on learning, students become more involved in learning so that students can retain more information. The following is a picture of using the PhET application.

As stated by (Riantoni et al., 2019) PhET contains physical conceptual models that are easily understood by students. PhET can be collaborated with real experiments or can be used as a substitute for a real laboratory. This simulation can help students get to know new topics, build concepts or skills, strengthen ideas, provide final results and reflections as well as provide a common visualization between students and teachers. Apart from that, the results of several studies show that the use of PhET has a different effect in terms of concept mastery, learning outcomes, and students' problem-solving abilities because PhET can explain abstract concepts and its use does not require a lot of time.

According to research conducted by (Ayub, 2023) the use of PhET simulation media has a significant influence on learning outcomes in physics learning. This media has been proven to be effective in improving learning outcomes, so it is recommended for use in learning, easy to use on electronic devices, including computers, laptops, and smartphones. PhET simulation media is also available offline so internet network limitations can be ignored.

Research conducted by several researchers' states that learning using PhET simulation media can improve learning outcomes and students' learning motivation. Not only that, learning that uses PhET simulation media can facilitate the limited references to practical instructions and practical tools for parabolic motion material. PhET simulation media is software that can facilitate students in learning activities (Ngadinem, 2019).

(Pramanda, 2016) in his research said that the PhET simulation media, if viewed based on Edgar Dale's Cone of Experience, then this media is included in the most concrete level, where 90% of students will be actively involved in observing learning activities, carrying out experiments, and concluding the data obtained. PhET's simulation media about Energy Forms and Changes presents visualizations of energy forms and energy changes that occur in everyday life.

Conclusion

The use of PhET software in physics learning can be a good alternative for increasing students' understanding of physical material. By incorporating technology into physics learning, PhET provides students with the opportunity to learn actively and exploratively, enabling them to improve their learning outcomes. Therefore, PhET can be a useful tool in developing better physics education and better teaching.

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