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Utilization of PhET Media in Understanding the Concept of Electrical Circuits of Elementary School Students: A Literature Review

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Abstract

This research aims to examine the use of PhET Interactive Simulation media in helping students facilitate understanding of the concept of electrical circuit material for elementary school students, through a qualitative approach based on Systematic Literature Review (SLR). The method used is a literature review by sharing and disseminating various scientific articles, books and relevant reference sources, various research related to certain topics in a structured manner. The results of the analysis show that from 13 articles that explain electrical circuit material at elementary school level, it can be seen that the use of Physics Education Technology (PhET) Simulation media has proven to be effective in helping construct conceptual understanding for elementary school students, especially in electrical circuit material because PhET Simulation has advantages such as tools. Virtual learning is economical, easy to access and interactive so that it makes them more interested and active in learning and can overcome time constraints, overcome limited resources thereby increasing effectiveness in the practical learning process. PhET Simulation Media can support students in understanding concepts better through interactive and interesting simulations, while providing opportunities for them to build knowledge independently through easy-to-access virtual laboratories. Thus, the use of PhET Simulation media has a significant positive impact on the development of students' cognitive understanding in the learning process.

Keywords: *PhET Media; electrical circuits; conceptual understandin; elementary school.*

INTRODUCTION

In the digital era, technology-based interactive learning media, such as Physics Education and Technology (PhET), has become an important innovation in education. The interactive simulations provided by PhET allow students to visualize scientific concepts in a concrete and fun way, especially in science learning. This media is considered relevant to 21st century learning needs because it is able to bridge the gap between theory and practice through immersive virtual simulations (Ariani, et al., 2023). In the context of learning in elementary schools, the use of media such as PhET Simulation is becoming increasingly important to help students understand abstract concepts such as electrical circuits, which are often difficult to understand through conventional approaches (Muazaroh, 2024). This trend shows that the integration of educational technology is not just a complement, but has become an urgent need to create a more meaningful learning experience. In addition, media such as PhET Simulation is also able to increase students' learning independence by providing space for them to explore independently in understanding science concepts through an interactive and flexible approach.

Learning electrical circuits in elementary schools should be designed so that students can understand concepts deeply through active activities, such as hands-on practice or experiments. Such activities not only help students understand the material concretely, but also encourage their active involvement in the learning process. The use of learning media supported by technological advances is also very important to create a conducive and interesting learning atmosphere, so that

students are more motivated to learn. Thus, learning does not only focus on theory, but also provides relevant real experiences (Sholihah, 2018). In addition, learning should always be related to everyday life, especially in electrical circuit material. For example, humans cannot be separated from the use of electricity in various aspects of life, because electricity is an important element that supports daily activities, from lighting to the use of electronic devices (Narulita et al., 2024). Therefore, learning electrical circuits must be designed to be relevant and applicable, so that students can understand the role of electricity in life as a whole.

But in reality, according to Bundu (in Aen & Kuswendi, 2020) said that the low understanding of science concepts is caused by learning methods that are dominated by lectures, so that students are less actively involved in learning. Then the lack of active involvement of students in the learning process can have a negative impact on learning outcomes and student understanding of the material being studied (Aisyah et al., 2024). In addition, the lack of experimental activities due to school difficulties in providing facilities such as laboratories or media for electrical circuit material is one of the factors causing students' low concept understandingding. This is in line with the opinion of Dachi (in Sakdiyah et al., 2024) who said that the low understanding of students' concepts of the material taught by the teacher is caused by the lack of use of learning media and experiments or practicums, as well as the selection of inappropriate learning models. In addition, empirical surveys conducted revealed several problems such as inadequate textbooks, lack of laboratory space and equipment for actual experiments (Mallari & Lumanog, 2020). Therefore, it is important to use media that utilizes technology so that it can support students' understanding of concepts and help students conduct experiments flexibly.

Based on the above problems, PhET Simulations media comes as an alternative to overcome these challenges. PhET Simulation media is a virtual laboratory application that assists students in demonstrating certain science concepts using animated graphic designs that emphasize the relationship between real-life phenomena around students (Tambunan et al., 2023). One of the goals of PhET Simulation is to provide open media that can be used by students to explore when learning certain concepts (Sylviani et al., 2020). According to Siregar (in Inayah & Masruroh, 2021), one of the uses of the PhET Simulation virtual laboratory is to facilitate the delivery of material and abstract concepts. This virtual laboratory has the advantage of being a place to conduct experiments in science lessons that cannot be done in a conventional laboratory and can explain abstract concepts that cannot be explained through verbal delivery (Saputra et al., 2017). In addition, practicum through this virtual laboratory students like doing experiments directly because this virtual laboratory is packaged as closely as possible to the original, so students can do their own practice at home (Fitriani & Cahyaningsih, 2023). Thus it can be concluded that PhET learning media can support the understanding of tthe concept of electrical circuit material.

Previous research shows that PhET Simulation media is significant in improving elementary school students' understanding of concepts (Ariyanto et al., 2022; Abdi et al., 2021). Based on differences in previous research, the purpose of this study is to analyze the use of PhET Simulation media in improving understanding of tthe concept of electrical circuits in elementary school students.

RESEARCH METHODS

This research uses the Systematic Literature Review (SLR) method. Systematic Literature Review is a research method used to collect and evaluate various studies related to a particular topic in a structured manner (Triandini et al., 2019). This SLR process involves identifying, reviewing, evaluating, and interpreting all relevant and available research (Putra, A & Afrilia, 2020).

The article search strategy was carried out through databases such as Google Scholar using the Publish or Perish application, with a publication time limit between 2020 and

2024. This research uses journals that are relevant to the topic, such as PhET media in learning science at the elementary school level, and PhET media, and electrical circuit material. The research stages include formulating research questions, data collection through search activities for articles relevant to the topic of discussion, data reduction by filtering inclusion/exclusion criteria articles, data analysis, and presentation of results or conclusions (Nengsih & Haryanti, 2024).

The inclusion criteria in this study included articles published within the specified time frame, specifically discussing the use of PhET Simulation media in science learning at the elementary school level, and available in full text. Meanwhile, the exclusion criteria included articles that did not fit the research topic or did not meet the quality standards, such as only including incomplete or less relevant information. The analysis process involved evaluating and synthesizing findings from the selected articles to identify relevant patterns and relationships.

RESULTS AND DISCUSSION

PhET Simulation is an interactive software created by the University of Colorado, United States that provides learning simulations for various fields, such as physics, biology, chemistry, mathematics, and earth science to support learning in the classroom or independently, and can be accessed for free easily (Fitriani & Cahyaningsih, 2023). Physics Education Technology (PhET) Simulation is used to determine how well students' level of understanding of concepts after being visualized and find student misconceptions that may occur (Rahmawati et al., 2022). According to Dale's Cone of Experience theory, the benefits of PhET Simulation media are included in the most concrete experience category because it allows around 90% of students to be actively involved in learning by observing, conducting experiments, and drawing conclusions from the resulting data (Haryadi & Pujiastuti, 2020). According to Price et al., (in Salame & Makki, 2021) stated that this interactive site offers visual displays and interactive features that allow students to interact directly with tthe concepts being taught, thus helping to improve students' concept understandingding. In addition, PhET Simulation also makes it easier for teachers and students to learn electrical circuits in a practical and interesting way, abstract material can be visualized directly, allowing students to understand concepts without having to always practice in the laboratory (Narulita et al., 2024).

The research data presented in this article is the result of analysis and summary of various articles documenting the use of PhET Simulation media in science learning, especially on electrical circuit material at the elementary school level. The data collection process is carried out by reading in depth the results and conclusions of each relevant article. The results of the analysis were then systematically organized and presented in tabular form (Table 1) to provide a clearer and more structured picture.

Table 1
Use of PhET Simulation Media in Learning Electrical Circuits in Elementary School

Researcher and Year	Journal	Methodology	Research Results
(Masruroh et al., 2021)	INSECTA: Integrative Science Education and Teaching Activity Journal	Descriptive Quantitative	The results showed that PhET Simulation media was used to help students understand the concept of material through experime

			nts that involve them actively in building knowledge. With this knowledge, students can more easily solve problems related to electrical circuits, both in assignments and everyday life.
(Sumiyati et al., 2021)	ẽl-Midad : Jurnal PGMI	Quantitative Correlation	The results showed that through PhET Simulation, learning is centered on students, where they actively build their understanding through virtual experiments. Students can solve everyday problems related to he concept of electrical circuits learned.
(Septiana et al., 2021)	DIDAKTIS 6 : Prosiding Seminar Nasional Pendidikan Dasar 2021	Qualitative	The results showed that PhET Simulation media is one of the interactive learning media that can be utilized by teachers to make learning Natural Sciences (IPA), especially on electrical circuit material, more interesting and not monotonous. This makes it easier for students to understand science concepts, because learning does not only focus

			on memorizing information, but also involves direct practical experience.
(Ariyanto et al., 2022)	At-Thullab: Jurnal Pendidikan Guru Madrasah Ibtidaiyah	Quantitative	The results showed that the use of PhET virtual laboratory media was proven to help students understand concepts, increase learning activeness, and improve learning outcomes. The t test shows sig. 0.00 t table 1.676, so there is a significant effect of using PhET on science learning
			outcomes of electrical circuit material for grade VI elementary school students.
(Salamah, 2022)	Haumeni Journal of Education	PTK	The results showed that the use of PhET virtual laboratory can improve the concept understanding of students in class VI B SD Negeri Bokong 2 on electrical circuit material because the PhET virtual laboratory makes practicum activities feel more real and relevant, compared to if the teacher only

			explains the concept in theory.	
(Yudiyanto et al., 2022)	Journal Murabbi	Qualitative	The results showed that PhET Simulation is an effective and positive learning media with a percentage of 91.85%. PhET supports learning without having to have a real laboratory, and helps students understand learning concepts in electrical circuit material because it can not only be used at school but can use	
				independently at home without having to be supervised by the teacher.
(Giawa, 2023)	Jurnal Ilmiah Mandalika Education (MADU)	PTK	The results showed that the combination of PhET Simulation and the Project Based Learning (PjBL) model was proven to have a significant positive impact on improving concept understanding and skills in developing simple series electrical circuits for students of SD Negeri No. 078139 Hilimbua	

			si O'o'u, South Nias, North Sumatra.
(Kurniawan et al., 2024)	AJCSEE: Asian Journal Collaboration of Social Environment and Education	PTK	The results showed that the use of PhET Colorado interactive media in learning science subjects, especially on electrical circuit material, showed very positive results. This can be seen from the significant increase in student learning outcomes after utilizing the media. The PhET Colorado interactive media proved to be a very effective learning tool to help students understand the concepts in electrical circuits better and be able to explain abstract concepts, thus improving their overall learning outcomes.
(Nisa et al., 2024)	Jurnal Pendidikan: SEROJA	Quantitative	The results showed that the use of PhET Colorado simulation media played a role in improving students' understanding of science concepts, especially on simple electrical circuits material. In general, the applicatio

			n of PhET simulation in learning simple electrical circuits is proven effective in improving the science learning outcomes of grade VI students at SDIT Luhur Al-Kautsar.
(Setyorini et al., 2024)	Pendas: Jurnal Ilmiah Pendidikan Dasar	Mix Method Research	The results showed that PhET simulation media had a significant effect on students' cognitive skills. PhET media is effective in improving student understanding and also cognitive skills of fifth grade students on electrical circuit material.
(Narulita et al., 2024)	El-Mujtama: Jurnal Pengabdian Masyarakat	Qualitative	The results showed that PhET media helps teachers in conveying various concepts of electrical circuits through interactive simulations and has a positive effect on student learning outcomes and can improve student learning outcomes because stimulating interest or interest in trying new things can be done through direct experience, such as

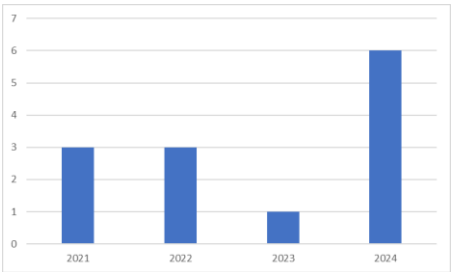
			conducting learning experiments using PhET simulation media. This interactive simulation allows students to experiment with abstract concepts visually and tangibly, without the risks involved in physical experiments.
(Pramesti et al., 2024)	Journal of Education for All	Quantitative	The results showed that the use of PhET Simulation learning media allows students to learn more effectively by visualizing concepts more realistically. In addition, students' interest in learning media in science subjects, especially about electrical circuits, is reflected through their active involvement, positive responses, and enthusiasm during the learning process. This shows that the material presented can be well understood by students. Therefore, the use of PhET simulation is considered appropriate and received positive responses from

			students.
(Almunawaroh & Dewi, 2024)	Cirebon International Conference on Education and Economics (CICEE)	Qualitative	The results showed that the use of PhET simulation learning media, makes students able to engage in learning actively, independently, think critically, improve digital literacy, and facilitate their understanding of the concept of electrical circuits. in the process students become active in the classroom and more enthusiastic in participaing in learning, this is because PhET media is a new media discovered and applied directly by students, with the use of PhET media students experience learning while playing games that attract attention and increase understanding of concepts.

Based on the research results that have been summarized in the previous table, the use of Physics Education Technology (PhET) Simulation media has proven effective in helping concept understandingding in electrical circuit material at the elementary school level (Salamah, 2022). PhET media showed a significant effect in improving students' cognitive understanding of the material (Kurniawan et al., 2024; Setyorini et al., 2024). In addition, PhET allows students to build understanding independently through an interactive, easy-to-use, and engaging virtual laboratory experience. This provides a more pleasant and less monotonous learning

atmosphere (Masruroh et al., 2021; Sumiyati et al., 2021; Septiana et al., 2021)

Picture 1
Number of articles by year of research



Research on the use of PhET media in Figure 1 in elementary schools shows a fairly consistent trend in recent years. Based on the data collected, the number of articles discussing the use of PhET at the elementary school level from 2021 to 2024. In the 2021 article year, there were 3 articles whose focus of discussion of PhET Simulation was to find out the application of learning electricity material online using PhET simulation media. Then PhET Simulation media as an effort to create a learning atmosphere that can actively involve students through innovative learning media and the discovery process so as to develop learning towards student centered which in turn can improve student learning outcomes. Not only that, PhET Simulation media motivates students to be enthusiastic about learning and can improve students' exploration abilities and be challenged to carry out an experiment or practice of the material being studied so that it makes it easier for students to understand tthe concept of material. Then for the focus of the 2022 article, the research focus is the same as the previous year, as many as 3 articles were published. Research this year began to highlight technical aspects to improve understanding of concepts such as the use of PhET virtual laboratory media that can be installed on Windows, Linux and Mac OS platforms, besides that it can also be used online by running the simulation directly. This simulation is also very interesting and easy to run so that it facilitates the understanding of students can improve students' skills in the field of technology such as making practicum more real or contextual, rather than the teacher only explaining tthe concept, then helping students understand learning concepts, especially in learning science in elementary schools, where a lot of natural science material is still abstract and requires semi-concrete or concrete media to inform students, one alternative is the use of learning media for PhET simulations.

Furthermore, in the 2023 article, there was only 1 article published in this year, which may indicate a decrease in attention or focus on other topics. The focus of the 2023 article was to reveal a significant improvement in learners' understanding and skills in constructing simple series electrical circuits after applying a learning method that combines PhET Simulation and the PjBL model.

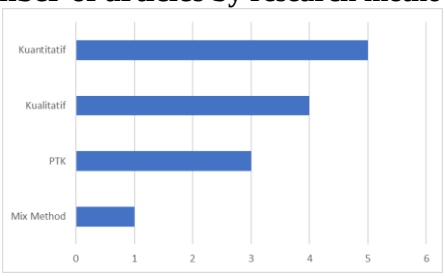
Furthermore, the last article in 2024, research again increased very drastically with 6 relevant articles. This year, the focus of research on learning outcomes and cognitive development of students such as the use of PhET Colorado interactive media in science subjects on electrical circuit material obtained very satisfying results, where student learning outcomes have increased and have an effect in improving student understanding of science concepts, especially in the context of simple electrical circuits and PhET simulation is proven to be a very useful and reliable teaching method to improve the quality of learning as indicated by the attitude of students who feel interested in the use of learning media in science subjects regarding electrical circuits by utilizing PhET Simulation media.

Then of the 13 articles for the use of PhET in elementary schools on electrical circuit material, there is only 1 relevant article analyzed in grade 4 elementary school students, 2 relevant articles analyzed in grade

5 elementary school students and 13 relevant articles analyzed in grade 6 elementary school students. The difference in the number of articles analyzing the use of PhET in grade 4, 5 and 6 elementary school students can be caused by several factors. One of them is the suitability of the electrical circuit material to the curriculum, where this concept is more often taught in grade 6 because students at this level are considered more cognitively prepared to understand more abstract concepts, such as series and parallel circuits and focus more on applications, mastery of concepts, or more complex experiments. In contrast, there is less research in grades 4 and 5 because the focus is more on mastering basic skills, so simulations such as PhET may not have been widely applied. In addition, the utilization of PhET Simulation in grades 4 and 5 elementary schools is introduced to strengthen the understanding of initial concepts because it is very important to ensure students are ready to receive and explore the next material. However, even at different grade levels, PhET Simulation media has a positive impact, especially in offering innovative and effective solutions to improve concept understandingding ability and make learning more meaningful because it involves students directly.

Some of the research results above suggest that PhET simulation media is effective when combined with certain learning models and learning methods such as the Project Based Learning (PJBL) model which provides opportunities for students to learn through concrete projects so as to improve their skills directly and create learning experiences that are contextual and relevant to the daily lives of students, so that they can more easily link theoretical concepts with their practical applications, This is proven to have a significant positive impact on improving concept understandingding (Giawa, 2023). Then PhET Simulation media can also be combined with a blended learning model which is basically a combination of the advantages of learning that is carried out face-to-face and virtually by making students able to construct new knowledge so that students learn meaningfully (Sumiyati et al., 2021) and a discovery learning model where students are directed to find learning concepts themselves so that students not only improve learning outcomes, but also affect students' understanding of concepts in student electrical circuit material (Nisa et al., 2024).

Picture 2
Number of articles by research method



Based on the results of the analysis in Figure 2, the data shows that there are variations in the research methods used in articles that discuss the use of PhET media in elementary schools to improve understanding of tthe concept of electrical circuits. Of the 13 articles analyzed, the research methods used include quantitative, Classroom Action Research (PTK), qualitative, and mixed methods. However, quantitative methods were the most widely used, with a total of five articles. This shows that quantitative research is preferred because it allows the measurement of student learning outcomes objectively and systematically. Meanwhile, the PTK method used in three articles aimed to identify and improve learning practices in the classroom. Qualitative and mixed methods were used in two and one articles respectively, indicating that although less dominant, these approaches are still relevant for exploring more in-depth data and integrating multiple perspectives. This variety of research methods shows that PhET media can be studied from various perspectives, ranging from the effectiveness of improving learning outcomes to analyzing the learning process. The dominance of quantitative methods reflects the researchers' desire to

obtain statistically measurable data in evaluating the effectiveness of PhET media as an interactive learning tool in elementary schools, but the presence of other methods such as PTK, qualitative, and mixed methods confirms the importance of a more in-depth and contextualized understanding of concepts in the use of this media in elementary school environments as well as to observe how students interact with simulations and deepen their conceptual understanding of electrical circuit material.

Based on the various studies summarized in the table, PhET Simulation has a number of significant advantages as a virtual learning tool. This media is not only economical and easily accessible, but also interactive, so it is able to improve students' understanding of concepts in an interesting way. This makes students more interested and active in the learning process (Setyorini et al., 2024). In addition, the use of PhET Simulation provides a solution to various obstacles in learning, such as limited time and resources. This media is also proven to increase the effectiveness of the practicum learning process, so that students can more easily understand tthe concepts taught (Ariyanto et al., 2022). Another advantage is the flexibility of its use. PhET Simulation can be accessed both online and offline, both in class and at home. This media is able to visualize concepts that are not visible and connect various representations explicitly. This allows students to repeat or deepen experiments independently at home, thus strengthening their understanding of the material learned (Yudiyanto et al., 2022). These advantages make PhET Simulation an innovative and relevant learning media in supporting modern learning.

Although PhET Simulation has many advantages, there are some limitations in its implementation, especially when implemented in schools. One of the main constraints is the dependence on the availability of computer units. If the number of computer devices is limited, students have to share, which can reduce learning effectiveness and hinder students' optimal interaction with the simulation (Kurniawan et al., 2024). In addition, another obstacle lies in the language used in PhET Simulation. Most of the materials use English as the language of instruction, which can make it difficult for students to understand tthe concepts presented, this requires teachers to provide more intensive assistance, such as translating instructions into Indonesian or finding other alternative solutions to overcome language barriers (Yudiyanto et al., 2022). Another limitation is that the practicum conducted using PhET Simulation is limited to the programs that are already available in the application, this may limit students' exploration of certain concepts that are not covered in the simulation. In addition, the use of PhET Simulation also requires students to be able to work independently with direction from the teacher, which can be a challenge for students who are less accustomed to independent learning. Therefore, it is necessary to have supporting strategies, such as careful learning planning and intensive assistance, so that these obstacles can be minimized (Yudiyanto et al., 2022). not only that, there is often a lack of stable connection or network in an elementary school during the simulation process using PhET, so in this case it becomes an obstacle in the learning process because in this case PhET is included in digital media that requires an internet connection (Almunawaroh & Dewi, 2024).

To overcome the limitations of using PhET Simulation in learning, several solutions can be applied. First, to overcome the limited number of computer devices, teachers can arrange alternate use schedules or utilize other devices such as tablets or smart phones that support PhET applications. In addition, simulation activities can be carried out in groups to encourage cooperation between students. Second, the English language barrier in the simulation material can be overcome by providing translation guides in Indonesian, both in the form of student worksheets and video tutorials prepared by the teacher. Teachers can also provide intensive assistance during the simulation to ensure students understand the instructions well. Third, to overcome the limitations on the variety of practicum in the application, teachers can

complement learning with simple experiments using tools and materials that are easily found around students, and it is important to use a stable internet connection during the learning process using PhET simulation media. With these steps, PhET Simulation can be optimally utilized in improving the quality of science learning in elementary schools.

CONCLUSION

Based on the results of the research and discussion, it can be concluded that the utilization of Physics Education Technology (PhET) Simulation media is proven to be effective in helping to construct elementary school students' concept understandingding, especially on electrical circuit material. PhET Simulation media can support students in understanding concepts better through interactive and interesting simulations, while providing opportunities for them to build knowledge independently through virtual laboratories that are easily accessible. Thus, the utilization of PhET media significantly has a positive impact on the development of students' cognitive understanding in the learning process. This finding is in line with the research objectives that want to analyze the effectiveness of PhET in learning tthe concept of electrical circuits in elementary schools.

Future research is recommended to explore the optimization of the use of PhET media in various learning contexts such as biology, physics, chemistry and mathematics and can be integrated with other teaching methods for maximum results such as PBL, PJBL and discovery learning to help students construct material concepts. In addition, teachers and educational practitioners are encouraged to integrate PhET media with various learning models to improve the quality of science learning in elementary schools.

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