

## The Use of PhET Simulations in Guided Discovery Learning to Enhance Critical Thinking Skills among Elementary School Students

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### Abstract

**Background:** Learning in elementary schools still faces challenges in developing students' critical thinking skills, especially when learning approaches do not provide opportunities for students to be actively involved in the learning process. The Guided Discovery Learning strategy directs student involvement to gain understanding through gradual exploration and reasoning. The use of PhET simulations as interactive digital media helps present concepts visually, making them easier for students to understand.

**Aims:** This article aims to examine the use of PhET Simulations in the Guided Discovery Learning Strategy as an effort to develop critical thinking skills in elementary school students.

**Methods:** This study employed a literature review, analyzing various relevant sources from national journals.

**Result:** The results of the study indicate that the integration of PhET Simulation with the Guided Discovery Learning Strategy has strong potential to support the development of students' critical thinking skills. These skills include problem analysis, information evaluation, conceptual interpretation, and the ability to draw logical conclusions. The reviewed literature consistently shows that interactive simulations encourage active learning, improve conceptual understanding, and support inquiry-based learning processes at the elementary school level.

**Conclusion:** This study provides an overview for elementary school educators in designing more active, meaningful learning that utilizes technology.

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## INTRODUCTION

Education in the 21st century emphasizes the development of critical thinking skills, as these skills play an important role in helping students analyze information, solve complex problems, and make appropriate decisions (Kusuma & Fauzi, 2025; Rusmin et al., 2024). In order for children to be able to do more than just passively absorb information, they also need to be taught critical thinking abilities at a young age (Nuraini et al., 2020; Pollarolo et al., 2023; Reilly et al., 2022). At the elementary school level, critical thinking skills are an important foundation because at this stage, students begin to develop mindsets and learning habits that will influence their lives and learning processes at subsequent levels (Anggraeni et al., 2022; Dilla, 2024). Therefore, elementary school education should not only focus on delivering content but also on fostering students' critical and active thinking skills.

However, in practice, elementary school learning still faces challenges in developing critical thinking skills in students. Learning still tends to be teacher-centered, with an emphasis on conveying information and curriculum targets (Komalasari et al., 2021). This results in limited opportunities for students to be actively involved in the learning process (Asy'arie et al., 2025). This condition causes students to memorize concepts rather than understand them, and they are less accustomed to asking questions, analyzing problems, and expressing opinions. Several studies indicate that the lack of exploratory learning activities contributes to the low level of critical thinking skills among elementary

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school students, Research (Cahyanisam et al., 2026) found that learning that is still dominated by teachers and minimal student involvement in exploratory activities results in low critical thinking skills among elementary school students. The lack of exploratory activities means that students are rarely involved in higher-level thinking processes such as analysis and evaluation. One relevant learning approach to address this issue is the Guided Discovery Learning Strategy. This strategy places students as active subjects in understanding concepts through a process of exploration. In the Guided Discovery Learning strategy, educators act as facilitators, providing gradual guidance so that students are able to observe, identify patterns, and draw conclusions based on their learning experiences (Andriyani et al., 2025; Hardianti et al., 2025; Irsyadah et al., 2025). Through these stages, students are trained to think actively, logically, and reflectively. The use of guided discovery learning successfully enhances students' critical thinking abilities and dispositions, according to research by (Noer, 2018). This approach promotes student participation in the learning process by requiring them to actively uncover topics through analysis and reasoning. In addition, the results of research by (Zahra & Suwarna, 2023) show that the use of Guided Discovery Learning significantly improves critical thinking skills because students are directly involved in analyzing information and solving problems during the learning process. This approach allows students to actively explore concepts, thereby increasing learning engagement.

The learning media used greatly influences the success of the Guided Discovery Learning Strategy (Wulandari & Wiarta, 2022). Learning media that is not varied and interactive can hinder the exploration and learning process of students, especially at the elementary school level, which requires visual aids and concrete learning experiences (Maulidiyah et al., 2025; Sattvika et al., 2024). The use of digital learning media is one alternative that can support the effectiveness of learning with the Guided Discovery Learning strategy (Lu'luilmaknun & Wutsqa, 2018; Partini et al., 2025). Interactive digital media allows for dynamic, visual, and contextual presentation of material. This can help students understand concepts more deeply and meaningfully. One interactive digital medium that can be used in learning is PhET Simulation (Kamilah et al., 2025). PhET Simulation is designed to provide a learning experience through exploration and direct interaction with virtual objects. The characteristics of PhET Simulation provide visualization, direct feedback, and the opportunity to try various conditions, making it very suitable for discovery-based learning approaches (Drastisianti et al., 2024). Through this simulation, students can observe cause and effect relationships, explore concepts, and conduct experiments independently in a learning environment.

PhET simulations can be used into the Guided Discovery Learning approach to give primary school pupils the chance to study in a more engaging and meaningful way. In this method, PhET simulations are crucial for exploration, and Guided Discovery Learning serves as a tactical framework that directs students' concept discovery process. When the two are combined, students can use observation, analysis, and conclusion-making to engage in critical thinking in addition to receiving knowledge. Therefore, through a survey of pertinent national scientific sources, this research seeks to investigate the application of PhET simulations in Guided Discovery Learning techniques as an attempt to enhance primary school students' critical thinking abilities.

## METHOD

This study examines the use of PhET simulations within the guided discovery learning approach to improve primary school students' critical thinking skills. The study adopts a literature review method to analyze findings from previous research, which was put together utilizing the literature review process. This approach was chosen because the study evaluated and reviewed findings from earlier studies pertinent to the use of PhET simulations in Guided Discovery Learning methodologies to foster critical thinking abilities in elementary school pupils rather than conducting direct research. Examining scholarly publications from national journals pertaining to the study's subject was the method used to gather data. The selection of references was based on recent literature relevant to the three focus areas of discussion, namely: the critical thinking skills of elementary school students, the application of the Guided Discovery Learning Strategy, and the use of PhET simulations or interactive digital learning media. Data collection was carried out through selection based on content relevance, clarity of research methods, and the relevance of findings to the objectives of the study.

Descriptive qualitative approaches were used to analyze the data by going over the publications' text, determining their key ideas, and contrasting them with earlier research. The analysis concentrated on how PhET simulations enhance the Guided Discovery Learning Strategy and how this affects primary school pupils' development of critical thinking abilities. In the discussion section, the analysis's findings are given as a narrative account. A conceptual overview of the possible incorporation of PhET simulations into the Guided Discovery Learning Strategy as active, relevant, and meaningful learning through the use of technology in elementary schools is the goal of the findings presentation.

## RESULTS AND DISCUSSION

### Results

Learning at the elementary school level requires strategies that encourage active student participation and develop critical thinking skills in a focused manner. Based on a literature review, the Guided Discovery Learning strategy is considered relevant for achieving the goal of placing students as the main subjects in the learning process. Through guided discovery stages, students are trained to observe, analyze problems, and draw conclusions based on their personal experiences in learning. This strategy provides opportunities for students to build knowledge independently with the guidance of educators, so that the learning process is not passive (Halim & Wulandari, 2024). This strategy is also considered capable of reducing the dominance of teacher-centered learning, which is one of the causes of low critical thinking skills among elementary school students. However, the effectiveness of Guided Discovery Learning is greatly influenced by the learning media used. Non-interactive learning media may limit students' opportunities to explore and discover concepts, especially at the elementary school level, which still requires concrete visuals and learning experiences. The use of digital learning media represents a strategic approach to supporting the implementation of the Guided Discovery Learning strategy.

Digital learning media is a learning tool that utilizes technology to present teaching materials in an interactive, visual, and contextual manner that can increase student motivation and engagement in learning (Prasetya et al., 2025). Interactive digital media can present teaching materials contextually to help students understand concepts more deeply. One type of interactive digital learning media that can be utilized is PhET Simulation. PhET Simulation is designed to provide learning experiences through interaction and exploration with virtual objects accompanied by visualizations and direct feedback (Gunawan et al., 2023). The characteristics of PhET Simulation allow students to observe and try various scenarios. PhET Simulations are considered flexible and easy to use as a learning medium in elementary schools. Research in Indonesia shows that the use of PhET Simulations can increase student engagement and support the development of critical thinking skills. PhET Simulations are considered a relevant learning medium to support discovery-based learning in elementary schools.

In addition, the findings from various studies indicate that the use of interactive digital media such as PhET Simulations can help bridge abstract concepts into more concrete learning experiences for elementary school students. This condition supports students in understanding learning materials more effectively through direct visualization and experimentation, which are essential components in the development of critical thinking skills. Furthermore, the reviewed literature shows that students who are actively involved in exploration-based learning tend to demonstrate higher levels of engagement and curiosity during the learning process. This engagement supports the development of analytical skills and encourages students to ask questions, test ideas, and reflect on learning outcomes, which are indicators of critical thinking development at the elementary school level.

### Discussion

The integration of PhET simulations into the Guided Discovery Learning strategy is conceptually and pedagogically appropriate. The Guided Discovery Learning strategy emphasizes the process of discovering concepts through guided exploration, while PhET simulations provide interactive and visual means of exploration. The combination of the two allows students to be actively involved in the learning process, from observing phenomena, gathering information, to drawing conclusions based on the results of their exploration. The use of PhET simulations combined with Guided Discovery Learning in the development of critical thinking skills provides opportunities for students. Interaction with

simulations accompanied by guidance from educators can help students develop reflective thinking patterns. Thus, the integration of PhET simulations and Guided Discovery Learning has the potential to be an effective learning method in supporting the development of critical thinking skills, especially in learning that utilizes digital technology in a meaningful way.

Thus, compared to conventional learning methods that use lectures and memorization, the Guided Discovery Learning strategy in PhET simulations provides a more meaningful learning experience. Students have the opportunity to think actively through an exploration process that supports interactive digital media. Findings from several journals show that this approach has the potential to improve the quality of learning in elementary schools. The use of PhET simulations in the Guided Discovery Learning Strategy demonstrates a relevant and promising approach to developing critical thinking skills in elementary school students. The integration of appropriate learning strategies and digital media can help educators create more active, interactive learning that is oriented toward the development of critical thinking skills.

### **Implications**

The results support constructivist learning theory, which highlights how students actively create knowledge through investigation and engagement with learning contexts. By promoting inquiry-based and experiential learning processes, the combination of PhET simulations and guided discovery learning aids in the development of critical thinking abilities. The results of this study can serve as a reference for elementary school educators in designing learning activities that integrate Guided Discovery Learning with interactive digital media. The use of PhET simulations allows teachers to create learning environments that are more engaging, meaningful, and supportive of students' critical thinking development. These findings support the implementation of educational policies that encourage the integration of digital technology in elementary school learning. The use of interactive simulations can be considered a strategic step in strengthening digital-based learning practices that align with 21st-century learning demands.

### **Research contribution**

This study contributes to the field of elementary education by providing insights into the integration of Guided Discovery Learning strategies with PhET simulations in developing students' critical thinking skills. The findings offer empirical support for the use of interactive digital media in discovery-based learning and enrich the existing literature on technology-enhanced learning in elementary schools.

### **Limitations**

This study is limited to a literature review of national journal sources, which may not fully represent broader international research findings. In addition, the discussion focuses primarily on conceptual and pedagogical aspects without empirical measurement of learning outcomes.

### **Suggestions**

Future research is recommended to conduct empirical studies to examine the effectiveness of integrating PhET simulations with Guided Discovery Learning strategies in classroom settings. Further studies may also explore the use of this approach in different subjects and educational levels to strengthen the generalizability of the findings.

## **CONCLUSION**

The findings indicate that the use of PhET simulations within the Guided Discovery Learning strategy has strong potential to support the development of critical thinking skills among elementary school students. The Guided Discovery Learning Strategy encourages students to actively engage in the learning process through targeted activities, so that students do not only receive information passively, but are also trained to be able to analyze problems, evaluate information, and draw conclusions rationally. PhET simulations, as interactive digital learning media, play an important role in supporting the process of exploration and concept discovery.

PhET's characteristics provide dynamic visualizations, immediate feedback, and opportunities for virtual experiments that allow students to gain more concrete and meaningful learning experiences. The integration of PhET simulations with Guided Discovery Learning enables active, interactive learning that is oriented towards developing the critical thinking skills of elementary school students. Thus, the use of PhET simulations in the Guided Discovery Learning strategy can be used as an alternative in technology-based learning that is relevant to improving the quality of learning in elementary schools, particularly in efforts to foster critical thinking skills in students.

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### AUTHOR CONTRIBUTION STATEMENT

RSA played a primary role in developing the research concept and objectives, conducting the literature search and selection, analyzing and synthesizing the findings from relevant studies, and preparing the initial draft of the manuscript. RSA also carried out revisions to ensure compliance with academic writing standards and journal guidelines. The author has reviewed and approved the final manuscript and takes full responsibility for the content of this publication.

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