

Implementation of Deep Learning to Improve Students' Physics Learning Outcomes: A Systematic Literature Review

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Article Info	Abstract
Article history: Received: June 6, 2025 Accepted: September 20, 2025 Published: October 30, 2025 Keywords: Deep learning Physics learning SLR This article is licensed under a Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License © 2025 Berkala ilmiah Pendidikan Fisika	Deep learning models have been increasingly adopted in education, including the humanities, arts, technology, and natural sciences. In physics education, deep learning offers promising opportunities to enhance students' learning outcomes. This study aims to systematically review research on the application of deep learning models in physics learning. Using the Systematic Literature Review (SLR) method, the research followed several steps: formulating research questions, defining selection criteria, designing a search strategy, selecting studies, assessing quality, and synthesizing results. Of the 360 identified articles, 11 met the eligibility criteria and were most relevant to the research focus. The review reveals that various models, such as Physics Deep Learning, ChatGPT, Deep Lagrangian Networks (DeLaN), smart virtual assistants, Fusing Dual Sampling Convolutional Neural Networks (FDS-MPI), Artificial Intelligence (AI), object detection algorithms, and Deep Neural Networks (DNN)—have been applied to topics including general physics, electronic physics, density and energy, wave propagation, and fluid dynamics. The findings suggest that deep learning improves students' physics learning outcomes and provides implications for practice and research. This study is limited to the scope of selected articles and does not include direct classroom experimentation, which future research should address.
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INTRODUCTION

Artificial Intelligence (AI) has become an integral part of modern education, enabling the processing of large amounts of data and supporting personalized learning. One of its branches, deep learning, plays a crucial role in enhancing students' understanding by enabling meaningful connections between prior knowledge and new information, and by applying concepts in real-life contexts (Davis, 2019; Jiang, 2022; Weng et al., 2023).

In recent years, educational approaches have shifted from merely transferring knowledge toward promoting higher-order skills such as critical thinking, creativity, collaboration, and communication—the 4Cs that characterize 21st-century competencies (Harris et al., 2019; Otto et al., 2020). Deep learning aligns with these demands by not only strengthening conceptual mastery but also preparing students with adaptive and critical skills for their future careers (Ahmad, 2020; Elbashbshy, 2024).

Within the natural sciences, physics represents a discipline where deep learning can be particularly impactful. Physics describes natural phenomena through mathematical representations, making abstract concepts more accessible and applicable in daily life

([Winter & Airey, 2022](#)). However, classroom physics instruction in many institutions still emphasizes rote mastery of concepts, often at the expense of scientific skills and problem-solving abilities ([Hudha et al., 2017](#)). This creates a gap between the expected learning outcomes and actual classroom practices.

Several studies have explored technology-based approaches in physics learning, including adaptive learning, algorithms, and machine learning ([Chusni, 2022](#)). Other research, such as the use of the Deep Learning Question (DLQ) program, has shown improvements in conceptual understanding and long-term retention ([Afwah & Latifah, 2016](#)). Nevertheless, no studies have systematically analyzed the impact of deep learning on physics education outcomes using the Systematic Literature Review (SLR) method.

Therefore, this study aims to fill that gap by applying the SLR approach to comprehensively examine how deep learning models influence students' physics learning outcomes. The novelty of this research lies in its systematic synthesis of prior studies, which enriches the literature and provides practical implications for the development of effective physics instruction.

METHODS

This study employs a SLR to identify, evaluate, and synthesize existing research on the application of deep learning in physics education. The SLR approach provides a structured process to ensure transparency, rigor, and replicability in the review of relevant literature.

Figure 1 illustrates the SLR procedure applied in this study, which includes the following steps: formulating research questions, defining inclusion and exclusion criteria, developing search strategies, selecting relevant studies, and assessing their quality. This systematic process ensures that the review is comprehensive and evidence-based, following established methodological guidelines ([Akmal et al., 2025](#); [Zawacki-Richter et al., 2019](#)).

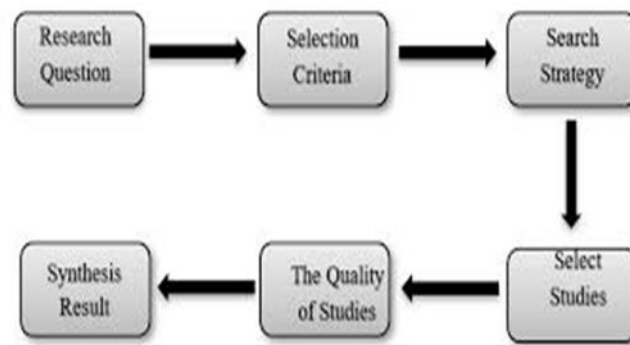


Figure 1 Procedure of SLR

Research Question

Research questions are used to answer research questions. At this stage, the researcher developed research questions as a basis for the research, which are presented in Table 1.

Table 1 Research question

#	Research Question
RQ1	What deep learning model affects students' physics learning materials based on SLR results?
RQ2	Can deep learning improve students' physics learning outcomes?

Selection Criteria

The next stage is the screening stage, which ensures the suitability of the scientific literature by categorizing it according to inclusion and exclusion criteria. The selection criteria in this study are shown in Table 2.

Table 2 Selection criteria

Aspect	Criteria
Inclusion	• The article discusses deep learning in student physics learning. • Last 4 years (2021-2025) • No fee • Accessible • English language journals
Exclusion	• The article only discusses deep learning. • Under the year 2021 • Paid • Abstract only • Indonesian-language journals

Search Strategy

The search was conducted using Google Chrome and the Google Scholar database. The search string needs to be refined to yield more specific results and avoid a large number of articles. The search string in this study is 'deep learning for students studying physics.' Article searches in Google Scholar.

Select Studies

In the research selection process, it is necessary first to review the article's title and abstract to determine whether it is relevant to the research being conducted ([Zawacki-Richter et al., 2019](#)).

The Quality of Studies

Research using the SLR model will evaluate data or articles identified through research questions and that meet the criteria used in this study. Each journal article obtained will be given an answer value for each question with Y (Yes) or T (No). These answers can assess the quality of each journal article.

QA1: Does the article present a research problem relevant to this study?

QA2: Does the article discuss the implementation of deep learning?

QA3: Does the article explain the improvement of students' physics learning outcomes relevant to this research?

RESULTS AND DISCUSSION

For research using the SLR method, there are four stages that must be carried out to obtain appropriate literature according to the criteria, according to ([Ali et al., 2023](#); [Nisa et al., 2025](#); [Suciati, 2022](#)), namely:

1. Identification of literature with relevant topics. This stage has been explained in the method section through the search keywords 'deep learning for students studying physics' on Google Scholar.
2. Screening: initial screening based on the title and abstract, using the literature identified. Articles that do not match the topic of this research will be eliminated.
3. Eligibility and completeness of text in articles that have gone through the identification and screening stages.
4. Included are articles that fulfill the eligibility criteria. This stage has been presented in the research method on inclusion and exclusion criteria.

Based on the four stages, researchers identified 16,900 results (including all types of literature, such as books and articles) from the Google Scholar database from 2021 to 2024. However, of the 360 articles identified from titles and abstracts, only 11 met the eligibility criteria and were most relevant to the research topic. Researchers chose these 11 articles because they met the inclusion criteria. From the search results, several articles discuss the

application of deep learning models to physics content for students. The results of the article search are presented in Table 3.

Table 3 Article search results

Article Title	Deep Learning Models	Physics Content
Combining physics and deep learning to learn continuous-time dynamics models (Lutter & Peters, 2023)	Deep Lagrangian Networks (DeLaN)	Robotics algorithm
Students' perceptions of using ChatGPT in a physics class as a virtual tutor (Ding et al., 2023)	ChatGPT	General physics questions
Deep learning for improving the spatial resolution of magnetic particle imaging (Shang et al., 2022)	fusing a dual-sampling convolutional neural network (FDS-MPI)	Magnetic particles
Physics-enhanced deep learning methods for modelling and simulating flow fields (Jin et al., 2021)	Physics Enhanced Deep Learning Methods	Flow field
Physics-Driven Deep Learning Inversion with Application to Magnetotelluric (Liu et al., 2022)	Physics Driven Deep Learning Magnetotelluric (PhyDNN)	Wave propagation
Increasing the Effectiveness of Electronic Physics Learning by Utilizing Extended Reality and Smart Virtual Technology Assistant as Interactive Media (Aryanto et al., 2023)	Smart Virtual Assistant	Electronic physics
Dual-energy CT based mass density and relative stopping power estimation for proton therapy using physics-informed deep learning (Chang et al., 2022)	Physics informed deep learning (PIDL)	Density and energy
Exploring user perceptions: The impact of ChatGPT on high school students' physics understanding and learning (Fadillah, 2024)	Chat GPT	General physics
Artificial Intelligence in Physics Education: Transforming Learning from Primary to University Level (Shafiq et al., 2025)	Artificial Intelligence (AI)	General physics
Research on object detection algorithm based on deep learning for mobile Terminal (Luo et al., 2021)	Object detection algorithm deep learning	Cellular terminals
Using deep learning to learn physics of conduction heat transfer (Edalatifar et al., 2021)	Deep Neutral Network (DNN)	Conduction heat transfer

After conducting the selection stage and identifying articles that meet the inclusion criteria, the researchers will read the titles and abstracts to determine whether each is relevant to the study's topics. At this stage, the researcher will review how many articles meet the research quality criteria by formulating them according to predetermined criteria (Q1, Q2, and Q3). If the scientific article is relevant and addresses the same topic as this study, it is included in the research quality criteria; otherwise, the answer is no.

Synthesis Result

The last stage of the systematic literature review procedure chart is to synthesize the data. This stage is useful for obtaining and combining information from selected research literature to help researchers answer this research question. Some of the relevant research articles found can solve the questions in this study.

RQ1: What deep learning models influence students' physics learning materials based on SLR results?

Before we answer research question 1, we will present the percentage of deep learning models across 11 studies identified through the SLR method in Figure 2.

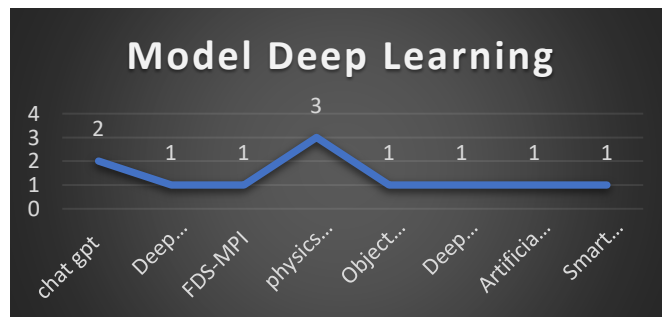


Figure 2 Models deep learning

In Figure 3, the y-axis shows the number of previous studies, and the x-axis shows the deep learning models. Thus, of the 11 previous studies that examined deep learning. There are three previous studies discussing physics deep learning models, two previous studies discussing ChatGPT, one previous study discussing deep Lagrangian networks, and one previous study discussing deep learning models that are interrelated with each other, such as FDS-MPI, smart virtual assistants, artificial intelligence, object detection deep learning algorithms, and deep neural networks.

Physics Deep Learning

Of the articles that fulfill the SLR stages and steps, three discuss and develop physics-based deep learning models, including physics-enhanced deep learning methods, physics-informed deep learning (PIDL), and physics-driven deep learning magnetotelluric (PhyDNN).

Physics-enhanced deep learning methods have been developed for natural language processing, image classification, and flow field prediction. Although theoretically, fluid flow can be described by the Navier-Stokes equations. However, for solving complex engineering flow problems and the difficulty of accurately and efficiently calculating the flow field, physics-enhanced deep learning can help through numerical simulation ([Jin et al., 2021](#)). This study states that the physics-enhanced deep learning method can model and simulate a more complex flow field.

Physics-Driven Deep Learning Magnetotelluric (PhyDNN) incorporates the laws of physics into deep learning model training to better model electromagnetic wave phenomena, including wave propagation in the Earth, the core of magnetotelluric data interpretation. This research states that PhyDNN does not change the laws of physics, especially Maxwell's laws; it only helps handle complex, realistic exploration scenarios, especially in the context of wave propagation. The development of physics-informed deep learning is trained with a physics loss function. As a result, physics-informed deep learning training can reduce uncertainty in physics information, thereby reducing significant errors or capturing data structures. This model integrates laws of physics, particularly density and energy, into artificial neural networks and can be applied in schools to teach density and

energy because it produces more accurate and efficient predictions, especially when the available data is limited ([Chang et al., 2022](#)).

ChatGPT

Among the articles that follow the stages and steps of SLR, 2 discuss the GPT Chat model, which is part of deep learning. However, the discussion of the two articles shows different findings. The research study conducted by Fadillah (2024) found that, based on a survey of 167 high school physics students, ChatGPT is considered helpful for improving understanding of concepts, correcting misconceptions, and providing a fun learning experience in physics classroom instruction. Meanwhile, a study ([Ding et al., 2023](#)) found that ChatGPT was not very accurate at answering general physics questions, yet most of the 40 students trusted its ability to answer them. However, using ChatGPT in the form of images, audio, and video can be a tool to support teachers in various materials for physics lessons.

Deep Lagrangian Networks (DeLaN)

Of the articles that follow the stages and steps of SLR, 1 discusses deep learning models for robotics. However, many deep learning models still ignore existing knowledge in physics or robotics, especially in learning dynamics models. Therefore, [Lutter & Peters \(2023\)](#) introduced Deep Lagrangian Networks (DeLaN), which combine deep learning with physical principles. The results of this study indicate that DeLaN can be used to learn dynamic models and apply them to control simulated and physical rigid-body systems. DeLaN learning can be provided to physics students interested in understanding principles such as mechanics, electronics, and system control.

FDS-MPI

Of the articles that follow the stages and steps of SLR, one discusses deep learning models for learning magnetic particles. This article combines deep learning with physics principles in biology and medicine. This research proposes the FDS-MPI model for learning physics, biology, and medicine because it generates high-resolution images from low-resolution inputs and avoids the drawbacks of lower sensitivity or reduced contrast. Physics students can also learn this, along with magnetic particle material, to deepen their understanding of the concepts and their knowledge ([Shang et al., 2022](#)).

Smart Virtual Assistant

Of the several articles that fulfill the SLR stages and steps, 1 article discusses a deep learning model for electronic materials in physics. This research found that smart virtual assistants can serve as interactive learning media in electronic physics materials, accelerating student understanding, reducing learning barriers, and helping students solve problems in electronic physics. By incorporating deep learning models into smart virtual assistants for learning, students can deepen their understanding, enrich their experiences, and be actively involved in learning electronic physics ([Aryanto et al., 2023](#)).

Artificial Intelligence (AI)

Of the articles that follow the stages and steps of SLR, one discusses a deep learning model for learning physics. The article's findings suggest that AI enables students to experiment with explaining complex physics concepts and helps them understand abstract knowledge in physics. In addition, the application of AI to physics education helps students achieve their accessibility goals and generate engaging learning experiences that facilitate the effective acquisition of 21st-century skills ([Shafiq et al., 2025](#)).

Object detection algorithm, deep learning

Of the several articles that follow the stages and steps of SLR, 1 article discusses deep learning models for mobile terminals. This article introduces a deep learning-based object detection algorithm that locates target objects in images. The findings in this study show that this deep learning model can be implemented on mobile terminals and improve their object detection capabilities, as demonstrated on a Raspberry Pi, with MAP (mean average precision) and FPS (frames per second) reaching 97%. Deep learning algorithms for object detection in physics education enrich students' knowledge of telecommunication devices ([Luo et al., 2021](#)).

Deep Neural Network (DNN)

Of the articles that follow the stages and steps of SLR, one discusses deep learning models for learning conduction heat transfer. This article explains that the Deep Neural Network (DNN) model is able to learn 2D heat transfer physics without knowing the partial differential equations underlying conduction heat transfer. The results also state that the Deep Neural Network (DNN) trained by Mean of Maximum Squared Errors (MMESE) gives a better temperature distribution compared to the Mean Squared Errors (MSE) trained DNN because the 2D heat equation is a practical Laplace equation in dual physics. This model can be introduced in secondary physics education through video and image processing projects on conduction heat transfer ([Edalatifar et al., 2021](#)).

From the 11 articles that researchers presented from Google Scholar, it shows that many deep learning models affect physics student learning materials, have a positive impact on physics students in understanding physics learning concepts, and help students solve problems, especially in physics learning materials such as general physics questions, electronic physics, density and energy material, wave propagation material, flow material, and other materials in student physics learning at school.

RQ2: Can deep learning improve students' physics learning outcomes?

Based on the data synthesis, integrating deep learning models into physics lessons at school can help students deepen their understanding of concepts, solve problems, and improve their cognitive learning outcomes. The application of deep learning can also improve students' abilities in line with 21st-century skills, as it shapes their critical thinking and collaboration. In addition, deep learning can improve students' problem-solving skills, especially in answering teacher-given physics questions. This aligns with the previous theoretical explanation, which states that deep learning meets the needs of 21st-century education by emphasizing mastery of concepts while also promoting deep understanding, collaboration, and critical thinking. With the 21st-century competencies comprising 4Cs (Critical Thinking, Communication, Creativity, and Collaboration), deep learning is increasingly important for prioritizing competencies to address challenges in education in the modern era.

The explanation above illustrates the complexity of deep learning in the context of 21st-century skills. It is also known that physics students can collaborate to analyze and solve problems in physics lessons using deep learning. So, physics teachers can give physics problems that are quite difficult, for example, problems on density and energy, or other physics materials. Students must solve the problem in groups and may use a deep learning approach. Deep learning also enables interaction between physics teachers and students, fostering a more pleasant classroom atmosphere. Student learning outcomes that are improved through deep learning are in several physics materials, among others:

1. General physics material
2. Algorithm material
3. Magnetic material
4. Flow material

5. Electronic physics material
6. Wave material
7. Density and energy
8. Conduction heat transfer material
9. Mobile terminals or telecommunication devices.

CONCLUSION

The results of this study indicate that applying various deep learning models in physics education has a positive impact on students' learning. Deep learning improves physics learning outcomes, strengthens conceptual understanding, enriches learning experiences, and supports problem-solving skills across areas such as general physics, electronics, energy and density, wave propagation, and fluid dynamics. These findings are in line with the demands of 21st-century education, which emphasize not only conceptual mastery but also critical thinking, collaboration, and deeper understanding.

This research has several implications. First, it provides important considerations for physics teachers to integrate deep learning into classroom practices. Second, it enriches the existing body of literature on the use of artificial intelligence in physics education. Third, it serves as a valuable reference for future researchers interested in similar areas.

However, this study has limitations. The search process was limited to articles indexed in Google Scholar, and its scope was limited to the application of deep learning in physics education. Further research is recommended to expand the database's scope and explore broader contexts to provide more comprehensive insights into the role of deep learning in education.

CONFLICTS OF INTEREST

The authors declare that there is no conflict of interest.

AUTHOR CONTRIBUTIONS STATEMENT

Conceptualization, AAI, and K; methodology, AAI; formal analysis, AAI; investigation, AAI; data curation, AAI; writing—original draft preparation, AAI; writing—review and editing, AAI and K; supervision, K and AT.

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