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REVIEW OF MAPPING RESEARCH TRENDS ON DEEP LEARNING IN PHYSICS TEACHING

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Abstract: Deep learning approach can be used for personalized, adaptive education systems. Personalized learning can be utilized to make this type of education more effective. Personalized learning (also known as competency-based learning) is an educational approach that adapts instruction to students' needs and abilities. This research aims to identify and analyze research trends of deep learning in physics. This research method is descriptive and analytical. The data used in this research was obtained from documents indexed by Google Scholar from 2016-2025 using Publish or Perish and Dimension.ai. Research procedures use PRISMA guidelines. The data identified and analyzed are the type of publication, publication source, and the title of research on deep learning in physics that is widely cited. The data analysis method uses bibliometric analysis assisted by VOS viewer software. The results of the analysis show the research trend on the deep learning in physics indexed by Google Scholar from 2016 to 2025 has experienced a fluctuating increase. However, in 2025 there will be a decline in the research trend on the deep learning in physics. There are many documents in the form of articles, proceedings, chapters, preprints, monograph and edited books that discuss research into the deep learning in physics. Key words that are often used in research about it are chatgpt, technology, learner, artificial intelligence, etc. The study results show that the implementation of deep learning has a positive impact on the development of higher-order thinking skills, such as critical thinking, creativity, and problem-solving, which are highly relevant to the demands of 21st-century competencies. However, its effectiveness depends heavily on the quality of the learning design, teacher preparedness, and an assessment system that supports meaningful learning.

Keywords: Deep Learning Approach, Education, Physics Learning, Review

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INTRODUCTION

In Time is changing rapidly. As the planet ages, the world becomes increasingly vulnerable. Advances in science and increasingly sophisticated technology come hand in hand with the changing times. These developments have a broad impact on various aspects of real life, particularly in the implementation of learning (Mutmainnah et al., 2025). Furthermore, in this modern era of globalization, technological development is inevitable and is growing rapidly, particularly in the field of artificial intelligence (AI). Artificial Intelligence (AI) itself is the competence of computer systems to perform tasks that typically require human intelligence, such as speech recognition, vision, and decision-making. It has been applied in various fields, from health and transportation to education, and has had a significant impact on increasing the efficiency and effectiveness of various services (Zuhro & A'yun, 2024).

Education in Indonesia is currently undergoing reform to meet the demands of the 21st century, where critical thinking skills, creativity, and the ability to collaborate are becoming increasingly important elements in education. With the goal of preparing a young generation capable of facing global challenges, Indonesian education requires an innovative approach, not only in terms of curriculum but also in the learning models used. One model currently receiving increased attention is deep learning, initiated by the Minister of Primary and Secondary Education (Mendikdasmen), Abdul Mu'ti. This model emphasizes the importance of learning that focuses on deep understanding, enabling students to go beyond memorization to meaningfully internalize knowledge (Santiani, 2025).

The deep learning approach itself is not new; the term has been around since 1976 (Khotimah & Abdan, 2025; K. Khotimah et al., 2024). Deep learning, first introduced by Marton and Säljö (1976), is a learning approach that emphasizes a comprehensive understanding of meaning and relationships between concepts (Wijaya et al., 2025; Wijaya, 2025). Deep learning (DL)-based learning models can be used for personalized, adaptive education systems. Personalized learning can be utilized to make this type of education more effective. Personalized learning (also known as competency-based learning) is an educational approach that adapts instruction to students' needs and abilities (Andriana, 2021).

Furthermore, the learning approach chosen by the teacher plays a crucial role in effectively achieving learning objectives. As the primary instrument in the educational process, the learning approach determines how material is delivered, received, and understood by students. Selecting the right learning approach allows students not only to understand theoretical concepts but also to develop critical, creative, collaborative, and communicative skills. Teachers need to consider student characteristics, the learning context, and the desired

end goal. In the modern education era, interactive and student-centered learning methods, such as deep learning, are increasingly important in preparing students to face global challenges (Afwa et al., 2016; Kurniawan, 2025; Nabila et al., 2025). Deep learning can also be integrated into physics learning in schools. Many physics lessons have used the deep learning approach and have been proven to provide positive results (Arteaga-Narváez et al., 2017; Edalatifar et al., 2021; Erdmann et al., 2021; Guo & Depaynos, 2023; Yulianto & Iryani, 2024).

Despite the growing body of literature on the *deep learning* approach in education and its widely acknowledged contribution to conceptual understanding and higher-order thinking skills, several critical research gaps remain. Early foundational studies led by John Biggs as well as Ference Marton and Roger Säljö primarily focused on categorizing learning approaches (i.e., *deep* versus *surface*) and examining their effects on learning outcomes. However, these studies were largely conducted within higher education contexts in developed countries, limiting their generalizability to broader educational settings, particularly in developing countries. Furthermore, existing research on *deep learning* tends to emphasize cognitive dimensions, such as conceptual understanding and critical thinking, while comparatively overlooking affective and social dimensions, including learning motivation, collaboration, and emotional engagement. This is noteworthy given that, from a constructivist perspective articulated by Lev Vygotsky, social interaction plays a crucial role in the construction of meaningful learning experiences.

Another significant gap lies in the practical implementation of *deep learning* in classroom settings. While numerous studies report its effectiveness, there is still limited exploration of how this approach can be systematically integrated into sustainable instructional design, particularly in terms of authentic assessment and *constructive alignment*. This indicates a need for more applicable and context-sensitive implementation models. In addition, the rapid advancement of digital technology and *e-learning* environments has not been fully leveraged within the *deep learning* framework. Many studies still treat pedagogical approaches and technological integration as separate domains, resulting in a lack of research that explicitly investigates how *deep learning* can be enhanced through interactive digital media, simulations, and *learning analytics*.

Based on the above background, this article aims to provide an understanding of the concept of deep learning, the urgency of its application in 21st-century education, and the components of this learning approach. Therefore, this research wants to know the research

trend of deep learning in physics. It is hoped that this research can become a reference in developing further research related to deep learning in physics.

METHOD

This research method is descriptive and analytical, which aims to understand and describe research trends in the deep learning in physics. The data used in this study was obtained from information sources indexed by Google Scholar using analytical tools such as Publish or Perish and Dimension.ai. To carry out a search on Google Scholar, keywords related to research trends on the deep learning in physics.

In this research, an analysis was carried out on 400 documents that had been indexed by Google Scholar between 2016 and 2025. The Google Scholar database was chosen as a place to search for documents because Google Scholar applies consistent standards in selecting documents to be included in its index, and Google Scholar displays more documents than the top databases. Others, especially research in the field of education (Hallinger & Chatpinyakoop, 2019; Hallinger & Nguyen, 2020; Zawacki-Richter et al., 2019). To filter data that has been collected via Publish or Perish, researchers used the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.

The study adopted the PRISMA framework to ensure a systematic and transparent literature selection process. A total of 1,250 records were initially identified through database searching. After removing duplicates, 1,000 records remained for screening. Based on title and abstract screening, 700 articles were excluded due to irrelevance, leaving 300 articles for full-text assessment. During the eligibility stage, 220 articles were excluded for not meeting the inclusion criteria. Finally, 80 studies were included in the systematic review.

FINDING AND DISCUSSION

This research aims to describe research trends on deep learning in physics conducted from 2016 to 2025. Research documents on research trends deep learning in physics in science learning are taken from documents from 2016 to 2025. Figure 1 is presented below regarding research trends on the deep learning in physics.

Figure 1 shows that the trend in research on the deep learning in physics from 2016 to 2025 has increased. Where the research trend is with an increase in the number of publications every year, namely from 2016 to 2024. However, in the middle of 2025 research trend on deep learning in physics has decreased. The increasing trend in research on the deep

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learning in physics caused by 21st century education has focused on improving various kinds of competencies by using various approaches, one of which is the deep learning approach.

In 2016 there were 323 publications related to the deep learning in physics, then this will continue to increase to 3538 publications in 2024. This increasing research trend This is in line with the fact that in the 21st-century educational landscape, expectations for the learning process are no longer solely focused on the transmission of knowledge, but also on the transformation of understanding and strengthening of students' character. Ideally, mathematics and physics learning at the high school/vocational school level should develop critical, collaborative, creative, and communicative thinking skills (the 4Cs) rooted in a love of lifelong learning. This ideal can be achieved through the implementation of learning that is not only oriented toward outcomes, but also toward the process, emotions, and awareness of student learning. The Deep Learning approach, which rests on the three main pillars of Joyful, Mindful, and Meaningful, is a path to transformation toward a more humane, adaptive, and relevant education in facing global challenges (Farley, 2023; Hassed, 2016).

Below are also table 1 presented research of deep learning in physics based on the type of publication.

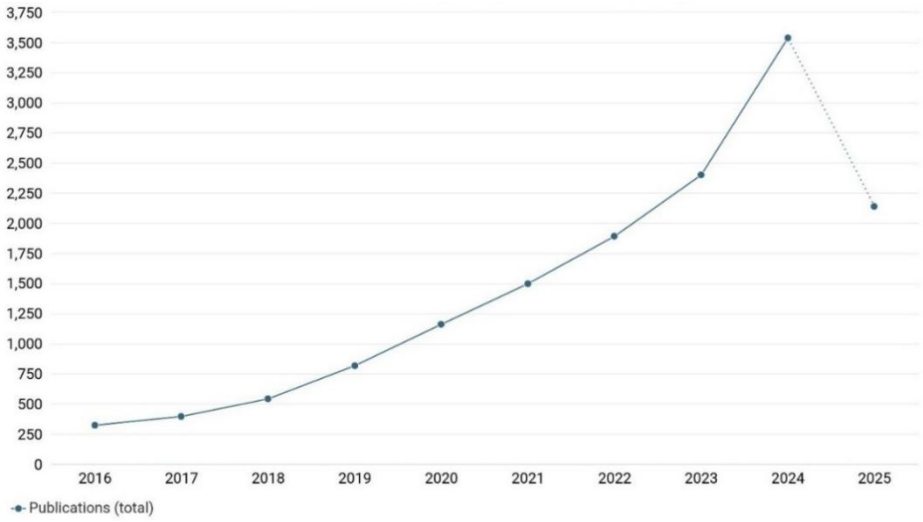


Figure 1. Research trends in deep learning in physics (app.dimensions.ai)

Publication Type	Publications
Article	10,282
Chapter	3,195
Proceeding	1,997
Preprint	610
Edited Book	535

Monograph	200

Table 1. Trends in deep learning in physics Based on Publication Types

Based on Table 1, it is known that research deep learning in physics from 2016 to 2025 contained in 6 types of publications. In the form of articles there were 10,282 documents, chapters as many as 3,195 documents, proceedings as many as 1,997 documents, edited book as many as 535 documents, preprints as many as 610 documents and monographs 200 publications. Research trends deep learning in physics in article form is the type of publication that contains the most research compared to other types of publications. Meanwhile, the type of publication contains the least amount of research deep learning in physics is a monograph. Article is a complete factual essay of a certain length created for publication in online or print media (via newspapers, magazines or bulletins) and aims to convey ideas and facts that can convince and educate (Oltarzhevskyi, 2019). These articles are usually published in scientific journals both in print and online (Suseno & Fauziah, 2020).

Below are also table 2 presented top ten (10) sources title trends in research on deep learning in physics which are often cited by other researchers related to this matter. Table 2 shows that the most widely published source of research trends on the deep learning in physics is the Journal of Physics Conference Series, namely 56 publications with 223 citations and an average citation of 3.98. Journal of Physics: Conference Series (JPCS) is an open-access journal published by IOP Publishing. It publishes papers from international conferences in physics. JPCS provides fast, flexible, and cost-effective publication of conference proceedings. Below are also table 3 presented top ten (10) article title trends in research on deep learning in physics which are often cited by other researchers related to this matter.

Table 2. Top 10 Sources Title Trend of Deep Learning in Physics Research in 2016-2025

Name	Publications	Citations	Citations Mean
Journal of Physics Conference Series	56	223	3.98
Lecture Notes of the Institute for Computer Sciences, Social Informatics and Telecommunications Engineering	55	33	0.60
Sustainability	52	1,795	34.52
Mobile Information System	50	356	7.12
Applied Sciences	49	1,036	21.14
Education Sciences	47	1,165	24.79
Medical Teacher	45	2,301	51.13
International Journal of Emerging Technologies in	45	653	14.51

Learning (iJET)			
AIP Conference Proceedings	44	197	4.48
Proceedings of SPIE--the International Society for Optical Engineering	44	34	0.77

Table 3 shows that research on the deep learning in physics that is widely cited by other researchers is about "Perspectives on the Impact of Machine Learning, Deep Learning, and Artificial Intelligence on Materials, Processes, and Structures Engineering" which is 55.86 (Dimiduk et al., 2018). Then the research entitled "Artificial intelligence in Physics Education: a comprehensive literature review" was cited 32.00 times (Mahligawati et al., 2023). Then the research entitled "An introduction to deep learning in medical physics: advantages, potential, and challenges" is also widely cited by other researchers, namely 29.00 per year. (Edalatifar et al., 2021) in their research entitled "Using deep learning to learn physics of conduction heat transfer" was cited 19.50 per year.

This research data is comparable to data on the increasing trend of research on the deep learning in physics from 2016 to 2025. This means that in that year, research related to it was continuously cited by other researchers. In the articles researched and written by these researchers, there are many terms/keywords related to deep learning in physics. Below are presented ten (10) popular keywords related to deep learning in physics.

Table 3. Top 10 Citations on Trend of deep learning in physics Research in 2016-2025

Cites/year	Author	Title
55.86	(Dimiduk et al., 2018)	Perspectives on the Impact of Machine Learning, Deep Learning, and Artificial Intelligence on Materials, Processes, and Structures Engineering
32.00	(Mahligawati et al., 2023)	Artificial intelligence in Physics Education: a comprehensive literature review
29.00	(Shen et al., 2020)	An introduction to deep learning in medical physics: advantages, potential, and challenges
19.50	(Edalatifar et al., 2021)	Using deep learning to learn physics of conduction heat transfer
19.38	(Farimani et al., 2017)	Deep Learning the Physics of Transport Phenomena
6.50	(Navarro et al., 2023)	Solving differential equations with deep learning: a beginner's guide

0.67	(Chusni, 2022)	A systematic review of adaptive learning research in physics education in Indonesia
0.13	(Arteaga-Narváez et al., 2017)	Exploring a Deep Learning Approach on the Teaching and Learning of Introductory Physics
0.00	(Guo & Depaynos, 2023)	Physics Experiment Teaching Based on Deep Learning
0.00	(Jiang, 2025)	Deep Learning-Based Prediction of Student Performance in Physics Education Using Multimodal Data

Table 4 shows that the keywords that often appear related to research on the the deep learning in physics are healthcare, 7 times with a level of 1.99. Deep learning approaches are beginning to be applied to various subjects, including medical physics for health purposes (Shen et al., 2020). Table 4 also shows that Chatgpt is also one of the keyword that appears frequently in research trends on the deep learning in physics, namely 7 times with a relevance of 1.89. This century's learning has integrated technology into its approach, including the integration of chatgpt into deep learning in physics subject (Bruneau et al., 2023; Robledo-Rella et al., 2023).

Table 4. Keywords on deep learning in physics Research in 2016-2025

Terms	Occurrences	Relevance
Healthcare	7	1.99
Chatgpt	7	1.89
Physics Research	12	1.79
Learner	7	1.17
Model	22	0.99
Artificial Intelligence	13	0.84
Development	12	0.81
Teaching	10	0.54
Consept	13	0.43
Technology	14	0.32

Below are the visualization is accomplished by generating a landscape map, which offers a visual representation of subjects related to scientific studies. The outcomes of

bibliometric mapping for the co-word network in articles related to the topic deep learning in physics illustrated in Figure 2.

Figure 2 shows the results of bibliometric keyword mapping on research trends on the deep learning in physics. In Figure 2 there are 48 keyword items that are often used in research on deep learning in physics from 2016 to 2025. Figure 2 also contains 6 clusters, where the first cluster is colored red and consists of 13 keyword items, namely analysis, survey, teaching, etc. The second cluster in green consists of 10 keyword items, namely chatgpt, data, model, neural network, etc. The third cluster in blue consists of 8 keyword items, namely approach, consept, learner, student, etc. The fourth yellow cluster consists of 7 keyword items, namely artificial intelligence, healthcare, training, etc. The fifth purple cluster consists of 6 keyword items, namely development, study, etc. And the last cluster consists 4 items, namely application, education, etc.

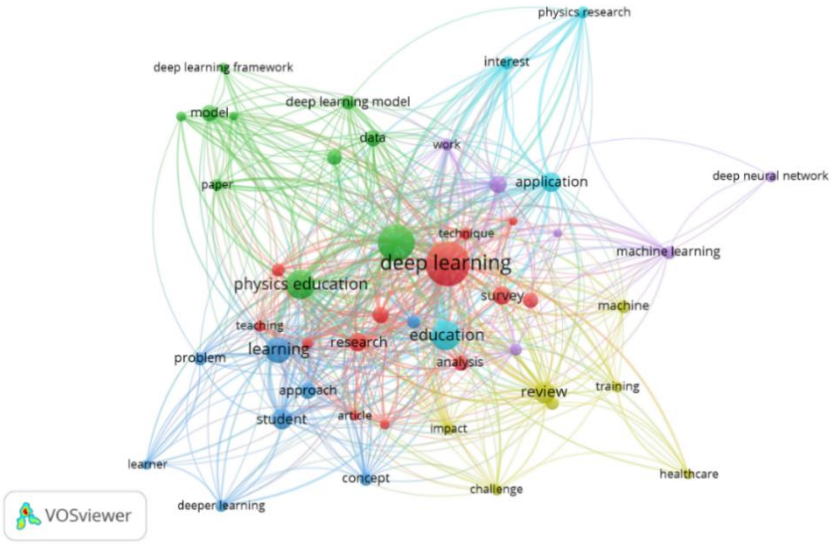


Figure 2. Network visualization on trend deep learning in physics research

Figure 2 above also shows that network visualization shows the network between the terms being visualized. Keywords classified into six clusters are arranged in a color chart showing the divisions/clusters that are connected to each other. The results of this analysis can be used to determine keyword research trends in the last year. This analysis shows several keywords that are often used in research on the deep learning in physics. The more keywords that appear, the wider the visualization displayed. Below are also presented keywords regarding the deep learning in physics based on overlay visualization.

Figure 3 shows the trend of keywords related to research on deep learning in physics in Google Scholar indexed journals from 2016 to 2025. Trends in the themes of writing articles related to deep learning in physics from the oldest to the newest year are marked with purple,

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blue themes, turquoise, dark green, light green and yellow. In the picture below you can see that study, application, student, approach, etc. This shows that these keywords were widely used by researchers in 2020. In 2021, the keywords that frequently appeared were concept, technology, student, etc. While in 2022, there were keywords like chatgpt, impact, interest, etc that frequently appeared.

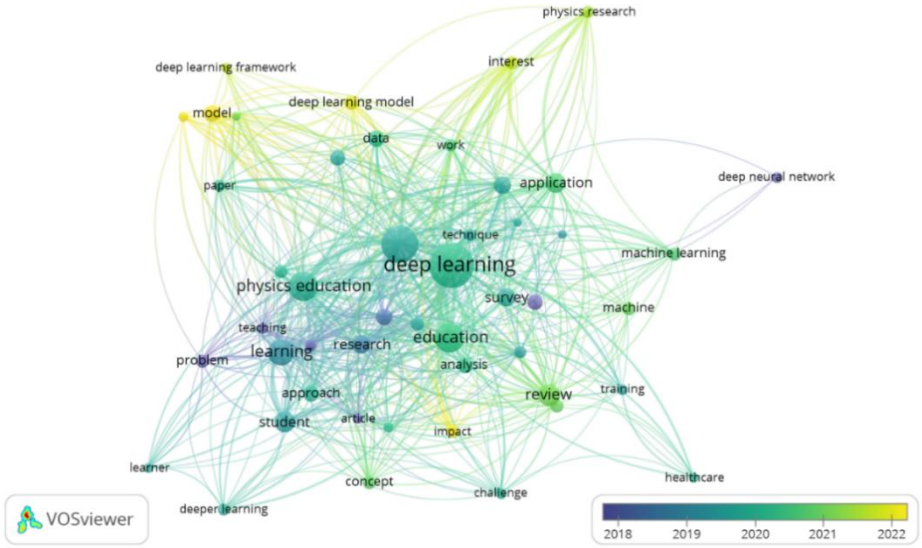


Figure 3. Overlay visualization on trend deep learning in physics research

Research on deep learning in physics is one area of research that has developed rapidly in recent years. The following also presents keywords for deep learning in physics research based on density visualization. Figure 4 shows density visualization. The density of research themes is shown in bright yellow. The brighter the colors of a theme, the more research is done. The fainter the color means the theme is rarely researched (Kaur et al., 2022; Liao et al., 2018). Faintly colored themes such as chatgpt and technology model are dimly colored keywords. This shows that these keywords can be used as a reference for further research. Doyan et al. (2023) and Bahtiar et al. (2023) stated that yellow indicates keywords that are currently and frequently used in research, like physics, education, learning, etc.

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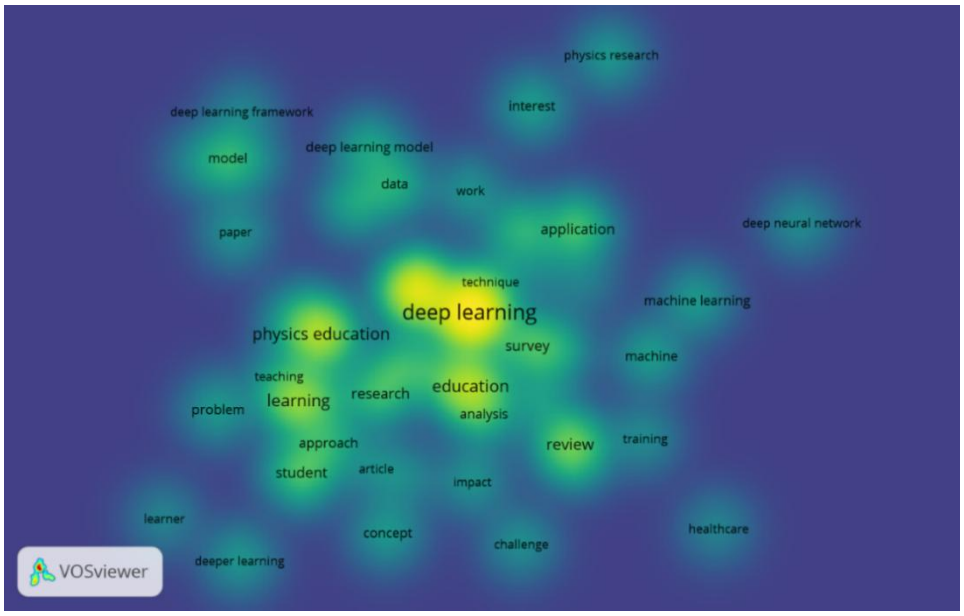


Figure 4. Density visualization on trend deep learning in physics research

The deep learning approach in an educational context refers to a learning process that emphasizes in-depth conceptual understanding, the interconnectedness of concepts, and the ability to transfer knowledge to new situations. Unlike surface learning, which tends to focus on memorization, this approach encourages learners to construct meaning through active exploration, reflection, and integration of knowledge (Biggs & Tang, 2011; Marton & Säljö, 1976). Theoretically, the concept of deep learning is heavily influenced by the thinking of John Biggs, who developed the constructive alignment framework, in which learning objectives, activities, and assessments are designed in harmony to foster deep understanding (Biggs, 1996). Furthermore, Ference Marton and Roger Säljö, in their classic study, identified fundamental differences between deep and surface approaches, which have become an important foundation in modern educational research (Marton & Säljö, 1976).

This approach is also firmly rooted in the constructivist theory pioneered by Jean Piaget and further developed by Lev Vygotsky, which emphasizes that knowledge is actively constructed by individuals through interactions with the environment and social context (Piaget, 1972; Vygotsky, 1978). From this perspective, meaningful learning occurs when students are able to connect new information with pre-existing cognitive structures. In its implementation, the deep learning approach is characterized by several key characteristics, including: (1) a focus on conceptual understanding rather than simply procedures; (2) active engagement through discussion, problem-solving, and inquiry; (3) the use of higher-order thinking; and (4) metacognitive reflection (Entwistle & Ramsden, 1983; Hattie, 2009). Strategies such as problem-based learning, project-based learning, and inquiry learning are often used to facilitate this approach.

Numerous studies have shown that the application of deep learning significantly contributes to improving critical thinking skills, creativity, and problem-solving abilities. This aligns with the demands of 21st-century competencies, which emphasize analytical and adaptive skills (Fullan et al., 2018; Trilling & Fadel, 2009). Therefore, learning designs that integrate this approach are crucial, particularly in science and technology education. However, the implementation of deep learning also faces challenges, such as limited learning time, teacher preparedness in designing meaningful activities, and an evaluation system that is still predominantly outcome-oriented (Biggs & Tang, 2011). Therefore, a comprehensive pedagogical transformation is needed, including teacher professional development and a reformulation of the assessment system, for this approach to be optimally implemented. Overall, deep learning is not simply a learning strategy, but a paradigm that positions students as active subjects in constructing knowledge. This approach is a crucial foundation for creating learning that is not only informative but also transformative.

Research on deep learning in physics is important because it makes significant contributions to the 21st century education and deep learning is a learning approach that is able to facilitate 21st century skills. Education in Indonesia is currently undergoing reform to meet the demands of the 21st century, where critical thinking skills, creativity, and the ability to collaborate are becoming increasingly important elements in education. With the goal of preparing a young generation capable of facing global challenges, Indonesian education requires an innovative approach, not only in terms of curriculum but also in the learning models used. One model currently receiving increased attention is deep learning, initiated by the Minister of Primary and Secondary Education (Mendikdasmen), Abdul Mu'ti. This model emphasizes the importance of learning that focuses on deep understanding, enabling students to go beyond memorization to meaningfully internalize knowledge (Santiani, 2025).

CONCLUSION

Research on trends in the deep learning in physics has urgency high because of its potential to provide various benefits to 21st century education. The research trend on the deep learning in physics indexed by Google Scholar from 2016 to 2025 has experienced a fluctuating increase. However, in 2025 there will be a decline in the research trend on the deep learning in physics. There are many documents in the form of articles, proceedings, chapters, preprints, monograph and edited books that discuss research into the deep learning in physics. Key words that are often used in research about it are chatgpt, technology, learner, artificial intelligence, etc.

The study results indicate that the implementation of deep learning has a positive impact on the development of higher-order thinking skills, such as critical thinking, creativity, and problem-solving, which are highly relevant to the demands of 21st-century competencies. However, its effectiveness is highly dependent on the quality of the learning design, teacher preparedness, and an assessment system that supports meaningful learning. Therefore, systematic efforts are needed to integrate the deep learning approach into educational practice, both through strengthening teachers' pedagogical competencies and through curriculum reform and learning evaluation. Thus, deep learning serves not only as a learning strategy but also as a foundation for creating transformative education oriented toward the sustainable development of students' thinking capacity.

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