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Deep Learning Pedagogy and Students' Critical Thinking in Indonesian Education: A Systematic Review

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ABSTRACT

Purpose – To synthesize evidence concerning deep learning pedagogy and students' critical thinking within educational transformation in Indonesia.
Methods – A systematic literature review following PRISMA 2020 reporting guidance searched Google Scholar, Scopus, ERIC, Dimensions, and Crossref. Of 132 records identified, 21 studies were included after duplicate removal, screening, and eligibility assessment. Findings were synthesized thematically.
Findings – Recurring themes concerned meaningful and reflective learning, critical thinking and higher-order thinking, teacher readiness, and implementation across educational contexts. The corpus included diverse empirical, conceptual, and review studies. It does not establish a pooled correlation or a uniform causal effect; some studies provide contextual rather than direct evidence about deep learning pedagogy.
Research implications – Implementation should combine teacher development, appropriate resources, and evaluation using clearly defined learning outcomes. The heterogeneity of the evidence and gaps in search and appraisal reporting limit the conclusions.
Originality – The review brings together pedagogical and implementation themes relevant to deep learning and critical thinking in Indonesian education.

INTRODUCTION

The rapid transformation of education in the twenty-first century has significantly changed the goals, processes, and outcomes of learning. Educational systems worldwide are increasingly expected to prepare students not only with academic knowledge but also with higher-order thinking skills, creativity, collaboration, communication abilities, and problem-solving competencies required to navigate complex societal challenges. In Indonesia, educational transformation has been accelerated through various reforms, including the implementation of the Merdeka Curriculum and the growing integration of digital technologies into teaching and learning processes. These reforms emphasize student-centered learning and the development of competencies that enable learners to adapt to rapidly changing social, technological, and economic environments [1], [2]. Consequently, the

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enhancement of students' critical thinking skills has become one of the primary objectives of contemporary educational practice.

Critical thinking enables learners to analyze information, evaluate evidence, solve problems, and construct reasoned arguments. Indah et al. examined digital literacy, research competence, and critical thinking, but did not find a significant relationship between digital literacy and critical thinking [3]. Their study therefore provides contextual evidence rather than direct evidence that deep learning pedagogy improves critical thinking. Muhsyanur reported improved critical thinking performance in learning activities involving inquiry, problem-solving, and collaborative reasoning [4].

Despite its importance, numerous studies indicate that the development of critical thinking skills remains a challenge in Indonesian education. Traditional instructional approaches that emphasize memorization, content transmission, and teacher-centered learning often provide limited opportunities for students to engage in deep analysis, reflection, and knowledge construction. As a result, many students demonstrate difficulties in applying concepts, evaluating information critically, and solving authentic problems encountered in real-world situations [1]. These challenges have prompted educators and policymakers to seek innovative pedagogical approaches capable of fostering deeper understanding and higher-order thinking among students.

One educational approach that has recently gained significant attention in Indonesia is the Deep Learning Approach. Unlike surface learning, which focuses primarily on memorization and the reproduction of information, deep learning emphasizes meaningful understanding, active engagement, critical reflection, and the integration of knowledge into authentic contexts. According to Nafi'ah and Faruq, deep learning in primary education is characterized by the integration of mindful, meaningful, and joyful learning experiences that encourage students to connect new knowledge with prior understanding while actively constructing meaning through inquiry and reflection. This perspective aligns with constructivist learning theories, which emphasize learners' active participation in knowledge construction rather than passive reception of information [5].

The growing interest in deep learning reflects broader efforts to transform Indonesian education into a more learner-centered and competency-oriented system. Ambarita et al. argue that deep learning serves as a pathway for pedagogical transformation because it encourages students to become active participants in learning processes while fostering critical thinking, creativity, collaboration, and problem-solving abilities [6]. Likewise, Afriani identifies deep learning as a strategic educational framework that supports the realization of Indonesia Emas 2045 by promoting meaningful learning experiences and strengthening future-ready competencies among students [7].

Several recent studies have demonstrated the potential of deep learning approaches to enhance critical thinking skills across different educational contexts. Puspaningrum found that deep learning strategies contribute significantly to the development of critical thinking skills and character formation among elementary school students [8]. Similarly, Sudarmono reported that the implementation of deep learning approaches in elementary education improves students' analytical reasoning, reflective thinking, and problem-solving capabilities [9]. Furthermore, Rosyad and Adelakun revealed that deep learning-based learning activities in Pancasila Education effectively strengthen students' critical thinking skills by encouraging active discussion, reflection, and evidence-based reasoning [10].

The positive relationship between deep learning and critical thinking is further supported by studies integrating innovative instructional models within deep learning frameworks. Taufik demonstrated that Project-Based Learning (PjBL) implemented through deep learning principles significantly enhances students' scientific and critical thinking skills [11]. Likewise, Chotimah developed and validated deep learning-based instructional tools designed specifically to strengthen higher-order thinking skills among elementary school students [12]. Their findings indicate that deep learning environments encourage learners to engage more deeply with learning content, evaluate multiple perspectives, and generate creative solutions to complex problems.

In addition to improving student outcomes, successful implementation of deep learning depends heavily on teacher readiness and educational support systems. Fitrah found that teachers' technological competence, pedagogical readiness, and mastery of twenty-first-century skills significantly influence the effectiveness of deep learning implementation [13]. These findings suggest that educational transformation requires not only changes in curriculum and instructional design but also substantial investment in teacher professional development and institutional support.

Although the growing body of literature highlights the educational benefits of deep learning, existing studies remain fragmented across different educational levels, disciplines, and contexts. Some studies focus primarily on pedagogical transformation, while others examine critical thinking, character development, teacher readiness, or curriculum implementation. Consequently, there remains a need for a comprehensive synthesis of existing evidence regarding the relationship between the deep learning approach and students' critical thinking skills within the broader context of educational transformation in Indonesia.

Therefore, this study employs a systematic literature review (SLR) to analyze and synthesize current research findings concerning the relationship between deep learning approaches and students' critical thinking skills. By reviewing relevant literature published in recent years, this study aims to identify key themes, determine how deep learning contributes to critical thinking development, and provide evidence-based insights for educators, policymakers, and researchers seeking to strengthen educational quality in Indonesia. The findings are expected to contribute to the ongoing discourse on educational transformation by highlighting the strategic role of deep learning in preparing students for the challenges of the twenty-first century.

METHOD

Research Design

This study employed a qualitative approach using library research combined with a systematic literature review (SLR) design. Library research is a research method that utilizes various scientific literature sources as the primary data for investigating, analyzing, and synthesizing knowledge related to a particular phenomenon [14], [15]. Through this approach, researchers systematically examine existing studies, theories, concepts, and empirical findings concerning the relationship between deep learning approaches and students' critical thinking skills in the context of educational transformation in Indonesia.

The qualitative approach was selected because it enables an in-depth exploration of educational phenomena through the interpretation and synthesis of existing scholarly evidence. According to Creswell and Creswell, qualitative research seeks to understand and interpret meanings derived from human experiences, social interactions, and contextual realities [16]. In the present study, qualitative synthesis was employed to identify patterns, themes, and relationships emerging from previous studies regarding deep learning implementation and critical thinking development.

A systematic literature review (SLR) design was used to organize the identification, selection, and synthesis of relevant studies. The review followed PRISMA 2020 reporting guidance [17]. Its conclusions depend on the completeness of the searches, eligibility decisions, and appraisal of the included evidence.

Literature Search Strategy

The literature search was conducted between January and June 2026 using several academic databases, including Google Scholar, Scopus, ERIC, Dimensions, and Crossref. These databases were selected because they contain a substantial collection of peer-reviewed publications related to educational innovation, deep learning approaches, critical thinking skills, and educational transformation.

The search process utilized combinations of keywords such as:

“deep learning approach”

“deep learning pedagogy”

“deep learning and critical thinking”

“critical thinking skills”

“higher-order thinking skills”

“educational transformation”

“Merdeka Curriculum”

“student-centered learning”

“Indonesia education”

“21st-century learning”

Boolean operators (AND, OR) were applied to refine the search results and improve relevance. The literature search focused on peer-reviewed publications published or indexed between 2020 and 2026 to capture recent developments in educational transformation and the implementation of deep learning approaches.

Inclusion and Exclusion Criteria

To ensure the relevance and quality of selected studies, specific inclusion and exclusion criteria were established.

Table 1. Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
Articles discussing deep learning approaches in education	Duplicate publications
Studies examining critical thinking skills	Articles unrelated to education
Research focusing on educational transformation	Non-peer-reviewed publications
Studies conducted in Indonesian educational contexts	Conference abstracts without full texts
Publications between 2020–2026	Incomplete or inaccessible articles
English and Indonesian language articles	Studies not addressing deep learning or critical thinking

The inclusion criteria were designed to ensure that all selected studies directly contributed to understanding the relationship between deep learning approaches and students’ critical thinking skills within educational transformation contexts.

Literature Selection Process

The literature selection process followed the PRISMA 2020 (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework proposed by Page. The PRISMA framework was adopted to enhance transparency, consistency, and methodological reliability throughout the review process [17].

The selection process consisted of four stages: identification, screening, eligibility assessment, and inclusion. During the identification stage, literature records were collected from multiple academic databases using predetermined keywords. Duplicate records were subsequently removed. The

remaining studies underwent title and abstract screening to determine their relevance to the research objectives.

Articles that passed the screening stage were subjected to full-text evaluation during the eligibility phase. At this stage, studies were assessed according to the inclusion and exclusion criteria. Finally, studies meeting all requirements were included in the qualitative synthesis.

The literature selection process is summarized in the PRISMA 2020 flow diagram in Figure 1.

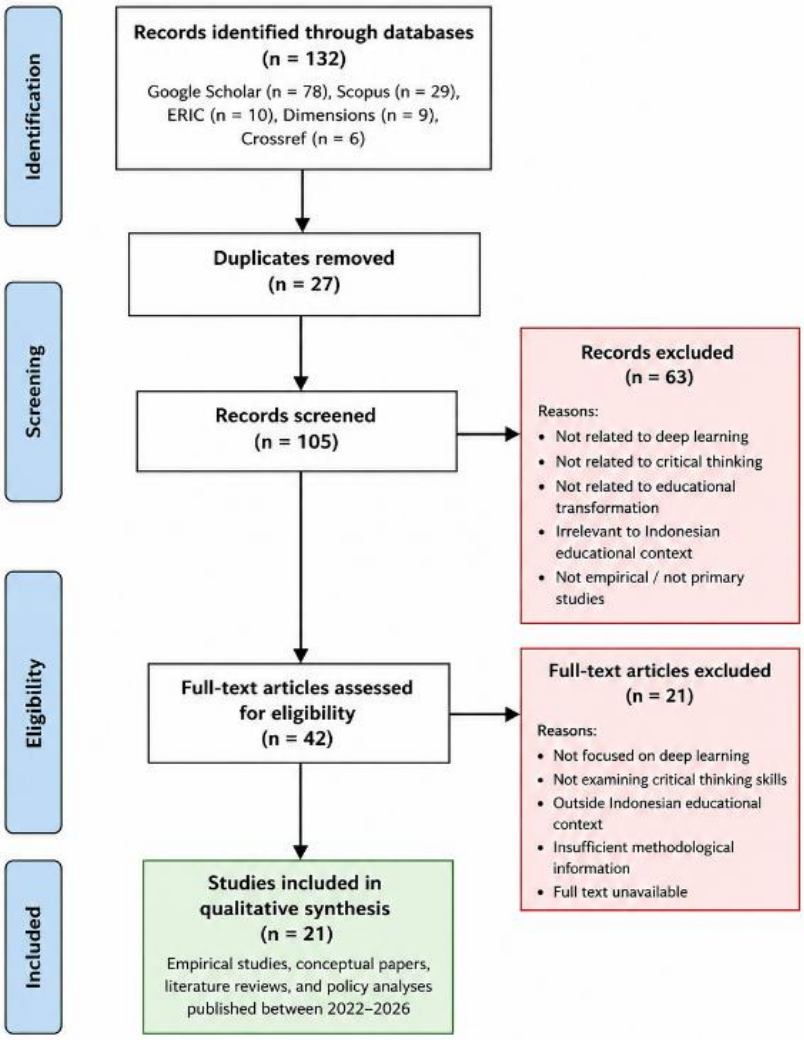


Figure 1. PRISMA 2020 Flow Diagram of Literature Selection Process

Figure 1 summarizes the selection of 21 studies. Of 132 records identified, 27 duplicates were removed, leaving 105 records for title and abstract screening. After 63 records were excluded, 42 full texts were assessed; a further 21 were excluded, leaving 21 studies for qualitative synthesis.

Data Extraction

Following article selection, data extraction was conducted using a structured review matrix to facilitate systematic analysis and comparison across studies. The extracted information included author(s), publication year, country of study, research objectives, research methodology, educational level, deep learning implementation characteristics, critical thinking indicators, main findings, and implications for educational transformation. This process enabled the researchers to identify recurring themes, similarities, differences, and emerging patterns across the reviewed literature.

Table 2 summarizes the authors and publication years, educational contexts, methods, research focus, and findings of the included studies. These characteristics informed cross-study comparison and thematic synthesis.

Table 2 summarizes 21 studies published between 2022 and 2026, including empirical research, conceptual papers, literature reviews, and policy analyses. The corpus addresses deep learning pedagogy, critical thinking, educational transformation, teacher readiness, and digital competence. The methodological diversity supports a thematic synthesis but does not provide a pooled estimate of the effect of deep learning pedagogy on critical thinking.

Table 2. Characteristics of Included Studies

Study	Context	Method	Focus	Main findings
Puspaningrum et al. (2025) [8]	Indonesia; Elementary school	Quantitative empirical study	Deep learning and critical thinking	Deep learning develops critical thinking skills and strengthens Pancasila character.
Prihantoro and Prayitno (2025) [18]	Indonesia; Senior high school	Policy and conceptual analysis	Deep learning policy	Explains the concepts, policies, and implementation of deep learning in Indonesian senior high schools.
Widyastika and Wahyudi (2025) [19]	Indonesia; Elementary school	Quantitative empirical study	Deep learning in elementary education	Deep learning improves disciplinary character and students' critical thinking skills.
Taufik et al. (2025) [11]	Indonesia; School students, level not specified	Quasi-experimental study	Project-based learning and deep learning	Project-based learning integrated with deep learning enhances scientific and critical thinking skills.
Ambarita et al. (2025) [6]	Indonesia; Indonesian education, general	Conceptual literature review	Pedagogical transformation	Deep learning supports the shift toward student-centered and competency-oriented education.
Rosyad and Adelakun (2025) [10]	Indonesia; School students, level not specified	Classroom implementation study	Pancasila Education	Deep learning strengthens critical thinking through discussion, reflection, and evidence-based reasoning.
Zebua (2025) [2]	Indonesia; Indonesian education, general	Conceptual literature review	Twenty-first-century learning	Deep learning supports educational transformation and twenty-first-century competencies.
Sudarmono et al. (2025) [9]	Indonesia; Elementary school	Quasi-experimental study	Elementary school students	Deep learning improves analytical reasoning, reflective thinking, and problem-solving skills.
Hunaepi and Suharta (2024) [1]	Indonesia; Indonesian education, general	Policy and literature analysis	Merdeka Curriculum	Identifies the effects and implementation challenges of educational transformation under the Merdeka Curriculum.

Study	Context	Method	Focus	Main findings
Afriani (2025) [7]	Indonesia; Indonesian education, general	Conceptual policy analysis	Indonesia Emas 2045	Positions deep learning as a roadmap for educational transformation toward Indonesia Emas 2045.
Paida (2026) [20]	Indonesia; Senior high school	Qualitative implementation study	Indonesian language learning	Deep learning-based language instruction develops critical and reflective thinking.
Sulastri et al. (2024) [21]	Indonesia; Integrated Islamic schools	Developmental and planning study	Islamic education	A deep learning-based planning model strengthens student engagement and learning effectiveness.
Indah et al. (2022) [3]	Indonesia; Higher education	Correlational quantitative study	Digital literacy	Digital literacy was significantly associated with research competence; its relationship with critical thinking was not significant.
Chotimah et al. (2025) [12]	Indonesia; Elementary school	Research and development (R&D)	Higher-order thinking skills tools	Validated deep learning-based instructional tools improve higher-order thinking skills.
Aribah et al. (2025) [22]	Indonesia; School education, level not specified	Qualitative descriptive study	Merdeka Curriculum and character education	Deep learning in Islamic Religious Education supports character development and meaningful learning.
Nafi'ah and Faruq (2025) [5]	Indonesia; Primary education	Conceptual literature study	Mindful, meaningful, and joyful learning	Deep learning integrates mindful, meaningful, and joyful learning to strengthen conceptual understanding.
Fitrah et al. (2025) [13]	Indonesia; Teachers and school education	Quantitative survey	Teacher readiness	Teacher readiness depends on technological competence, pedagogical flexibility, and twenty-first-century skills.
Mayasari et al. (2024) [23]	Indonesia; School students, level not specified	Quasi-experimental study	Artificial intelligence-supported learning	AI-supported learning and customized curricula improve students' critical thinking skills.
Apriliyana (2025)	Indonesia; School education	Qualitative school-practice study	School practice	School practice integrates the four core elements of deep learning into classroom implementation.
Anggrayni et al. (2025) [24]	Indonesia; School students in Pancasila Education	Research and development (R&D)	Instructional module	A deep learning-based instructional module improves critical thinking in Pancasila Education.
Muhsyanur (2023) [4]	Indonesia; Language education, level not specified	Quasi-experimental study	Problem-based learning	Problem-based learning significantly improves students' critical thinking performance.

Data Analysis

Data analysis employed the interactive model developed by Miles, Huberman, and Saldaña, consisting of three interconnected stages: data condensation, data display, and conclusion drawing/verification [25].

Data Condensation

Data condensation involved selecting, simplifying, and organizing relevant information obtained from the selected studies. During this stage, findings related to deep learning implementation, critical thinking development, and educational transformation were categorized into meaningful thematic groups.

Data Display

The organized data were presented through tables, thematic matrices, and narrative descriptions to facilitate interpretation and comparison among studies. Data displays enabled researchers to identify recurring trends, conceptual relationships, and evidence supporting the relationship between deep learning approaches and critical thinking skills.

Conclusion Drawing and Verification

The final stage involved drawing conclusions based on patterns identified across the reviewed studies. Conclusions were continuously verified through cross-study comparisons and thematic validation to ensure consistency and credibility.

Trustworthiness

To enhance the trustworthiness of the review, source triangulation was applied by comparing findings from studies employing different methodologies, educational levels, and research contexts. Furthermore, transparency was maintained throughout the review process by documenting search strategies, inclusion criteria, selection procedures, and analytical decisions.

This procedure aligns with qualitative research principles emphasizing credibility, dependability, confirmability, and transferability [14]. Through the integration of library research, systematic literature review, PRISMA 2020 procedures, and thematic analysis, this study aims to provide a comprehensive synthesis of current evidence regarding the relationship between deep learning approaches and students' critical thinking skills in the context of educational transformation in Indonesia.

RESULTS

The systematic review analyzed 21 studies published between 2022 and 2026 concerning the relationship between deep learning approaches and students' critical thinking skills in the context of educational transformation in Indonesia. The selected studies consisted of empirical research, conceptual studies, literature reviews, instructional development research, and educational policy analyses. Based on the thematic synthesis of the reviewed literature, five major themes emerged: (1) deep learning as a transformative educational approach, (2) deep learning and critical thinking skills development, (3) deep learning and higher-order thinking skills (HOTS), (4) teacher readiness in educational transformation, and (5) deep learning implementation across Indonesian educational contexts.

Deep Learning as a Transformative Educational Approach

The reviewed literature consistently identifies deep learning as an educational approach that supports pedagogical transformation and competency-based learning. Deep learning emphasizes meaningful understanding, active participation, reflective inquiry, and authentic learning experiences that encourage students to construct knowledge independently rather than merely memorizing information [6].

Ambarita reported that deep learning contributes to educational transformation by shifting instructional practices from teacher-centered approaches toward student-centered learning

environments [6]. Similarly, Afriani described deep learning as an educational strategy capable of supporting the vision of Indonesia Emas 2045 through the development of future-oriented competencies, including critical thinking, creativity, communication, and collaboration skills [7].

Prihantoro and Prayitno further examined the concepts, policies, and implementation of deep learning in Indonesian senior high schools [18]. Their study indicates that effective implementation requires alignment between educational policy, teachers' conceptual understanding, and classroom practices. This finding confirms that deep learning transformation should be supported by clear implementation guidelines that enable teachers to translate its principles into meaningful and student-centered learning activities.

Furthermore, Nafi'ah and Faruq conceptualized deep learning within primary education as a learning framework integrating mindful, meaningful, and joyful learning experiences. According to their findings, these three dimensions encourage students to engage more actively in learning processes and facilitate deeper conceptual understanding [5]. Collectively, the reviewed studies suggest that deep learning serves as an important foundation for contemporary educational transformation in Indonesia.

Deep Learning and Critical Thinking Skills Development

A recurring theme was the potential of deep learning pedagogy to support critical thinking through analysis, evaluation, problem-solving, and reflection. The included studies used different designs and measures, so their findings should be interpreted within their respective contexts.

Puspaningrum found that the implementation of deep learning strategies significantly improved elementary school students' critical thinking skills while simultaneously strengthening character development [8]. Similar findings were reported by Sudarmono, who observed improvements in students' analytical reasoning, problem-solving abilities, and reflective thinking after the application of deep learning approaches in elementary classrooms [9].

Widyastika and Wahyudi similarly found that the implementation of deep learning in elementary education improved students' critical thinking skills while strengthening disciplinary character. Their findings indicate that deep learning can support cognitive development and character formation simultaneously by involving students in reflective, meaningful, and responsible learning activities [19].

Rosyad and Adelakun also reported that deep learning implementation within Pancasila Education enhanced students' critical thinking abilities by encouraging active participation in discussions, reflection activities, and evidence-based reasoning. Likewise, Paida found that deep learning-based Indonesian language instruction promoted both critical and reflective thinking through activities requiring students to interpret information, evaluate arguments, and construct logical conclusions [20].

These findings indicate that deep learning approaches create learning conditions that support the development of critical thinking by promoting active inquiry, meaningful engagement, and independent knowledge construction.

Deep Learning and Higher-Order Thinking Skills (HOTS)

Several studies identified a strong relationship between deep learning implementation and the development of higher-order thinking skills (HOTS). HOTS encompass analytical thinking, evaluation, synthesis, problem-solving, and creativity, which are increasingly recognized as essential competencies in twenty-first-century education.

Chotimah developed and validated deep learning-based instructional tools designed specifically to improve HOTS among elementary school students. Their findings demonstrated that students participating in deep learning-oriented instructional activities showed higher levels of analytical thinking and conceptual understanding compared to conventional learning environments [12].

Similarly, Taufik found that Project-Based Learning (PjBL) implemented through deep learning principles significantly enhanced students' scientific reasoning and critical thinking skills. The study revealed that authentic project activities encouraged learners to investigate problems, evaluate information sources, and generate evidence-based solutions [11].

In addition, Anggrayni reported that deep learning-based instructional modules contributed positively to students' critical thinking performance within Pancasila Education. Across the reviewed studies, HOTS development emerged as one of the most frequently reported outcomes of deep learning implementation [24].

Teacher Readiness in Educational Transformation

Another recurring theme identified in the literature concerns teacher readiness as a prerequisite for successful deep learning implementation. Several studies emphasize that educational transformation requires teachers to possess not only pedagogical competence but also technological literacy, adaptive capacity, and twenty-first-century teaching skills.

Fitrah found that teachers' readiness to adopt deep learning pedagogy was significantly influenced by their technological competence and ability to integrate digital tools into instructional practices. Teachers demonstrating stronger mastery of educational technology were more likely to implement deep learning principles effectively [13].

Similarly, Hunaepi and Suharta highlighted that curriculum transformation under the Merdeka Curriculum framework requires substantial teacher adaptation and continuous professional development. The reviewed studies consistently suggest that teacher readiness functions as a key enabling factor influencing the effectiveness of deep learning implementation in educational settings [1].

Deep Learning Implementation Across Indonesian Educational Contexts

The reviewed studies reveal that deep learning approaches have been implemented across various educational contexts in Indonesia, including elementary education, secondary education, language learning, religious education, and character education.

Aribah found that deep learning implementation within Islamic Religious Education supported character formation and meaningful learning experiences aligned with the objectives of the Merdeka Curriculum [22]. Likewise, Sulastri reported that deep learning-based instructional planning strengthened student engagement and learning effectiveness in integrated Islamic schools [21].

Zebua demonstrated the practical implementation of deep learning through a learning design that integrated real-world connections, personalization, student collaboration, and digital technology [2]. The study found that the simultaneous application of these four elements improved student engagement, strengthened the meaningfulness of learning, and supported the development of twenty-first-century competencies. These findings illustrate how deep learning principles can be translated into contextual and applicable classroom practices.

Mayasari et al. reported that artificial intelligence-supported learning tools and customized curricula contributed to students' critical thinking [23]. Indah et al. found a significant relationship between digital literacy and research competence, but the relationship between digital literacy and critical thinking was not significant [3]. The latter study did not directly evaluate deep learning pedagogy.

Across the included literature, deep learning pedagogy was discussed in relation to meaningful learning, critical thinking, and educational transformation. The diversity of study designs and outcomes limits conclusions about the size or consistency of its effects.

DISCUSSION

Deep Learning as a Catalyst for Educational Transformation in Indonesia

The findings of this review indicate that the deep learning approach has emerged as one of the most significant pedagogical innovations supporting educational transformation in Indonesia. Unlike conventional learning approaches that emphasize memorization and content transmission, deep learning encourages meaningful understanding, active participation, reflection, and knowledge construction. These characteristics align closely with the objectives of contemporary educational reforms that prioritize competency development and student-centered learning.

The reviewed studies consistently demonstrate that deep learning supports the transformation of educational practices by shifting instructional focus from teaching activities toward meaningful learning experiences. Ambarita et al. argue that deep learning functions as a pathway toward pedagogical transformation because it enables students to become active participants in learning rather than passive recipients of information [6]. Similarly, Zebua explains that deep learning aligns with the demands of twenty-first-century education by encouraging inquiry, collaboration, creativity, and problem-solving [2].

The implementation of the Merdeka Curriculum has further strengthened the relevance of deep learning within Indonesian education. Hunaepi and Suharta note that educational transformation under the Merdeka Curriculum requires learning environments that emphasize student autonomy, critical inquiry, and contextual understanding. Deep learning supports these objectives by creating opportunities for students to explore knowledge deeply and apply it to authentic situations [1].

Furthermore, Afriani identifies deep learning as a strategic educational framework supporting the realization of Indonesia Emas 2045 [7]. According to this perspective, educational transformation requires not only curriculum reform but also pedagogical approaches capable of developing future-ready competencies. Consequently, deep learning should be viewed not merely as a teaching strategy but as a comprehensive educational philosophy supporting long-term national educational goals. This interpretation is further supported by Prihantoro and Prayitno, who emphasize that the implementation of deep learning requires consistency between educational policy, teachers' conceptual understanding, and classroom practices [18]. Their study suggests that policy reform alone is insufficient unless teachers receive clear implementation guidance and institutional support to translate deep learning principles into meaningful learning activities.

The Relationship Between Deep Learning and Critical Thinking Skills

One of the most consistent findings emerging from the reviewed literature concerns the positive relationship between deep learning approaches and students' critical thinking skills. Across different educational levels and learning contexts, deep learning was found to facilitate the development of analytical reasoning, reflective thinking, evaluation skills, and problem-solving abilities.

Puspaningrum found that deep learning strategies significantly improve elementary school students' critical thinking skills while simultaneously fostering character development [8]. Similar findings were reported by Sudarmono, who observed improvements in analytical thinking, reasoning abilities, and problem-solving performance following the implementation of deep learning approaches [9]. Widyastika and Wahyudi extend these findings by demonstrating that deep learning can strengthen students' critical thinking skills while simultaneously developing disciplinary character in elementary education [19]. This result indicates that deep learning contributes not only to cognitive development but also to the formation of responsible learning behavior through reflective and meaningful learning activities

These findings suggest that critical thinking develops when students actively engage with learning materials rather than merely receiving information passively. Deep learning encourages learners to question assumptions, analyze evidence, evaluate arguments, and construct knowledge independently. Such processes correspond closely with the core dimensions of critical thinking, including interpretation, analysis, evaluation, inference, and reflection.

Rosyad and Adelakun further demonstrate that deep learning-based instructional activities enhance critical thinking by encouraging students to participate in discussions, engage in reflective inquiry, and justify their conclusions using evidence [10]. Similarly, Paida reports that deep learning implementation in Indonesian language learning supports the development of both critical and reflective thinking through activities requiring interpretation, evaluation, and argument construction [20].

The consistency of these findings across different studies suggests that deep learning provides a learning environment particularly conducive to critical thinking development. Students are encouraged to engage deeply with concepts, connect ideas across contexts, and apply knowledge to authentic situations. Consequently, critical thinking emerges not as an isolated skill but as a natural outcome of meaningful and reflective learning experiences.

Deep Learning and the Development of Higher-Order Thinking Skills

Another important theme emerging from this review concerns the contribution of deep learning to Higher-Order Thinking Skills (HOTS). The reviewed studies indicate that deep learning promotes cognitive processes extending beyond memorization and factual recall toward analysis, evaluation, synthesis, and creative problem-solving.

Chotimah found that deep learning-based instructional tools significantly improved students' higher-order thinking skills by encouraging active exploration, inquiry, and knowledge application. Their findings suggest that deep learning facilitates deeper cognitive processing because students are required to interpret information, evaluate alternative perspectives, and construct solutions to complex problems [12].

Similarly, Taufik demonstrated that Project-Based Learning integrated with deep learning principles significantly enhances scientific reasoning and critical thinking. Project-based activities encourage students to investigate authentic issues, collaborate with peers, and develop evidence-based solutions, thereby fostering higher-order cognitive engagement [11].

Anggrayni also reported positive effects of deep learning-based instructional modules on students' critical thinking performance within Pancasila Education. Their findings indicate that learning environments emphasizing inquiry, reflection, and problem-solving create conditions that support the development of advanced cognitive competencies [24].

Collectively, these studies suggest that deep learning serves as an effective mechanism for developing HOTS because it emphasizes meaningful understanding, authentic learning experiences, and active knowledge construction. Such competencies are increasingly important within contemporary educational systems that prioritize innovation, adaptability, and lifelong learning.

Mindful, Meaningful, and Joyful Learning as Foundations of Deep Learning

The literature reviewed in this study consistently highlights the importance of mindful, meaningful, and joyful learning as foundational principles of deep learning implementation. Nafi'ah and Faruq conceptualize deep learning in primary education through the integration of these three dimensions, arguing that effective learning occurs when students are cognitively engaged, emotionally connected, and actively involved in the learning process [5].

Mindful learning encourages students to develop awareness of their thinking processes and learning strategies. Through reflective activities, learners become more capable of monitoring their understanding, identifying misconceptions, and evaluating their learning progress. Such metacognitive processes are closely associated with critical thinking development because they require learners to reflect upon their reasoning and decision-making processes.

Meaningful learning occurs when students connect new knowledge with prior experiences and existing conceptual frameworks. Several reviewed studies suggest that deep learning facilitates meaningful understanding by encouraging learners to explore authentic problems and real-world applications. This process strengthens conceptual understanding while simultaneously supporting critical analysis and problem-solving.

Joyful learning, meanwhile, contributes to increased engagement and motivation. Students who experience positive emotional connections with learning activities are more likely to participate actively, persist in challenging tasks, and engage deeply with learning content. Consequently, the integration of mindful, meaningful, and joyful learning creates optimal conditions for developing critical thinking skills. Zebua provides practical support for this interpretation by showing that deep learning principles can be implemented through real-world connections, personalized learning, student collaboration, and the integration of digital technology [2]. The combination of these elements creates more contextual learning experiences, strengthens student engagement, and supports the practical application of mindful, meaningful, and joyful learning in classroom settings.

Teacher Readiness and the Success of Deep Learning Implementation

The reviewed studies consistently indicate that teacher readiness plays a crucial role in determining the success of deep learning implementation. Educational transformation requires teachers to possess not only pedagogical competence but also technological literacy, adaptability, and the ability to facilitate student-centered learning environments.

Fitrah found that teachers' readiness to adopt deep learning pedagogy is strongly influenced by technological competence and mastery of twenty-first-century teaching skills. Teachers who demonstrate stronger digital literacy and pedagogical flexibility are more likely to implement deep learning effectively [13].

The importance of teacher readiness is further supported by studies emphasizing the role of professional development in educational transformation. Effective implementation of deep learning requires teachers to redesign instructional activities, facilitate inquiry-based learning, integrate digital technologies, and assess complex learning outcomes. Such responsibilities demand continuous professional learning and institutional support.

Therefore, educational transformation initiatives should prioritize teacher capacity development alongside curriculum reform and technological investment. Without adequate teacher preparation, the potential benefits of deep learning may not be fully realized.

Deep Learning, Digital Literacy, and Future Educational Competencies

The reviewed literature suggests that deep learning contributes not only to critical thinking development but also to broader twenty-first-century competencies. These include digital literacy, research competence, creativity, collaboration, communication, and adaptability.

Digital literacy may support access to information and learning resources, but its relationship with critical thinking should not be assumed. Indah et al. reported a significant relationship between digital literacy and research competence, while its relationship with critical thinking was not significant [3]. This finding limits the use of that study as evidence for the effectiveness of deep learning pedagogy.

Similarly, Mayasari demonstrated that artificial intelligence-supported learning tools contribute positively to critical thinking development when integrated within student-centered instructional frameworks. These findings indicate that deep learning and technological innovation can complement one another in supporting educational transformation [23].

As educational systems increasingly integrate digital technologies, the ability to think critically becomes even more important. Students must evaluate information sources, assess the credibility of digital content, and make informed decisions within increasingly complex information environments. Deep learning supports these competencies by encouraging reflective inquiry, evidence-based reasoning, and independent knowledge construction.

The synthesis of the reviewed literature demonstrates that deep learning approaches contribute significantly to the development of students' critical thinking skills within the context of educational transformation in Indonesia. The relationship between deep learning and critical thinking appears consistently across different educational levels, subject areas, and learning contexts.

The findings indicate that deep learning promotes critical thinking by encouraging meaningful learning, reflective inquiry, active participation, problem-solving, and higher-order cognitive engagement. Furthermore, successful implementation depends upon teacher readiness, technological competence, supportive educational policies, and learning environments characterized by mindful, meaningful, and joyful learning experiences.

Overall, the reviewed evidence suggests that deep learning represents a promising pedagogical approach capable of supporting educational transformation while simultaneously strengthening critical thinking skills and other competencies required for success in the twenty-first century.

CONCLUSION

This review synthesized 21 studies concerning deep learning pedagogy, critical thinking, and educational transformation in Indonesia. The recurring themes concerned meaningful and reflective learning, higher-order thinking, teacher readiness, and the conditions needed for implementation. The findings suggest potential educational value, but the heterogeneous evidence does not establish a pooled correlation or a uniform causal effect on critical thinking.

Implementation should be accompanied by teacher development, appropriate resources, and evaluation of learning outcomes. The review is limited by the diversity of included sources and the reporting gaps in its search, eligibility, and quality-appraisal procedures. Future studies should use transparent review protocols and comparable critical-thinking measures to distinguish pedagogical effects from contextual and technological influences.

AUTHOR CONTRIBUTION STATEMENT

Windi Widayanti conceptualized the study, developed the systematic review methodology following PRISMA 2020 guidance, conducted the literature search, and prepared the initial manuscript. Danik Widati contributed to the research design, supervised the review process, validated the study selection procedures, and critically revised the manuscript. Elin Yufriyani contributed to literature screening, eligibility assessment, data extraction, and thematic synthesis of the 21 included studies. Hamidah supervised the research, contributed to the interpretation and validation of the findings, and critically reviewed the manuscript. All authors read and approved the final manuscript.

AI DISCLOSURE STATEMENT

ChatGPT was used during copyediting to assist with language and formatting. The authors should review and verify the edited manuscript and remain responsible for its final content.

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