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Bridging the Gap: A Systematic Review of Deep Learning Pedagogy for Indonesia's Curriculum Reform

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ABSTRACT. This study aims to systematically analyse the implementation of deep learning pedagogies across international educational contexts and assess their relevance to Indonesia's curriculum reform. Deep learning is defined as student-centred instruction that enhances critical thinking, knowledge transfer, and reflective understanding. A systematic literature review (SLR) was conducted following the PRISMA 2020 guidelines, synthesising 31 peer-reviewed articles published between 2015 and early 2024. The findings indicate that project-based, inquiry-based, and reflective learning strategies are most commonly employed to foster deep cognitive engagement. However, successful adoption requires comprehensive policy support, continuous teacher professional development, and adaptation to local cultural and infrastructural contexts. In Indonesia, although the Kurikulum Merdeka reflects the principles of deep learning, its implementation remains fragmented and uneven. The study concludes that embedding deep learning in the Indonesian curriculum necessitates systemic reforms in curriculum design, assessment practices, teacher preparation, and digital infrastructure. These insights offer practical implications for policymakers and educators aiming to align global pedagogical innovations with national educational goals.

Keywords: *Curriculum reform, Deep learning, Education policy in Indonesia, Pedagogical strategies*

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INTRODUCTION

Developing an adaptive and future-oriented education system is essential for addressing the challenges of the 21st century, particularly in developing countries like Indonesia. A central concern within this transformation is the enhancement of students' literacy and higher-order thinking skills, which are indispensable for personal development, democratic engagement, and economic competitiveness. However, Indonesia's education system continues to rely heavily on rote memorisation and teacher-centred instruction, limiting students' ability to think critically, solve problems creatively, and apply knowledge in real-world settings (OECD, 2023; Rahmah et al., 2024a). This gap between the national curriculum's intended learning outcomes and the realities of classroom practice remains a major barrier to achieving transformative learning in Indonesian schools.

One promising response to this challenge is the adoption of deep learning pedagogical strategies that emphasise meaningful learning, critical thinking, and knowledge transfer. In educational contexts, deep learning does not refer to artificial intelligence, but to pedagogical frameworks that encourage students to go beyond surface-level memorisation and develop deeper

conceptual understanding, reflective thinking, and transferable skills (Biggs & Tang, 2011; Chen & Singh, 2024; Marton & Säaljö, 1976). Despite increasing global evidence of the effectiveness of these approaches, the implementation of deep learning in Indonesia continues to face structural and practical challenges, including rigid curricula, limited teacher preparedness, and unequal access to digital infrastructure (Handayani et al., 2023; Mustafa et al., 2024).

Pan et al. (2023) and Winje and Løndal (2020) highlight that most empirical investigations on deep learning have been conducted in high-income countries, with limited representation from developing education systems. This imbalance presents a significant research gap in understanding the applicability and challenges of implementing deep learning in contexts such as Indonesia. To date, few studies have examined the alignment between Indonesia's current curriculum and the pedagogical requirements of deep learning, nor have they provided concrete recommendations for integration that consider local constraints and opportunities. This study addresses that gap by systematically reviewing and synthesising global literature on deep learning pedagogy and evaluating its relevance and applicability to Indonesia's curriculum. The objective of this study is to analyse international practices and generate evidence-based recommendations that support the effective implementation of deep learning strategies in Indonesian schools.

This review contributes to academic knowledge by extending the theoretical discourse on deep learning into under-researched developing country contexts. Practically, it offers actionable insights for policymakers, curriculum designers, and educators to modernise instructional practices in alignment with 21st-century learning goals. By bridging the gap between global pedagogical innovations and local implementation challenges, this study aims to support Indonesia's broader educational reform agenda.

METHOD

This study employed a Systematic Literature Review (SLR) to synthesise research evidence on deep learning pedagogy and evaluate its applicability to Indonesia's educational context. The review followed the PRISMA 2020 (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines (Haddaway et al., 2022; Page et al., 2021) to ensure transparency and methodological rigour. The review process, including identification, screening, eligibility assessment, and inclusion of studies, is illustrated in Figure 1, which details the PRISMA-based SLR process.

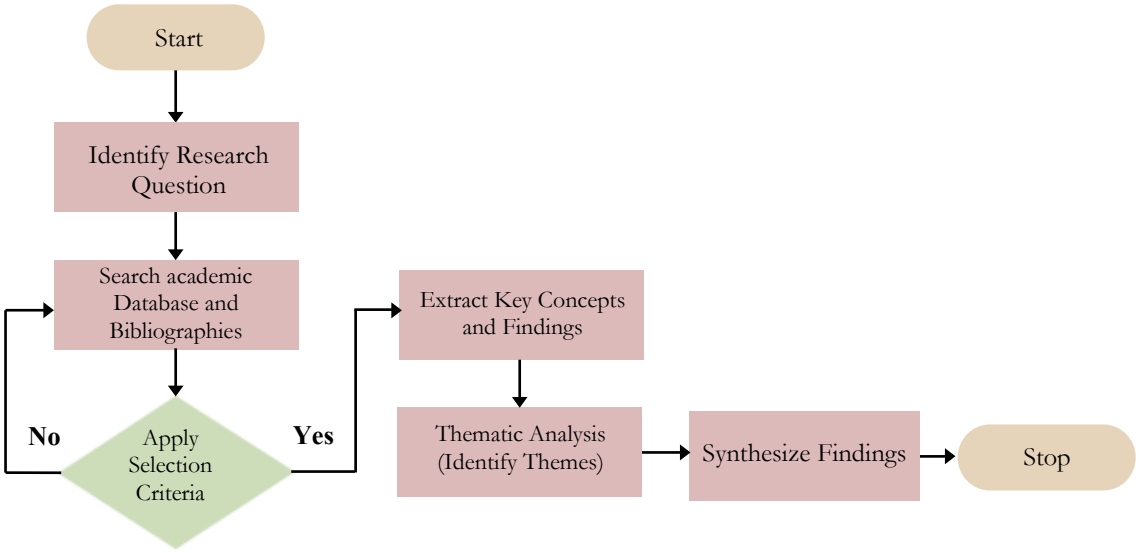

Figure 1. SLR Flowchart

Research Question and Protocol

This review was guided by a set of research questions formulated to explore how deep learning pedagogical strategies have been implemented across various educational contexts and how such strategies could be effectively applied within Indonesia's curriculum. The research questions aim to identify implementation practices, compare outcomes across regions, and generate practical recommendations suitable for curriculum reform in Indonesia. Specifically, the review sought to answer the following:

*RQ*1: What insights can be synthesised from existing literature regarding the implementation of deep learning pedagogical strategies (defined as approaches promoting deep understanding, critical thinking, and application of knowledge) in education to inform effective application within the Indonesian curriculum?

*RQ*2: How does the literature compare the implementation and outcomes of deep learning pedagogical strategies between Indonesia and other international educational contexts?

*RQ*3: Based on the synthesised literature, what evidence-based recommendations can be formulated for the effective implementation of deep learning pedagogical strategies within the Indonesian curriculum?

To guide the entire review process systematically, a protocol was developed using the PRISMA 2020 and PICOS frameworks. The PICOS model (Population, Intervention, Comparison, Outcomes, and Study Design) helped determine inclusion criteria and define the focus of the review (Methley et al., 2014). Although the protocol was developed and followed internally throughout the research process, it was not preregistered on international platforms such as PROSPERO or OSF. Nonetheless, the review maintained methodological transparency and rigour through comprehensive documentation, reviewer cross-checking, and systematic procedures aligned with best practices for SLR.

Search Strategy and Databases

A comprehensive search strategy was implemented to identify relevant studies published between 2015 and 2024, a range chosen to capture contemporary developments in deep learning pedagogy following major curriculum reforms in Indonesia (Kurikulum 2013 and Kurikulum Merdeka). The development of the search strategy was informed by established guidance for systematic reviews (Petticrew & Roberts, 2006). Searches were conducted in four academic databases: Scopus, Web of Science, ERIC, and Taylor & Francis Online, using the Boolean string: "deep learning" AND "education" AND NOT "machine learning" AND NOT "artificial intelligence". This query was adjusted based on the specific syntax of each platform. To expand coverage, backwards snowballing was conducted by manually screening the reference lists of included articles. The initial search yielded 345 records, with duplicates and irrelevant studies removed through title and abstract screening.

Inclusion and Exclusion Criteria

Studies were selected based on criteria outlined in Tables 1 and 2. Included studies focused on the implementation or evaluation of deep learning pedagogy in education, reported empirical findings or systematic reviews, and were peer-reviewed, published between 2015 and 2024, and written in English. Excluded studies were those focusing solely on artificial intelligence or lacking clear methodological rigour.

Table 1. Inclusion Criteria

No.	Criteria	Description
1.	Focus	Studies explicitly focused on the implementation or evaluation of deep learning pedagogical strategies in education.

2.	Study Type	Studies reporting empirical research, case studies, or systematic reviews relevant to literacy development or the cultivation of higher order thinking skills through deep learning.
3.	Publication Type	Studies published in peer-reviewed journals or conference proceedings indexed by Q1, Q2, Q3, Q4
4.	Publication Year	2015 - 2024
5.	Language	Studies available in English.

Table 2. Exclusion Criteria

No.	Criteria	Description
1.	Focus	Studies solely address the technological aspects of artificial intelligence or machine learning without a clear pedagogical application.
2.	Data & Methods	Studies lacking empirical data or clearly defined methodological frameworks.
3.	Publication Type	Grey literature (e.g., unpublished theses, reports), unless they meet specific criteria for rigor and relevance.
4.	Duplication	Duplicate publications.

Study Selection and PRISMA Flow

The selection process began with the removal of duplicate records and irrelevant entries. Following this, all remaining titles and abstracts were screened for relevance to the research questions. Articles that met the initial criteria were retrieved in full text and assessed for eligibility based on the predefined inclusion and exclusion parameters. Finally, studies that met all eligibility requirements were included in the synthesis. The flow of this selection process is visualised in Figure 2.

Quality Appraisal and Data Extraction

To ensure the reliability and validity of the findings, all included studies underwent a structured quality appraisal. Quantitative studies were assessed using the Cochrane Risk of Bias Tool, which examines potential issues such as selection bias, performance bias, and reporting bias. For qualitative studies, the Critical Appraisal Skills Programme (CASP) Qualitative Checklist was employed to evaluate aspects such as research design appropriateness, clarity of aims, and adequacy of data analysis. These assessments were conducted independently by two reviewers, with differences in scoring resolved through discussion and consensus-building.

Data extraction was conducted using a standardised form developed to capture key information from each study systematically. It included bibliographic details such as author names, year of publication, and country of study, along with methodological characteristics including research design, educational level, and participant demographics. Additionally, the specific deep learning strategies examined and the learning outcomes reported were carefully recorded. To support comparative analysis, studies were also coded by pedagogical strategy, level of education, and methodological rigour. It enabled the development of a categorised dataset that facilitated structured thematic synthesis in the subsequent analysis phase.

Data Synthesis

The extracted data were subjected to a thematic analysis approach following the six-phase method outlined by Braun & Clarke (2006). In the first phase, the reviewers familiarised themselves with the dataset through repeated reading to gain a comprehensive understanding of its content. It was followed by the generation of initial codes across the entire dataset, capturing salient features relevant to the research questions. In the third phase, codes were organised into potential themes by identifying recurring patterns and relationships among coded data. These preliminary themes

were then reviewed with the full dataset to ensure internal coherence and consistency with the sources.

Next, each theme was clearly defined and named to reflect its essence and relevance to deep learning pedagogy. This definition phase helped ensure clarity, theoretical alignment, and practical relevance. In the final phase, themes were refined and assembled into a coherent narrative that addressed the research questions, supported by illustrative evidence from the reviewed studies. Peer debriefing and cross-checking among researchers further enhanced the credibility of the thematic synthesis. This rigorous analytical process enabled the identification of dominant trends, context-specific challenges, and actionable recommendations for integrating deep learning strategies within Indonesia's school curriculum.

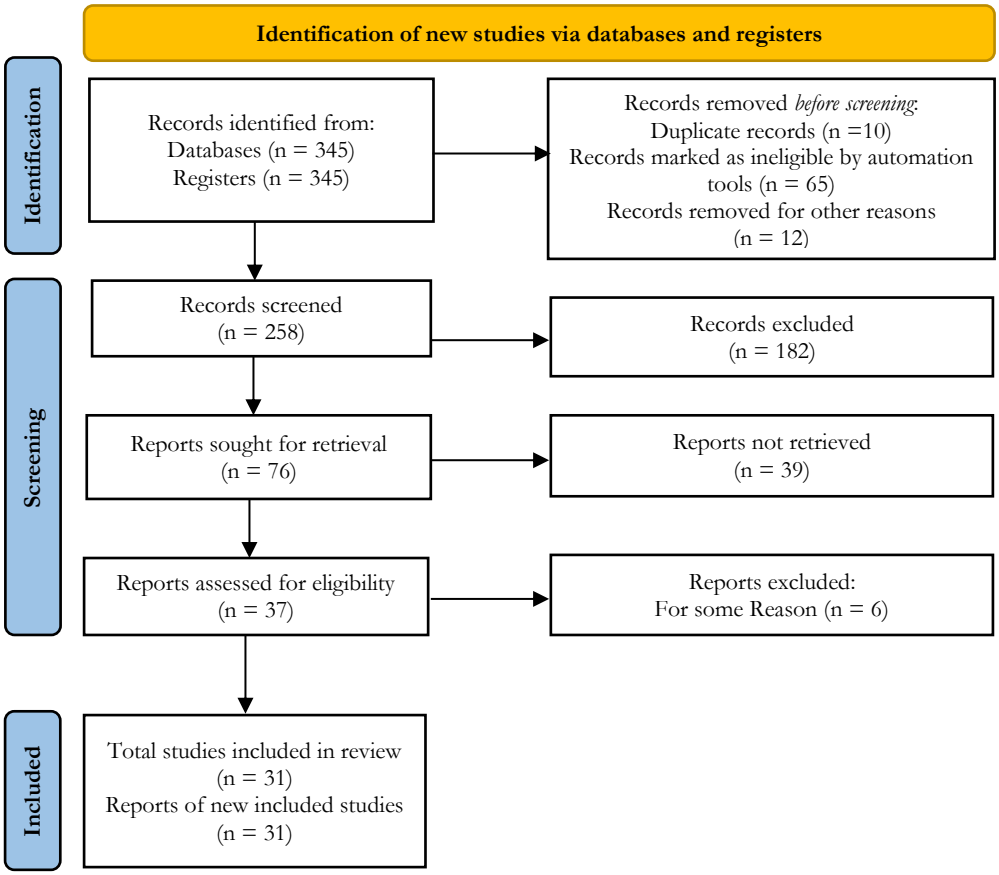

Figure 2 PRISMA flow diagram

RESULT AND DISCUSSION

Result

This systematic literature review synthesised findings from 31 peer-reviewed articles published between 2015 and 2024. The distribution of publication years shows increasing attention to deep learning pedagogy, especially after 2020, likely due to the acceleration of digital education during and following the COVID-19 pandemic. The year 2024 marked the peak in the number of publications among the reviewed articles, followed by a steady presence in 2022 and 2023. This pattern indicates a recent surge in academic interest in deep learning within educational contexts, suggesting that it is an emerging and timely topic within the scholarly community. Educational institutions worldwide have increasingly prioritised innovative teaching strategies to foster higher-

order thinking skills in response to digital learning demands. This pattern is illustrated in Figure 3, which visualises the yearly publication distribution of the included studies.

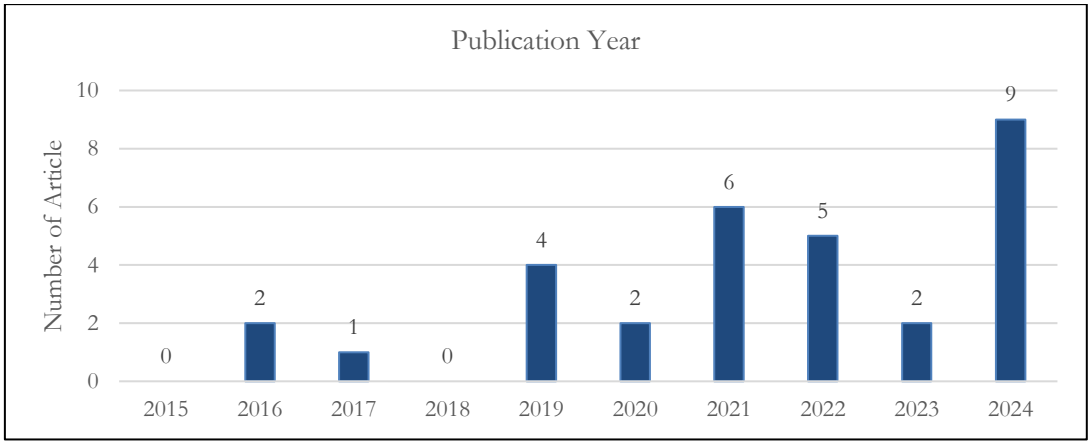

Figure 3. Distribution of publication year

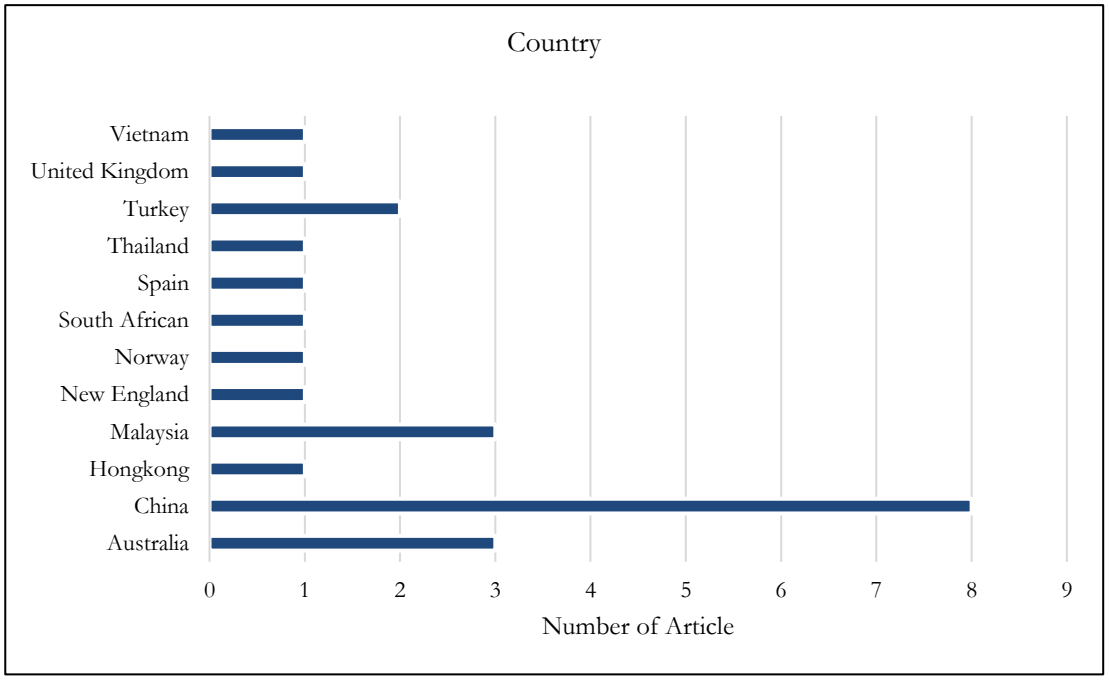

Figure 4. Distribution of countries

The included studies were conducted across 12 countries, with the largest number from China (8 studies), followed by Malaysia (3 studies), Australia (3 studies) and Turkey (2 studies). The remaining studies came from Vietnam, Norway, Spain, New England, South Africa, Thailand, the United Kingdom, and Hong Kong, each contributing one study. The international distribution is illustrated in Figure 4, which presents a geographic breakdown of study origins. Strikingly, no studies from Indonesia were included, primarily due to the lack of peer-reviewed empirical research that met the inclusion criteria. This absence highlights a substantial research gap, particularly considering Indonesia's ongoing educational reforms such as *Kurikulum Merdeka* (Kemendikbudristek, 2022).

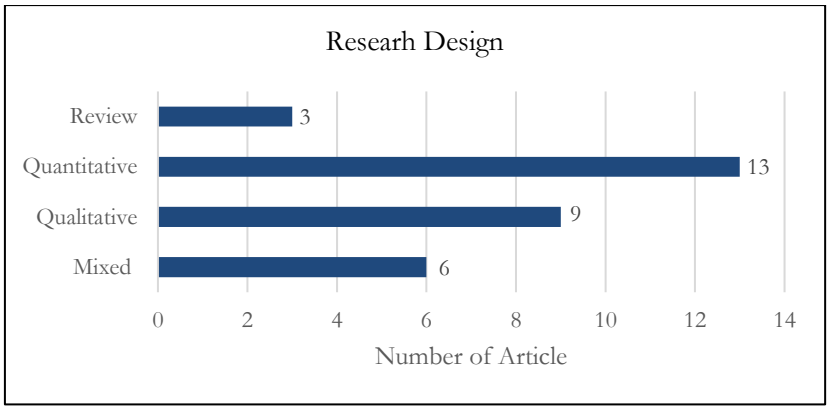

Figure 5. Distribution of countries

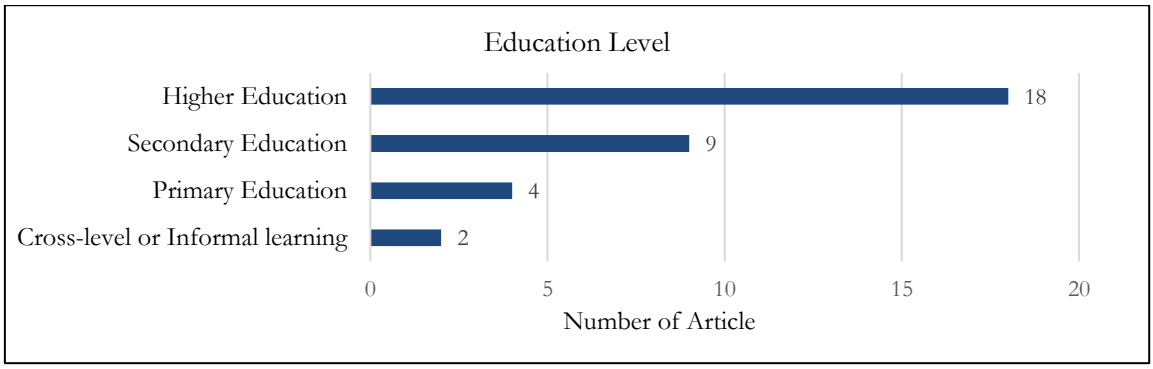

Figure 6. Distribution of education level

The research designs were distributed as follows 60% of the studies (n = 18) used qualitative designs (interviews, case studies, ethnography), 30% (n = 9) employed quantitative methods (surveys, quasi-experiments), and the remaining 10% (n = 3) utilised mixed-method approaches. These education level distributions are as illustrated in Figure 5. In terms of educational level, 16 studies focused on higher education, nine on secondary, and four on primary education, while 2 addressed cross-level or informal learning environments. These characteristics are summarised in Figure 6.

Pedagogical Strategies for Deep Learning

Across studies, deep learning was consistently conceptualised as promoting analytical thinking, knowledge transfer, and meaningful engagement with content. However, implementation strategies varied across contexts. Common pedagogical models included project-based learning, flipped classrooms, inquiry-based approaches, and dialogic or reflective instruction. Notably, there was convergence on the idea that deep learning necessitates going beyond rote memorisation toward student-centred tasks that foster autonomy and sustained inquiry.

While some studies emphasised learner autonomy and student-driven inquiry, others focused on the design of learning tasks that encourage sustained inquiry and problem-solving. There was also consensus that deep learning involves helping students analyse, synthesise, and apply knowledge in authentic contexts. Table 3 presents a summary of the deep learning pedagogical strategies identified in the reviewed studies. This table categorises the strategies by article title, author, year of publication, and the type of strategy used. It is intended to provide readers with an overview of how different approaches are distributed across the literature and to illustrate patterns of implementation across varied contexts.

Table 3. Pedagogical Strategies Summary

No.	Pedagogical Strategy	Title	Authors, Publication Year
1.	Collaborative Learning	Lecture-Based and Project-Based Approaches to Instruction, Classroom Learning Environment, and Deep Learning	Paleenud et al. (2024)
2.	Critical Thinking Approach	Digital storytelling, student engagement and deep learning in Geography	Ryan & Aasetre (2021)
		Factors contributing to Gen Z's deep learning: investigating undergraduates' course experience in Malaysian private higher education institutions	Thien et al. (2022)
		Lecture-Based and Project-Based Approaches to Instruction, Classroom Learning Environment, and Deep Learning	Paleenud et al. (2024)
		Research on Design of PBL in Blended Learning Environment Aiming at Promoting Students' Deep Learning	Yushun et al. (2019)
		Understanding, Investigating, and promoting deep learning in language education: A survey on Chinese college students' deep learning in the online EFL teaching context	Jiang (2022)
3.	Flipped Classroom	Factors contributing to Gen Z's deep learning: investigating undergraduates' course experience in Malaysian private higher education institutions	Thien et al. (2022)
4.	Inquiry-Based Learning	Student Engagement and Deep Learning in Higher Education: Reflections on Inquiry-Based Learning on Our Group Study Program Course in the UK	Archer-Kuhn et al. (2020)
5.	Blended Learning	Factors affecting deep learning of EFL students in higher vocational colleges under small private online courses-based settings: A grounded theory approach	Jiang (2022)
6.	Problem-Based Learning	Assessment in the context of problem-based learning	Van Der Vleuten & Schuwirth (2019)
		Will personalized e-Learning increase deep learning in higher education?	Sáiz-Manzanares et al. (2019)
		Factors contributing to Gen Z's deep learning: investigating undergraduates' course experience in Malaysian private higher education institutions	Thien et al. (2022)
		Lecture-Based and Project-Based Approaches to Instruction, Classroom Learning Environment, and Deep Learning	Paleenud et al. (2024)
		Surface and deep learning: a blended learning approach in preclinical years of medical school	Khong & Tanner (2024)
		Understanding, Investigating, and promoting deep learning in language education: A survey on Chinese college students' deep learning in the online EFL teaching context	Jiang (2022)
7.	Project-Based Learning	Factors contributing to Gen Z's deep learning: investigating undergraduates' course experience in Malaysian private higher education institutions	Thien et al. (2022)
		Lecture-Based and Project-Based Approaches to Instruction, Classroom Learning Environment, and Deep Learning	Paleenud et al. (2024)
		Understanding, Investigating, and promoting deep learning in language education: A survey on Chinese college students' deep learning in the online EFL teaching context	Jiang (2022)
8.	Reflective Learning	Digital storytelling, student engagement and deep learning in Geography	Ryan & Aasetre (2021)
		Research on Design of PBL in Blended Learning Environment—Aiming at Promoting Students' Deep Learning	Yushun et al. (2019)
9	Others (Interactive Teaching, Peer-to-peer Teaching, Learning Communities, students' interest)	The Impact of Online Interactive Teaching on University Students' Deep Learning the Perspective of Self-Determination	Zhou et al. (2024)
		Professional learning communities: building skills, reinvigorating the passion, and nurturing teacher wellbeing and "flourishing" within significantly innovative schooling contexts	Owen (2016)
		Peer-to-peer Teaching in Higher Education: A Critical Literature Review	Stigmar (2016)
		Construction of a teaching mechanism for ideological and political theory courses in universities based on deep learning theory	Wang et al. (2024)
		Why do students change their learning approaches? A mixed-methods study	Xie et al. (2022)

In terms of outcomes, most strategies reported positive impacts on students' cognitive, affective, and behavioural domains. Project or problem-based learning, the most frequently used strategy, was consistently associated with improvements in critical thinking, collaborative problem-solving, and knowledge application in real-life contexts. For example, students engaged in long-

term projects were more likely to demonstrate persistence in solving complex problems and showed higher levels of analytical reasoning.

Flipped classroom approaches contributed to increased learner autonomy, engagement, and preparation before class, especially in tertiary settings. Several studies noted that flipped models supported student accountability and fostered greater interaction during classroom activities. Inquiry-based learning promoted students' curiosity, self-directed learning, and metacognitive skills, especially when supported by structured reflection and scaffolding from instructors. Reflective and dialogic strategies were found to enhance self-awareness, conceptual clarity, and interpersonal understanding, particularly in teacher education programs. Learners reported better articulation of their learning process, deeper engagement with course materials, and stronger connections between Theory and practice.

Through the reviewed studies, there was a recurring consensus that deep learning pedagogy fosters not only improved academic performance but also richer meaning-making, student motivation, and lifelong learning competencies. However, the magnitude and sustainability of these outcomes were often linked to contextual enablers such as teacher expertise, curriculum alignment, and institutional support systems.

Regional and Contextual Variation

The reviewed studies revealed notable variations in how deep learning strategies are interpreted and applied across national and educational contexts. In Malaysia, for instance, Thien et al. (2022) emphasised the integration of flipped classroom and project-based learning to foster student engagement and autonomy in higher education institutions. In Spain, Sáiz-Manzanares et al. (2019) described the use of problem-based and personalised e-learning systems enhanced by formative feedback to support deep learning in university-level settings. In Norway, reflective and affective learning strategies were central to implementation. Ryan & Aasetre (2021) explored how digital storytelling supported emotional engagement and contextual understanding in environmental education. From Thailand, Paleenud et al. (2024) investigated the integration of collaborative, investigative, and participatory learning models in engineering education, aimed at improving critical thinking and self-directed learning.

The United Kingdom provided insight into inquiry-based learning in secondary science education. According to Yushun et al. (2019), facilitating student-led questioning and argumentation played a central role in promoting cognitive depth and reflection. Differences were also observed in terms of educational levels. Malaysia and Thailand applied strategies at both secondary and tertiary levels, while Spain and Norway focused primarily on university learners. These differences suggest that institutional autonomy, digital readiness, and policy alignment significantly shape how deep learning pedagogies are operationalised.

These regional differences, shaped by varying levels of policy support, digital infrastructure, and cultural orientations toward pedagogy, set the stage for a deeper exploration of their implications. The following discussion engages with these findings to reflect on their relevance and applicability within Indonesia's evolving educational landscape.

Discussion

The growing volume of publications, particularly in 2024, reflects an increasing global recognition of deep learning as a cornerstone of educational innovation in the post-pandemic era. This shift aligns with the broader pedagogical transformation toward student-centred learning that fosters critical thinking, collaboration, and real-world problem-solving. Empirical evidence from reviewed studies supports the efficacy of deep learning strategies such as project-based, inquiry-based, and reflective learning in cultivating higher-order cognitive skills and lifelong learning dispositions.

Theoretically, Bronfenbrenner (1992) explains that educational practices are influenced by multiple, interconnected layers of the environment, from direct classroom interactions to broader social and policy factors. Deep learning implementation is not isolated to the classroom environment but is shaped by institutional policies, cultural norms, and systemic support. Complementarily, Educational Change Theory from Fullan (2006) underscores that sustainable pedagogical change requires multi-level engagement, including leadership, professional learning communities, and policy coherence. These frameworks help explain why pedagogical innovation succeeds in some contexts while struggling in others.

Following the synthesis of global trends, it is essential to examine how these dynamics are reflected in the Indonesian educational context. Despite notable efforts to reform the national curriculum, particularly through the Kurikulum Merdeka, which emphasises flexible, student-centred learning, significant implementation challenges persist (Lestari et al., 2024; Rahmah et al., 2024b). Indonesia's education system continues to grapple with entrenched traditional instructional models, limited teacher readiness, and unequal access to digital infrastructure, especially in rural and remote areas (Hazin et al., 2025; Rusydiyah et al., 2024; Shalihin, 2023). The PISA 2022 results underscore these challenges, revealing that Indonesian students continue to lag the OECD average in both literacy and numeracy (OECD, 2023). These structural limitations point to the urgent need for context-sensitive strategies that can adapt deep learning principles to Indonesia's diverse and complex realities.

The urgency for adopting deep learning in Indonesia is further reinforced by recent policy initiatives such as the Profil Pelajar Pancasila, which promotes the development of critical thinking, creativity, and collaboration among students (Asy'arie et al., 2024; Sukmantoro & Sunarso, 2025; Yasmen, 2022). This vision requires a fundamental shift in the role of teachers from content transmitters to facilitators of contextualised, inquiry-based, and character-oriented learning. While this pedagogical direction aligns with global conceptions of deep learning, the realisation of these ideals remains inconsistent across schools. Many institutions, particularly in under-resourced areas, lack sufficient capacity, professional development opportunities, and systemic support to implement these changes effectively (Aldridge & McLure, 2024). This misalignment between policy ambition and institutional reality reflects the absence of robust system-level support, a factor identified across international literature as critical to the successful implementation of educational innovation.

Addressing *RQ*1, this review confirms that effective deep learning strategies share core characteristics: meaningful engagement, active inquiry, self-regulation, and knowledge transfer. These pedagogies are effective across disciplines and levels of education when supported by appropriate instructional design and digital tools. In response to *RQ*2, comparative analysis reveals substantial variation in implementation practices. Countries such as China and Malaysia demonstrate integrated models supported by national policy frameworks and technological investments. By contrast, Indonesia's efforts remain fragmented and often hindered by teacher-centred traditions and infrastructural disparities. Building on these observations, regarding *RQ*3, this review presents several evidence-based recommendations for effective integration of deep learning within the Indonesian curriculum. These include: (1) embedding deep learning principles in national curriculum frameworks; (2) restructuring assessment systems to evaluate critical thinking and authentic performance; (3) expanding teacher professional development through practice-based, iterative models; and (4) strengthening digital infrastructure and equity. These measures must be operationalised through a systems-thinking approach, where policy, pedagogy, and institutional conditions are mutually reinforcing.

In addition to pedagogical recommendations, further contextual insights emerge from the distribution of the reviewed studies across countries and educational levels. Most studies originated from upper-middle-income or high-income countries such as China, Malaysia, Australia, and Spain, where national policies and investments have facilitated pedagogical innovation (Chen & Singh,

2024; Pan et al., 2023). These nations benefit from robust digital infrastructure and structured teacher training programs that support deep learning implementation. In contrast, the absence of Indonesian studies meeting the inclusion criteria highlights a notable research gap and signals the need for stronger local empirical engagement in this domain.

Moreover, most reviewed studies focused on higher education settings, with fewer addressing secondary or primary education. This concentration suggests that universities often serve as testing grounds for innovative pedagogy due to greater institutional autonomy and access to resources. However, it also reveals a critical blind spot: the application of deep learning in early education levels, where foundational thinking skills are formed, remains under-researched. In the Indonesian context, this indicates the importance of tailoring deep learning approaches to fit various stages of education, from basic to tertiary, while also ensuring that teacher capacity building is appropriate to each level's pedagogical demands (Handayani et al., 2023).

Beyond structural and instructional factors, it is also essential to recognise that the success of deep learning strategies depends heavily on sociocultural and economic contexts. In collectivist societies such as Indonesia, collaborative learning approaches may resonate more deeply, aligning with cultural norms of cooperation and mutual support (Letchumanan et al., 2023). However, persistent digital divides and unequal access to quality learning environments hinder equitable implementation. Therefore, a context-sensitive framework is necessary that adapts global insights to local realities and recognises Indonesia's cultural and infrastructural diversity.

Kurikulum Merdeka reflects a promising alignment between Indonesia's national education goals and the core principles of deep learning. However, translating this vision into tangible outcomes demands more than pedagogical adjustments; it necessitates a comprehensive transformation encompassing governance structures, teacher professional development, and equitable distribution of educational resources. Without system-level coherence and sustained support, the risk of uneven or superficial adoption remains high.

This review is subject to several limitations that may affect the interpretation of its findings. The inclusion was limited to English-language, peer-reviewed publications, potentially excluding relevant studies published in other languages, particularly from underrepresented regions like Indonesia. Although the search strategy followed PRISMA guidelines, it may not have captured all relevant literature, and subjective judgment in applying inclusion criteria could have introduced selection bias. The reviewed studies also varied widely in terms of design, participant characteristics, and outcome measures, which limits cross-study comparability and the generalizability of findings to different educational contexts. In addition, this review did not conduct a meta-analysis due to the methodological heterogeneity of the included studies. While thematic synthesis provided valuable insights, the absence of quantitative effect size aggregation restricts the ability to evaluate the relative strength of specific pedagogical strategies. The review also inherits limitations from the primary studies, such as potential bias in data collection or reporting, and the lack of longitudinal evidence. These factors highlight the need for more robust, context-sensitive research, particularly in Indonesia, to validate and extend the applicability of deep learning pedagogy across diverse educational environments.

The findings of this review present actionable implications for education practitioners, curriculum designers, and policymakers seeking to implement deep learning effectively within the Indonesian context. Importantly, classroom instruction must shift from teacher-centred approaches to student-centred pedagogies that prioritise inquiry, collaboration, and reflective learning. This transition demands structured professional development programs that not only introduce deep learning concepts but also model their application in real teaching scenarios. Moreover, assessment practices must be restructured to capture higher-order thinking skills, creativity, and problem-solving, moving beyond traditional standardised testing. Authentic and formative assessment models should be embedded in learning activities to encourage deeper

engagement and critical reflection. Schools and local education offices should be supported in aligning their assessment policies with these broader learning goals.

In addition, to ensure equity in implementation, system-level interventions are needed to address the digital divide, particularly in rural and underserved regions. Investments in digital infrastructure, access to learning technologies, and teacher capacity building are essential to enabling deep learning practices across diverse school contexts. Finally, aligning these pedagogical innovations with the goals of Kurikulum Merdeka and Profil Pelajar Pancasila can enhance coherence between policy and practice. By fostering an ecosystem that supports deep learning through governance, training, and infrastructure, Indonesia can move closer to realising a transformative education system grounded in 21st-century competencies and local cultural values.

Future research should prioritise empirical studies in underrepresented contexts like Indonesia to better understand how deep learning pedagogies can be effectively implemented and sustained. Particular attention is needed on factors such as teacher readiness, curriculum flexibility, digital access, and the sociocultural dynamics of learning environments. Mixed-method and longitudinal studies that examine the long-term impact of deep learning interventions on student outcomes are also warranted. Further research is needed to explore the effectiveness of different technology integration strategies and to identify the best practices for using technology to enhance deep learning.

Methodologically, future research could benefit from employing mixed-method approaches that combine quantitative and qualitative data to provide a more comprehensive understanding of the complex dynamics of deep learning in educational settings. Additionally, research should continue to refine the conceptualisation and measurement of deep learning, developing more robust and valid assessment tools that capture the multifaceted nature of this construct. Finally, there is a need for more collaborative research that involves educators, researchers, policymakers, and other stakeholders to ensure that research findings are relevant, practical, and effectively translated into educational practice.

CONCLUSION

Student-centred strategies—such as project-based, inquiry-based, and reflective learning—consistently promote higher-order thinking, learner autonomy, and meaningful engagement when supported by adequate teacher training, curriculum alignment, and institutional infrastructure. While countries like China and Malaysia demonstrate more systemic support, implementation in Indonesia remains fragmented. Theoretically, this review contributes to the discourse on deep learning by integrating system-level and contextual dimensions through an ecological and educational change framework. Practically, it highlights the need for comprehensive reforms in the Indonesian education system, including curriculum redesign, investment in digital infrastructure, and professional development for teachers. The study acknowledges limitations, including the lack of meta-analyses and the underrepresentation of local empirical studies. Future research should adopt longitudinal, mixed-methods, and regional approaches to support evidence-based policymaking and the continued integration of deep learning into Indonesian education.

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