Primary School Teachers' Perceptions and Readiness for Deep Learning Pedagogy: A Global Scoping Review

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Abstract
Deep learning has been a major goal for basic education and curriculum reform. But its implementation in classrooms is highly dependent on teachers, and evidence about their views is still lacking. A scoping review is conducted to map the global literature on primary school teachers' opinions of, readiness for, obstacles in, and supportive variables for applying deep learning as a pedagogical strategy. We looked for records published between 2014 and 2026 in Scopus using the JBI approach and PRISMA-ScR standards. Seventy-eight records were examined, 22 full-text publications were reviewed for eligibility, and 17 research studies from 11 nations were mapped and thematically synthesised according to the dimensions of Population, Concept and Context. Overall, teachers see deep learning positively; however, this favourable attitude is often not reflected in effective classroom practice. All the studies identify several obstacles and facilitating elements connected with deep learning, but the least researched facet is preparedness. When absent, general conditions like professional growth, collaboration, leadership, time and infrastructure operate as barriers, but when present, they act as enabling factors. In addition, vague definitions of deep learning and the constant gap between perception and practice are found in numerous situations. These findings suggest that the imposition of deep learning, as in the Indonesian Curriculum, necessitates aligned curriculum, evaluation, professional development, leadership, and resources, with particular attention to equality. Priorities are validated measures of readiness and longitudinal, observational and comparative research.

1. Introduction

As stipulated in Government Regulation No. 22 of 2016 about Elementary and Secondary Education Since it is necessary to prepare primary school kids for a complex and rapidly changing world, education systems have focused on basic comprehension, transfer and higher-order thinking rather than rote learning (Pellegrino & Hilton, 2012; Voogt & Roblin, 2012). Deep learning has become a major, although controversial, structuring notion within this approach. The word connects two intellectual lineages. The first, based on student approaches to learning research, differentiates between a deep approach that seeks meaning, links ideas to prior knowledge, and transfers learning to new settings, and a superficial, reproductive approach (Hattie & Donoghue, 2016; Marton & Säljö, 1976). The second is a policy-oriented framework in which deep learning is a set of transferable competencies (the 6Cs: character, citizenship, collaboration, communication, creativity and critical thinking) developed through "new pedagogies" and accelerated by technology (Fullan & Langworthy, 2014). Since then, practical guidance has translated these ideas into principles for classroom design (McTighe & Silver, 2020), making deep learning both a learning process and a curricular objective.

This double framing has gained significant policy traction. Deep learning and related competence frameworks are now included in national curricula and reforms internationally (Darling-Hammond et al., 2020; Voogt & Roblin, 2012), with a notable push when international assessments highlight underperformance. In Indonesia, where 15-year-olds performed well below OECD averages in PISA 2022 (mathematics 366 vs. 472; reading 359 vs. 476) (OECD, 2023), the Ministry of Primary and Secondary School Education required the integration of a deep learning approach framed as "mindful, meaningful, and joyful" learning into the Merdeka Curriculum from the 2025/2026 school year (Alim et al., 2025; Rahmawati et al., 2025). However, a curriculum reform in Indonesia has been difficult to implement, as evidenced by ongoing disconnects between policy and classroom practices Al Arsyadhi et al., (2024); Rohmah et al., (2024); Yusa et al., (2023) and potential obstacles in teachers' readiness for the new mandate (Kasi et al., 2025; Subiyantoro & Musa, 2024).

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This is consistent with the broader notion of teachers being drivers of innovation in learning. Studies over the past few decades have shown that effective pedagogy depends on teachers' competence and that professional progress can only be achieved by consistent, sustained and collaborative implementation (Amemasor et al., 2025; Darling-Hammond et al., 2020; Sims et al., 2025). Therefore, significant studies in primary schools have been done on teachers' comprehension, preparation and use of deep learning. Teachers like these tactics, but their operational capacity is restricted (Sudirman & Pandang, 2025). Teachers' self-efficacy and goal orientation determine the deployment of deep learning approaches (Sangkawetai et al., 2020). Unclear definitions make implementation difficult (Burner & Schipor, 2025). "Training, technology and support are the building blocks of readiness. Reports from teachers and classroom observations suggest that engaging behaviour does not necessarily lead to deep classroom relationships (France, 2021), and students' pedagogical assessment of deep learning may also depend on the context (Sarkar Arani et al., 2024).

Unfortunately, there is not enough proof to back up this position just yet. The idea of 'deep learning' is still divided among researchers, politicians and the media and means different things to different people. The conceptual clarity of deep learning is still limited, and hence it is quite rare in actual practice (Burner & Schipor, 2025; Winje & Løndal, 2021). Elementary school education has received very little attention compared to secondary and university education (Winje & Løndal, 2021). Research, in various nations, topics, and research methodologies, has only concentrated on views, preparation, obstacles, and supporting variables, rather than all facets of the idea. To date, no study has mapped teachers' views on deep learning, their preparedness to deploy it in schools, and the problems and factors that may impact its implementation in the classroom. Under these conditions, this study was undertaken with the scoping review mapping the extent and reach based on the current literature. In addition, the paper explains how the themes work and highlights areas for further investigation.

Therefore, the present scoping review deals with the following key question: What does the worldwide literature say about primary school teachers' opinions of, readiness for, problems with, and enabling factors for applying deep learning as a pedagogical approach? Population, Concept, Context framework (primary teachers' views, preparation, difficulties and enabling elements of deep learning implementation; primary education internationally). The three sub-questions are: (1) What is the perception of elementary teachers towards deep learning, and what are the most stated dimensions of perception? (2) What elements are reported to shape the readiness of teachers and schools to adopt it? (3) What are the observed problems and the enabling factors identified to address them? The review brings together such information and places it in the context of Indonesia's recent mandate. The review seeks to contribute to teacher professional development, school leadership and policy implementation for deep learning in primary education.

2. Method

This scoping review was developed according to the Arksey and O'Malley (2005) framework, as updated by Levac et al., (2010) and conducted in accordance with the Joanna Briggs Institute (JBI) approach for scoping reviews (Peters et al., 2020). The reporting was guided by the PRISMA Extension for Scoping Reviews (PRISMA-ScR; Tricco et al., 2018). An a priori protocol was designed describing the purpose, eligibility criteria and analytic approach. The review focused on one main issue: How does the global literature portray primary school teachers' opinions of, preparedness for, problems with and enabling factors for using deep learning as a pedagogical approach? supplemented by three sub-questions for each facet of the concept.

2.1. Eligibility Criteria

Eligibility was framed using the Population, Concept, Context (PCC) mnemonic. The *Population* was primary school teachers (in-service or pre-service) and the school context; the *Concept* comprised perceptions, readiness, challenges, and enabling or constraining factors in implementing deep learning as a pedagogical approach (e.g., deep or deeper learning, the 6C/New Pedagogies for Deep Learning framework); and the Context was primary education internationally. We included peer-reviewed articles and reviews published in English or Indonesian between 2014 and 2026. That year was selected because many articles discuss deep learning as a pedagogical approach rather than as machine learning; consequently, the articles will focus on the concept of deep learning as a pedagogical approach to learning. We excluded studies in which "deep learning" denoted computational machine learning; studies set outside primary education without separable primary level data; studies addressing none of perceptions, readiness, challenges, or enabling factors of implementation; and nonempirical or purely conceptual works lacking an implementation dimension.

2.2. Information Sources and Search Strategy

The Scopus search was performed on 2 April 2026. Due to the use of only one database, no duplicates had to be eliminated. This is a recognised drawback. The search was a combination of three concept blocks deep learning, teachers and primary education. Boolean operators, truncation and phrase searching were used. A Boolean NOT clause was used to omit computational definitions of the term. The core Boolean query resulted in a total of 220 records, which were reduced to 78 records for screening after applying the limits provided in Table 1. The complete search string and restrictions are shown in Table 1.

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Table 1. Search Strategy in Scopus

Element	Detail
Database	Scopus
Search date	2 April 2026
Search string	TITLE-ABS-KEY (("deep learning" OR "deeper learning" OR "deep approach* to learning" OR "deep learning pedagog*" OR "new pedagogies for deep learning" OR "pembelajaran mendalam") AND (teacher* OR educator* OR "pre-service teacher*" OR "in-service teacher*" OR teaching) AND ("primary school*" OR "elementary school*" OR "primary education" OR "elementary education" OR "primary teacher*" OR "elementary teacher*" OR "basic education" OR "primary grade*" OR "young learner*" OR "K-12")) AND NOT TITLE-ABS-KEY ("neural network*" OR "machine learning" OR "convolutional" OR "image classification" OR "deep neural")
Limits	Publication year 2014–2026; document type *article* or *review*; subject area *Social Sciences*; language *English* or *Indonesian*
Records	220 (core query) → 78 (after applying limits)

2.3. Study Selection

The search retrieved 78 records. Titles and abstracts were screened against the eligibility criteria in two independent rounds; inter rater agreement was substantial (Landis & Koch, 1977), and disagreements were resolved by consensus. Fifty-two records were excluded, and 26 reports were sought for retrieval. Four reports could not be obtained because of access restrictions and were recorded as "reports not retrieved." The remaining 22 full texts were independently assessed for eligibility; five were excluded, one for not addressing primary education and four for lacking a teacher-focused or deep learning implementation dimension, yielding 17 studies for inclusion. The selection process is depicted in Fig. 1.

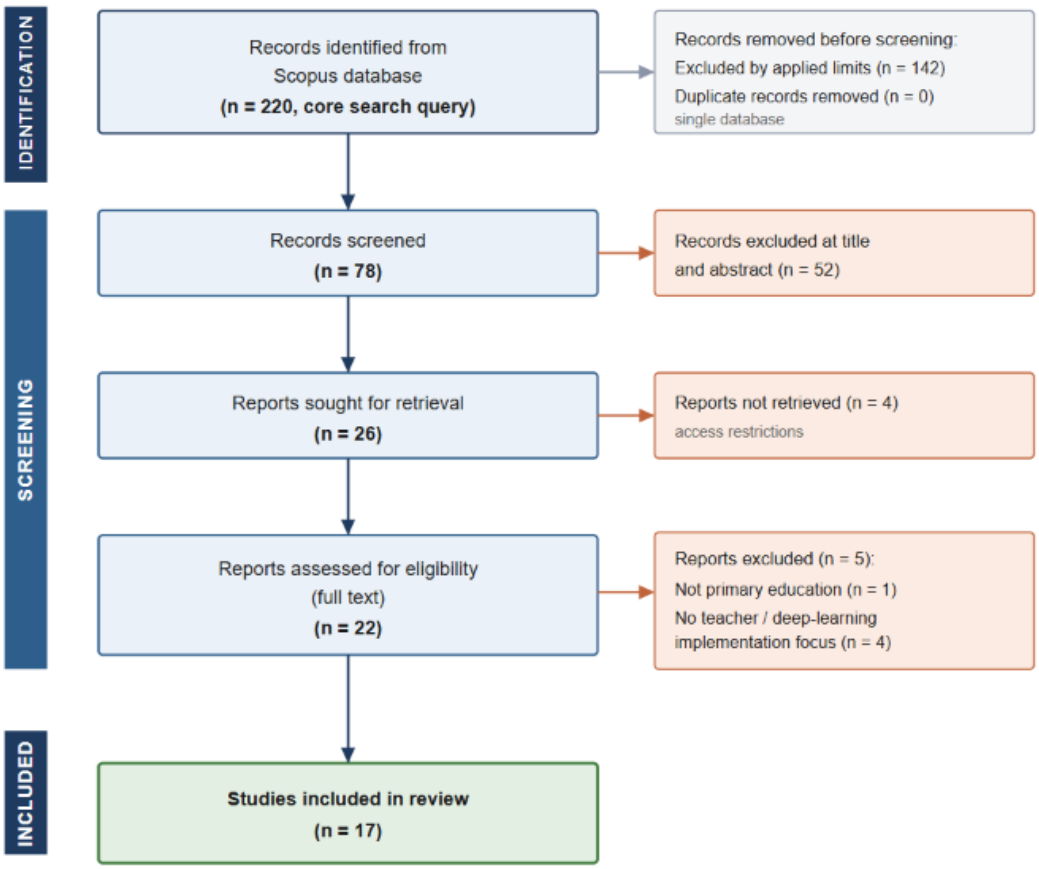


Figure 1. PRISMA-ScR Flow Diagram of the Study Selection Process

2.4. Data Charting and Synthesis

Data were organised with a form modified from the JBI guidelines (Peters et al., 2020). For each study, we extracted the reference, country, study design, participants and sample, educational level, subject, conceptualisation of deep learning, addressed concept dimension(s) (perceptions, readiness, challenges, enabling factors), key findings, reported challenges, reported enabling factors, and study limitations; study characteristics are summarised in Table 2 (Section 3). Due to the diversity of designs and outcomes, meta-analysis was unsuitable; instead, we performed a theme synthesis (Thomas & Harden, 2008). The findings were

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systematically coded and categorised deductively according to the four dimensions of PCC concepts, with an inductive discovery of recurring sub-themes within each dimension, followed by analytical interpretation across studies to address the study questions.

3. Results and Discussion

3.1. Results

3.1.1. Characteristics of the Included Studies

There were 17 studies total. Their comprehensive characteristics are delineated in Table 2, while their distribution by publication year, country, study design, and subject area is illustrated in Fig. 2. The corpus is contemporary and expanding. The initial study is from 2019 (Becker & Jacobsen, 2019), although over fifty percent of the studies were published from 2024 onwards (n = 10), peaking in 2024 (n = 5) and maintaining production in 2025 (n = 3) and 2026 (n = 2). This trend is reflected in the increasing prominence of deep learning in curriculum policy over this timeframe. The selecting process is shown in Fig. 1. The literature is consequently limited within most individual countries but distributed across nations, with no national system represented by more than three research.

Qualitative designs were most common (n=13), including case studies, semi-structured interviews, classroom observations, content analyses of lesson plans, design-based research and cross-cultural learning analysis. Only three studies used quantitative surveys (Le et al., 2023; Putri et al., 2025; Sangkawetai et al., 2020) and one study used research and development (Aryana et al., 2026). Data sources consisted mostly of interviews and observations, which were often triangulated with focus group talks (Aryana et al., 2026; Sudirman & Pandang, 2025) or with classroom films and pupils' work samples (Fielding & Makar, 2022).

The sample sizes were diverse, ranging from single-teacher case studies (Becker & Jacobsen, 2019; Fielding & Makar, 2022), focus groups of 11 teachers (Šmitienė et al., 2026), purposeful samples of six to nine teachers (Burner & Schipor, 2025; Hà & Gómez Parra, 2024; Sudirman & Pandang, 2025), surveys of 174, 543 and 810 teachers (Le et al., 2023; Putri et al., 2025; Sangkawetai et al., 2020) to a national needs analysis with 1,875 respondents (Aryana et al., 2026). The topic concentration was dominated by cross-curricular frameworks or general pedagogy (n=6) and science (n=5). Mathematics (n=2), languages/CLIL (n=2), STEM (n=1) and music (n=1) were also represented. All studies were conducted at primary school level (pupils aged about 6–12 years); the Croatian study was conducted in Year 7 in an eight-year primary school system (Mirosavljević et al., 2024). Some of the studies were conducted as practitioner-led research, with class teachers also acting as authors (Becker & Jacobsen, 2019; Fielding & Makar, 2022), offering a more detailed insight into the practices implemented at the cost of sample coverage. The other two studies were embedded in school–university partnerships (Becker & Jacobsen, 2019; Korsager et al., 2024). Only one quantitative study published the results at the primary school level independently (Sangkawetai et al., 2020) which covered primary and secondary school instructors and so is relevant to this review.

Table 2. General Characteristics of the 17 Included Studies (P = Perceptions; R = Readiness; C = Challenges; E = Enabling Factors).

Reference	Country	Design & data sources	Participants	Subject	Conceptualisation of deep learning	Dimensions
Winje & Løndal (2021)	Norway	Qual.; multiple case study, observations + interviews	Teachers, 2 primary schools (pupils 6–13)	Outdoor / cross-curricular	Deep approach (experiential)	P, C, E
Šmitienė et al. (2026)	Lithuania	Qual.; focus group	11 primary teachers	PBL / cross	Deeper learning via PBL	P, R, C, E
Hà & Gómez Parra (2024)	Vietnam	Qual.; semi-structured interviews	6 primary teachers	CLIL / language	Deeper learning (transfer)	P, C, E
Le et al. (2023)	Vietnam	Quant.; survey	543 primary teachers	Experiential / cross	Deeper learning	P, C, E
Korsager et al. (2024)	Norway	Empirical PD-framework validation; observations + interviews	18 teachers + 2 leaders (primary, gr. 1–7)	Maths & science	NPDL-aligned PD module	R, C, E
Sangkawetai et al. (2020)	Thailand	Quant.; survey, PLS-SEM	810 primary & secondary teachers	ICT / cross	Deep-learning strategies (Fullan & Langworthy)	P, R, C, E

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Reference	Country	Design & data sources	Participants	Subject	Conceptualisation of deep learning	Dimensions
France (2021)	Australia	Qual.; case study, interviews + observations	4 primary teachers	Science (dialogue)	Deep learning via dialogue	P, C, E
Becker & Jacobsen (2019)	Canada	Qual.; design-based research	1 grade-6 teacher + class	Science (makerspace)	Deeper learning via making	P, R, C, E
Sarkar Arani et al. (2024)	Japan–Malaysia	Qual.; cross-cultural lesson analysis	Educators; teacher + 19 pupils	Mathematics	Deeper learning	P, C, E
Davies & Mansour (2022)	UK	Empirical classroom study; interviews	Primary pupils (Y4–Y6); non-specialist teachers	Science / foundation	Deeper learning (cognitive science + SOLO)	R, C, E
Aryana et al. (2026)	Indonesia	R&D (4D); needs analysis (survey, interviews, FGD)	Primary teachers; 1,875 respondents	Cross-curricular	DL theory (mindful, meaningful, joyful)	P, R, C, E
Putri et al. (2025)	Indonesia	Quant.; cross-sectional survey	174 primary teachers	STEM	6C / NPDL framework	P, R, C, E
Burner & Schipor (2025)	Norway	Qual.; longitudinal interviews + observations	9 English teachers, 4 primary schools	English	Deep/deeper learning (curriculum)	P, C, E
Fielding & Makar (2022)	Australia	Qual.; case study, video + work samples	1 primary teacher + 28 pupils (9–10 yr)	Mathematics (inquiry)	Deep learning via conceptual challenge	C, E
Chen (2024)	Hong Kong	Qual.; content analysis of lesson plans (PD)	30 in-service primary music teachers	Music	Mobile learning as deep learning	R, C, E
Mirosavljević et al. (2024)	Croatia	Qual.; case study, interviews + 12 observations	6 primary teachers (gr. 7)	Biology / science	Deep learning via active learning	P, C, E
Sudirman & Pandang (2025)	Indonesia	Qual.; case study, interviews + FGD	8 primary teachers	Cross / curriculum reform	DL pedagogy (national mandate)	P, R, C, E

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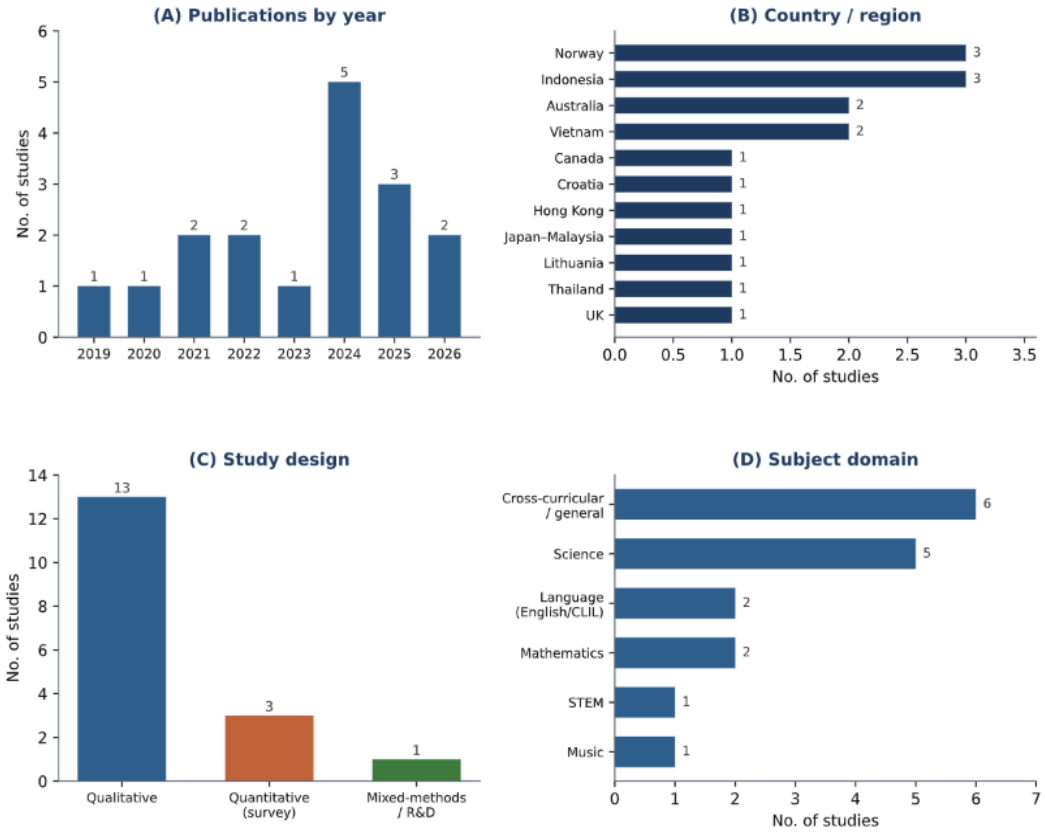


Figure 2. Characteristics of the 17 Included Studies

3.1.2. Conceptualisation of Deep Learning

Two intellectual lines may be readily distinguished throughout the text. Deep learning is also seen by others as a powerful style of learning, one that emphasises understanding, connecting new ideas to current knowledge, and applying what we learn to new contexts. This is often operationalised through related pedagogy. These pedagogical means include classroom dialogue (France, 2021), inquiry and conceptual challenge (Fielding & Makar, 2022), experiential and outdoor learning (Le et al., 2023; Winje & Løndal, 2020), project-based learning integrated with digital platforms (Šmitienė et al., 2026), content and language integrated learning (Hà & Gómez Parra, 2024), mobile learning (Chen, 2024) and cognitive science routines combined with the SOLO taxonomy (Davies & Mansour, 2022). The second group clearly refers to the policy-centric 6C/New Pedagogy for Deep Learning (NPDL) framework and its country-level versions (Korsager et al., 2024; Putri et al., 2025; Sudirman & Pandang, 2025). The 3 Indonesian studies are unique in using the official policy vocabulary of learning that is full of attention, meaningful and fun and 6C competencies (Aryana et al., 2026; Putri et al., 2025; Sudirman & Pandang, 2025) in line with the national mandate introduced for the 2025/2026 academic year.

Deep learning is usually defined as the reverse of surface learning or rote memorization, and is connected with the transfer of knowledge to new contexts (Burner & Schipor, 2025; Sangkawetai et al., 2020), in line with deep learning methodologies. For example, Norwegian teachers conceptualize deep learning as applying knowledge and skills in both known and unknown contexts (Burner & Schipor, 2025), and this is an illustration of how definitions in policies have a direct effect on conceptualizations in the classroom. However, certain authors observe that this construct remains loosely defined and inconsistent, and the absence of concrete examples in the classroom makes it more difficult for teachers to interpret and implement (Burner & Schipor, 2025; Putri et al., 2025) a recurring conceptual ambiguity that acts as a practical barrier in the next themes.

The four conceptual dimensions in this review, i.e., perceptions, readiness, obstacles, and supporting factors, are not equally represented (Figure 3). Challenges and supportive factors were explored in all 17 investigations, views in 13 studies, and readiness in only 9 studies. Thus, literature chronicles barriers and supports for implementation more fully than it measures teacher preparedness, and most studies address three or four variables simultaneously rather than individually.

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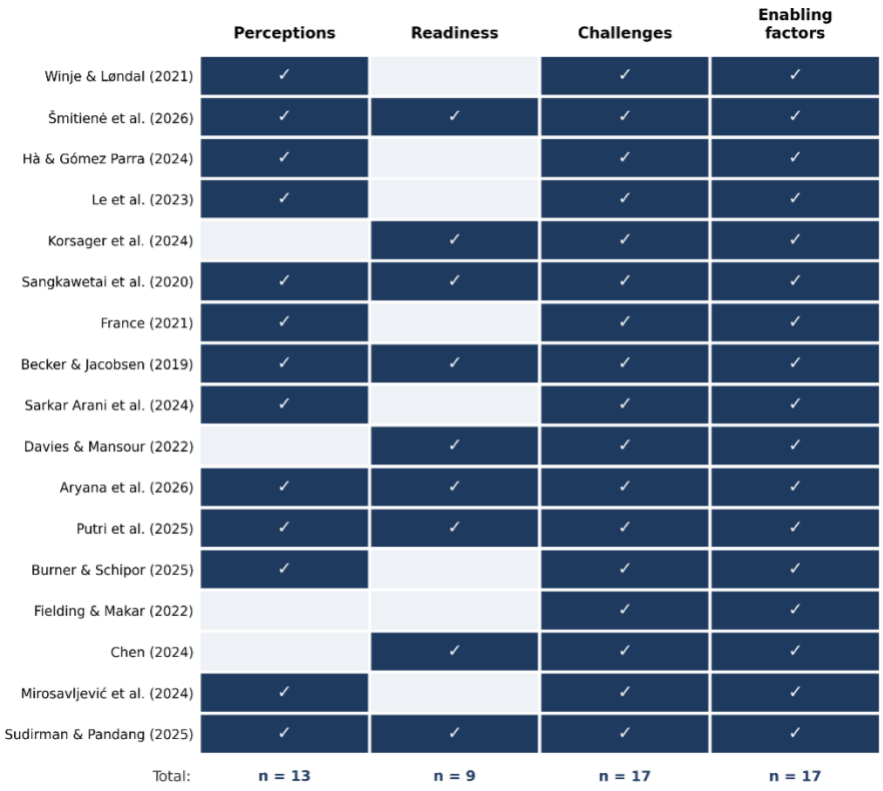


Figure 3. Coverage of the Four PCC Concept Dimensions Across Included Studies

3.1.3. Teachers' Perceptions of Deep Learning

In perception survey (n = 13), teachers tended to have positive views, considering deep learning oriented approaches relevant to meaningful learning and 21st century competencies (Hà & Gómez Parra, 2024; Le et al., 2023; Putri et al., 2025). In the largest perception survey, 543 Vietnamese elementary school teachers expressed positive views on experiential learning as a pathway to deeper learning and critical thinking (Le et al., 2023). In Indonesia, 174 teachers who completed the government mandated training widely endorsed the relevance of deep learning pedagogy across the four dimensions surveyed school vision and mission, implementation and impact, training support, and technology based media with high internal consistency (Cronbach's α = 0.890–0.948); however, agreement weakened especially on the use of technology, training support, and the practicality of implementation in the classroom (Putri et al., 2025).

A study combining teacher reports and classroom observations found that there were clear limitations in its use. In four elementary school classrooms in Australia, although educators valued discussion as a way to encourage critical thinking, more than half of the students' responses consisted of vague statements rather than reasoning (France, 2021). Although they acknowledged practical difficulties, Vietnamese teachers endorsed top-down content and language policies and were ready to implement them. For two consecutive years, nine Norwegian English teachers held conceptions that were broadly aligned with scientific definitions and partially implemented them through interdisciplinary themes, formative assessment, and multilingual practices. This development has been evident since the 2020 curriculum, but the curriculum's definition remains unclear (Burner & Schipor, 2025). An Indonesian teacher stated, "I know that deep learning is important, but I don't know how to implement it in my classroom" (Sudirman, 2025). Furthermore, perceptions influence learning. In an analysis of cross-cultural learning, teachers in Japan and Malaysia interpreted a math lesson featuring the same problem in different ways: as an opportunity to learn more or as something boring, illustrating how pedagogical judgments are shaped by implicit cultural scripts (Sarkar Arani et al., 2024). In general, a positive perception appears to be necessary but not sufficient for classroom interactions related to deep learning.

3.1.4. Teacher and School Readiness

The nine research investigated consistently found features of preparation to be incomplete and multifaceted. Teachers' capacity to use deep learning pedagogy is restricted and relies on continuous professional development (Korsager et al., 2024; Sudirman & Pandang, 2025). The strongest quantitative evidence is a structural equation analysis of 810 teachers that found self-efficacy in ICT teaching to be the strongest predictor of teachers' instructional strategies . Elementary school teachers' classroom goal structures were positively related to the use of ICT-supported deep learning strategies (Sangkawetai et al., 2020). Elementary school teachers who are generalist and non-specialist report low self-confidence and inadequate

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content preparation, especially in science . Elementary school teachers are often described as lacking a personal scientific background and confidence in teaching science (Becker & Jacobsen, 2019) and elementary school teachers expected to teach multiple subjects are positioned as non-specialists who need support to build deeper knowledge (Davies & Mansour, 2022).

The level of preparation depends on the approach. In a focus group study on the praxis, technology, and cognitive dimensions, the experiences of teachers were described, and it was noted that the teachers were more receptive to the justification of project-based learning than to the technical and design aspects of their realization (Šmitienė et al., 2026). Even though about one third of teachers use project-based learning regularly and more than 60% implement it only occasionally or inconsistently (Aryana et al., 2026), a national needs analysis identified the components of "fun" and "meaningful" as those most needed. Even in well-designed professional development, teachers' prior knowledge and different beginning points influence the extent to which a module develops their competencies (Korsager et al., 2024). In sum, readiness is not an independent trait but a mix of topic knowledge, 21st-century and technology skills, and self-efficacy. This focus helps to explain why one-shot training is always found to be insufficient.

3.1.5. Challenges to Implementation

Figure 4 shows that the seventeen studies acknowledge the existence of challenges and a thematic synthesis that reveals six distinct subthemes. First, teachers' collaboration, preparation, and planning are constrained by time and workload. Those who teach outdoors report feeling frustrated by the time required (Winje & Løndal, 2021). On the other hand, a lack of time and resources is a major obstacle to experience- and project-based approaches (Le et al., 2023; Šmitienė et al., 2026). Second, there is a general deficit in training and methodological support. This includes inconsistent professional development and a lack of guidance on how to implement policies (Aryana et al., 2026; Hà & Gómez Parra, 2024; Sudirman & Pandang, 2025). Third, implementation is hampered by infrastructure and technological limitations, such as limited access and a shortage of hardware (Becker & Jacobsen, 2019), fragmented digital integration (Šmitienė et al., 2026), and structural constraints. In Indonesia, large class sizes are considered the main barrier to personalized learning, followed by time constraints and the inadequate availability of learning aids. Fourth, teachers often lack sufficient competence and confidence. Teachers lack a comprehensive understanding of and techniques for dialogic practice (France, 2021), and non-specialist teachers lack confidence in core subjects (Davies & Mansour, 2022). Fifth, traditional practices persist. For example, in elementary school biology classes in Croatia, only 3% of student activities involve questions and discussions, while a larger proportion of students listen (34%) and answer closed-ended questions (18%) (Mirosavljević et al., 2024). Furthermore, teachers tend to "rescue" students who are struggling with elementary level mathematics, which reduces their cognitive load (Fielding & Makar, 2022). Sixth, the gap between policy and practice and the lack of equity is evident in the disparity between reform mandates and their implementation in the classroom (Putri et al., 2025; Sudirman, 2025) and in unequal access. For example, the costs of providing integrated content and language instruction are limited to wealthier socioeconomic groups (Hà & Gómez Parra, 2024).

Importantly, these issues were rarely isolated. In particular, in Indonesian studies, limited training, large classes and limited infrastructure compounded to such an extent that policy aspirations for mindful, meaningful and joyful learning met material conditions that constrained personalisation and sustained enactment (Aryana et al., 2026; Sudirman, 2025). In numerous reports, the continuance of transmission-oriented instruction seemed less a matter of resistance on the part of teachers than of these cumulative limitations (Mirosavljević et al., 2024).

3.1.6. Enabling Factors

Supporting factors were also present in all 17 studies and were grouped into five subthemes (Figure 4). The most consistently reported factors were professional development and mentoring. Well-designed programs characterized by coherence, voluntariness, support, and facilitation of teacher implementation influence practice, although these design features are necessary but not sufficient on their own (Korsager et al., 2024); a five-week government-sponsored course enabled in-service music teachers to redesign lessons centered on mobile learning as deep learning (Chen, 2024); and familiarizing non-specialist teachers with the principles of cognitive science was deemed beneficial (Davies & Mansour, 2022). Teacher collaboration and partnerships among teachers, as well as between schools and universities or researchers, support implementation, whether through collaborative co-design in makerspaces (Becker & Jacobsen, 2019), cross-cultural lesson analysis (Sarkar Arani et al., 2024), or collegial engagement during curriculum reform (Sudirman & pandang, 2025). Leadership and systemic support, including adequate resources and alignment of curriculum and assessment, are identified as conditions for sustainability (Putri et al., 2025; Sudirman, 2025). Teachers' self-efficacy and motivation, particularly their self-efficacy in teaching ICT and their intrinsic motivation, facilitate the use of deep learning strategies (Burner & Schipor, 2025; Sangkawetai et al., 2020). Finally, concrete pedagogical frameworks re-emerge as practical drivers, including structured dialogue (France, 2021), project- and experience-based learning (Le et al., 2023; Šmitienė et al., 2026), makerspaces (Becker & Jacobsen, 2019),

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mobile music-making (Chen, 2024), cognitive science routines using the SOLO taxonomy (Davies & Mansour, 2022), and an iterative challenge-support cycle in mathematical inquiry (Fielding & Makar, 2022).

Supporting components are typically considered interdependent rather than isolated across various subthemes. It has been shown that professional development is best achieved through supportive leadership and teamwork. Conversely, building a concrete pedagogical structure requires sufficient time and resources (Korsager et al., 2024; Sudirman, 2025). Because of this interdependence, individual interventions such as workshops or new technologies are unlikely to change practices unless the surrounding conditions are also addressed.

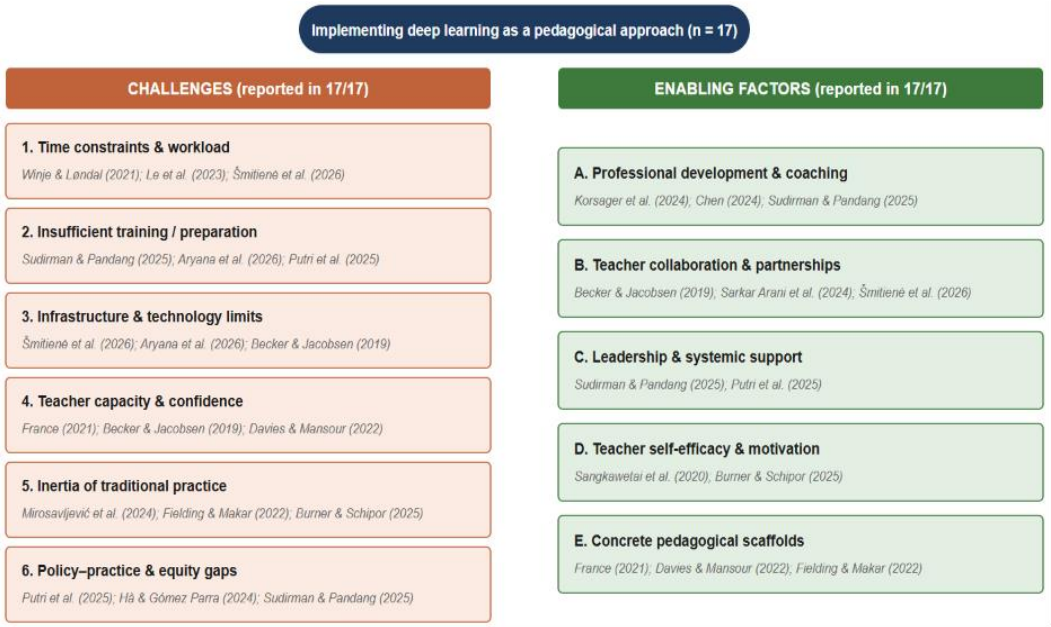


Figure 4. Thematic Map of Challenges and Enabling Factors for Implementing Deep Learning in Primary Education.

3.1.7. Summary of Patterns

This corpus is divided into three patterns. First, the problem and supporting elements are consistently described (17/17), but readiness is the least explored (9/17), indicating an asymmetry between defining the implementation environment and assessing teachers' readiness for it. Second, the perception-practice gap reemerges regardless of location and subject area: positive opinions coexist with poor practical skills, exacerbated by an unclear concept of deep learning. Third, professional development, collaboration, and leadership are the most frequently cited levers. The same factors most notably training, time, and infrastructure appear on both sides of the balance, acting as barriers when absent and as enablers when present. The discussion interprets these trends and their implications for Indonesian policy-making.

3.2. Discussion

This scoping review examines the international literature on elementary school teachers' perspectives, readiness, challenges, and supporting factors for using deep learning as a pedagogical strategy. Four issues require discussion: the persistent perception-practice gap, rooted in conceptual ambiguity; the relative neglect of readiness as a measurable construct; the interrelationship between barriers and drivers, with professional development, collaboration, and leadership repeatedly emerging as key levers; and the implications of these patterns for the deep learning mandate in Indonesia. We also consider the fundamental nature of the evidence.

3.2.1. A Perception Practice Gap Rooted in Conceptual Ambiguity

Teachers generally agree on deep learning across the corpus, but there are still problems implementing it. Teachers who "know" that deep learning is important but do not know "how to implement it" (Sudirman & Pandang, 2025) and classrooms that allow for debate but where more than half of students' questions go unanswered In Indonesia, recent findings indicate that teachers understand deep learning and its 21st-century principles, but its implementation through institutional structures and infrastructure is still lacking (Fitrah et al., 2025), and readiness still requires clearer guidance and support (Maghfiroh et al., 2026). Common contributing factors include incomplete definitions of deep learning and a lack of examples (Burner & Schipor, 2025; Putri et al., 2025), which is consistent with long-standing findings that interpretations of this construct vary (Winje & Løndal, 2020), and frameworks that view deep learning as meaning-making and knowledge

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transfer rather than fixed techniques (Fullan & Langworthy, 2014; Hattie & Donoghue, 2016; Marton & Säljö, 1976). Perceptions are also shaped by culture. For example, lessons in Japan and Malaysia are perceived as boring or more in-depth by teachers (Sarkar Arani et al., 2024), suggesting that local curricula shape "deep learning." Without practical examples, teaching can only be considered rhetoric. According to McTighe and (Fullan et al., 2018; McTighe & Silver, 2020), specific and concrete models of the subject may be needed to realize ambitions.

3.2.2. Readiness: Under Examined and Multidimensional

Readiness is the least researched dimension of implementation, with only 9 of 17 studies (Becker & Jacobsen, 2019; Davies & Mansour, 2022; Sangkawetai et al., 2020) examining this dimension, despite it being central to implementation. Those studies that have examined readiness appear to be multidimensional, rather than unitary, incorporating content knowledge, 21st-century competencies, and self-efficacy. Teaching self-efficacy in information and communication technology (ICT) is the strongest predictor of teachers' use of deep learning strategies (Sangkawetai et al., 2020), consistent with broader evidence linking self-efficacy to pedagogical-technological competence and the implementation of ambitious pedagogies (Fitrah et al., 2025). Consistent with our findings, other recent studies have separately shown that elementary school teachers' readiness for deep learning is hampered by low capacity, resources, and institutional support in the Indonesian context (Al Arsyadhi et al., 2024; Kasi et al., 2025; Subiyantoro & Musa, 2024). The relative under-measurement of this readiness represents a gap in itself: without validated instruments, the education system cannot know whether mandatory training is transforming skills or merely ensuring administrative compliance (Fitrah et al., 2025). Therefore, developing and validating metrics for teacher readiness for deep learning is a priority for research and system monitoring.

3.2.3. Barriers and Enablers as Two Sides of the Same Conditions

A striking pattern is that the same features, training, time, and infrastructure emerge as barriers when they are lacking and as enablers when they are present. Furthermore, enabling factors are interconnected rather than separate. Leadership, teacher collaboration, and professional development are the most consistent enablers (Korsager et al., 2024; Putri et al., 2025; Sudirman & Pandang, 2025), but professional development can only influence practice if it is systematically implemented and focused on teacher implementation (Korsager et al., 2024). This qualification aligns with meta-analytic evidence that the impact of professional development on outcomes is significant but moderate and highly dependent on design quality (Sims et al., 2025), as well as reviews indicating that ongoing, collaborative, and mentored development is the best way to support digital and pedagogical integration (Amemasor et al., 2025). Findings from learning and developmental science suggest that a supportive and empowering environment is necessary for successful pedagogy (Darling-Hammond et al., 2020). In our corpus, there are numerous examples of school-university collaboration and partnerships, as well as systemic leadership and alignment (Becker & Jacobsen, 2019; Šmitienė et al., 2026). In contrast, transmission-oriented teaching (Becker & Jacobsen, 2019; Šmitienė et al., 2026) and teachers' tendency to "help" struggling students to reduce cognitive demands appear to be counterproductive. Rather, these appear to be logical responses to the mounting challenges posed by large class sizes, limited time, and scarce teaching materials (Aryana et al., 2026; Le et al., 2023). This reimagining is important for policy because isolated interventions, such as workshops or new tools, are unlikely to impact practice unless surrounding factors are addressed simultaneously.

3.2.4. The Character of the Evidence Base

The level of confidence in the conclusions depends on the quality of the data used. The available data is preliminary and varies across countries in the region. Most of the data comes from qualitative studies involving small groups of people surveyed, with only three surveys providing figures and one study on research and development. While these study designs clearly show how teachers understand and use deep learning, they also limit the applicability of the results and prevent us from understanding its impact. Differences in focus within each study, such as between Norway and Indonesia, make it difficult to compare the results. Furthermore, differences in how people view and understand deep learning exacerbate the problem. This often occurs in less developed fields, where the primary focus is on describing and exploring, rather than measuring or conducting research over long periods. These differences need further investigation in the future, using proven tools, long-term research, and rigorous classroom observations, with greater attention to equity in resource-constrained regions. Using different approaches and comparing countries could be helpful. This allows you to test the detailed reports that are now a key part of research, and helps you understand whether key areas such as professional development, teamwork and leadership perform similarly across situations with different policies and resources.

3.3. Implications

Recent Indonesian research (Aryana et al., 2026; Putri et al., 2025; Sudirman & Pandang, 2025) is organized into clusters. These clusters reflect the national demand for the inclusion of deep learning in the Independent Curriculum (Kurikulum Merdeka) by 2025 to 2026. Deep learning is described as "mindful,

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meaningful, and joyful." We find that the success of this reform will depend more on the enabling conditions mentioned above than on the policy itself. We found evidence from outside the corpus to support this. Teachers support the reform, but they report unclear technical guidance, difficulties in lesson planning and assessment design, administrative burdens, and resource imbalances (Maghfiroh et al., 2026; Rohmah et al., 2024; Yusa et al., 2023). On the other hand, academics demand increased capacity, instructional leadership, and adequate facilities for schools. Equity is also crucial: deep learning is resource-dependent, which can deepen disparities between advantaged and disadvantaged schools (Hà & Gómez Parra, 2024). This is a particularly pronounced problem in Indonesia's geographically and socioeconomically diverse education system. Therefore, based on recent national literature compilations and analyses (Alim et al., 2025; Hà & Gómez Parra, 2024; Kasi et al., 2025; Riani & Sujarwati, 2025), curriculum planning, assessment, professional development, and resource provision are the most important practical implications, not simply issuing mandates.

3.4. Limitations

The limitations of the review process should be acknowledged. We searched a single database (Scopus), although it was selected for its broad multidisciplinary coverage; this may have missed eligible studies indexed elsewhere (e.g., Web of Science, ERIC, or national databases such as Garuda), and we did not undertake citation (snowball) searching.

4. Conclusion

This scoping review combines 17 studies from 11 countries to describe how elementary school teachers perceive, prepare for, navigate, and support the implementation of deep learning as a pedagogical approach. Teachers generally view deep learning positively and believe it is linked to meaningful learning in the 21st century. However, these views rarely translate into deep learning practices in the classroom. Teacher readiness, arguably a key pillar of implementation, is the least discussed aspect in each study, although issues and supporting factors are mentioned in each. Across contexts, the same conditions, such as professional development, collaboration, leadership, time, and infrastructure, serve as both enablers and barriers when absent. They complement each other rather than stand alone. Two prominent cross-cutting barriers are the notion of deep learning, which is vaguely defined and has few examples, and the persistent discrepancy between teachers' support for the idea and their operational capabilities. These patterns suggest that mandating deep learning, as demonstrated by Indonesia's 2025/2026 Independent Curriculum, will not automatically transform classrooms. Success depends on the alignment of curriculum, assessment, professional development, leadership, and resources, with particular attention to equity in schools with limited resources. In terms of research and policy, this review reveals a growing but uneven field, where small-scale descriptive research is more prevalent than measurement evidence and longitudinal studies. Priorities include tried-and-tested tools for assessing teacher readiness for deep learning, classroom observations, and longitudinal research designs, as well as comparative studies across policy settings and resource contexts. By identifying what is understood and what is unknown, this review provides a basis for improving teacher career development, school leadership, and policy implementation, so that deep learning is achievable, not just mandated, in primary education.

Author Contributions

The first author formulates research ideas and questions (conceptualization); develops the protocol, PCC, and search terms (methodology); conducts the search, screening, and eligibility assessment as the first reviewer (investigation); conducting thematic synthesis (formal analysis); creating data charts (data curation); creating figures/tables (visualization); writing original draft. The second author verifies the decisions and charting data and calculates the inter-rater agreement (validation); contributes to the synthesis; and edits and revises the manuscript (writing review and editing). The third author reviews the entire manuscript (supervision) and performs a critical edit of the manuscript (writing review and editing).

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Declaration of Conflicting Interests

The authors declare that they have no competing interests.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Declaration on AI Use

During the preparation of this work, the authors used an AI (ChatGPT & Grammarly) based assistant to support language and text readability. All AI-assisted outputs were reviewed, verified, and adjudicated by the authors.

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