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Deep Learning and Collaboration Skills in Elementary Education: An Analytical Review of Challenges and Opportunities

Lutfiana Nurohmah[1], Indriani Nur Amanah[2], Junia Amalia[3], Kumala Wahyu Widowati[4], Melata Warisma[5], Muhammad Rafli[6], Brigida Intan Printina[7]
[1,2,3,4,5,6,7] Teacher Professional Education Program, Sanata Dharma University, Indonesia

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ABSTRACT

Collaboration skills represent a crucial 21st-century competence integrated through the mutual cooperation (gotong royong) dimension of the Pancasila Student Profile. However, empirical evidence indicates that the collaborative abilities of elementary school students in Indonesia remain considerably low. While previous studies have extensivelyl focused on field-based interventions, there remains a critical gap in comprehensively synthesizing the theoretical rediness and systemic hurdles of shifting traditional paradigms toward deeper learning models in the Indonesian context. This study aims to examine the concept of collaboration skills, analyze the contribution of the deep learning approach to strengthening students' cooperative character, and map the challenges and opportunities of its implementation in elementary schools. The research method employed is library research utilizing content analysis techniques on reputable academic literature published within the last ten years. The findings indicate that the deep learning approach, anchored on mindful, meaningful, and joyful learning principles, holds the potential to transform the classroom climate into a student-centered environment, which may facilitate enhanced social interaction, empathy, and shared responsibility. The primary opportunity of this approach lies in its capacity to shift the traditional memorization paradigm toward holistic conceptual understanding through concrete activities such as Project-Based Learning (PjBL) and interactive learning. Nevertheless, systemic challenges persist, including limited teacher pedagogical capacity, rigid administrative burdens, disparities in digital infrastructure, and the heterogeneity of students' academic backgrounds, which risk inducing cognitive overload. This study concludes that strengthening deep learning-based collaboration requires holistic policy interventions, continuous teacher professional development, and the provision of authentic affective assessment instruments.

Corresponding Author:

Lutfiana Nurohmah
Teacher Professional Education Program, Sanata Dharma University
Teacher Professional Education Program, Sanata Dharma University, Jalan STM Pembangunan, Mrican, Caturtunggal, Kec. Depok, Kabupaten Sleman, Daerah Istimewa Yogyakarta 55281
Email: nurohmahlutfiana@gmail.com

INTRODUCTION

The 21st-century learning paradigm shifts the focus from mere knowledge transmission toward the holistic cultivation of the 4C competencies: critical thinking, creativity, collaboration, and communication (Hasibuan et al., 2025). Within the Indonesian educational landscape, these competencies serve as a fundamental cornerstone for the implementation of the Merdeka Curriculum (Nurhayati et al., 2024). Specifically, the development of collaboration skills is structurally facilitated through the Pancasila Student Profil, particularly within the mutual cooperation (gotong royong) dimension, which demands that students demonstrate effective teamwork, active engagement, and shared social responsibility (Swara et al., 2024). This pedagogical direction aligns with recent regulatory frameworks, including the Regulation of the Minister of Education, Culture, Research, and Technology No. 12 of 2024 and the Regulation of the Minister of Primary and Secondary Education No. 13 of 2025, both of which mandate the reinforcement of student competencies through character-driven learning outcomes.

To address the need for transforming conventional pedagogical practices, the "deep learning" approach has emerged as a prominent discourse, fostering students' active involvement in the meaningful construction of knowledge (Rochmah & Alifiani, 2026). Grounded in the core principles of mindful, meaningful, and joyful learning, this approach emphasizes learners' cognitive awareness, contextual experiences, and a positive psychological environment. Prior theoretical discussions suggest that these interconnected principles are instrumental in promoting authentic participation and facilitating collaborative dispositions among young learners (Andayanie et al., 2025).

Despite these ideal conceptual frameworks, empirical evidence indicates a persistent disparity in fiels implementation. Recent diagnostic studies and surveys underscore that the collaborative abilities of elementary school students in Indonesia remain considerably low (Taruni et al., 2024) and (Satria et al., 2024). Preliminary observations at SD Negeri Sidurejan and SD 2 Talang Benteng further validate this issue, revealing that a majority of students exhibit low engagement and passive tendencies during group-based learning activities.

However, existing literature addressing this problem remains significantly fragmentes. Previous studies have predominantly focussed on narrow, field-based interventions such as applying specific classroom action research (PTK) or quasi experimental designs to isolated subject without critically evaluating the broader systemic readiness required for a paradigm shift. There is a lack of critical syntesis regarding how the structural principles of deep learning (mindful, meaningful, and joyful) can be comprehensively mapped against the socio pedagogical constraints of Indonesian elementary schools. This study addresses this critical gap. By moving away from isolated empirical trials, this article provides a much needed qualitative synthesis and conceptual framework that bridges the macro level curriculum policies (such as the 2025 ministerial regulations) with micro level classriim realities. Consequently, the novelty of this research lies in its comprehensive mapping of the structural, cultural, and pedagogical challenges that dictate the success or failure of deep learning integration.

Based on the foregoing discussion, this article aims to: (1) explore the concept of collaboration skills within the framework of 21st-century education; (2) examine the role and contribution of the deep learning approach in strengthening collaboration skills among elementary school students; and (3) map the challenges and opportunities involved in integrating deep learning into elementary education to foster students' collaborative dispositions and competencies.

METHOD

This study employs a qualitative library research design using a structured literature review protocol to ensure transparency, objectivity, and replicability. Rather than a descriptive narrative review, this research systematically tracks, evaluates, and synthesizes existing academic literature concerning the implementation of deep learning to enhance collaboration skills in elementary education (Agus et al., 2023). Literature searching was conducted systematically across three reputable electronic databases: Google Scholar, Neliti (Indonesian Research Repository), and DOAJ (Directory of Open Access Journals). To capture both global conceptual frameworks and localized Indonesian educational realities, the search string utilized specific Boolean operators combining English and Indonesian keywords, namely: ("deep learning" OR "mindful learning" OR "meaningful learning") AND ("collaboration skills" OR "cooperative character") AND ("elementary school" OR "primary education"), as well as ("pembelajaran mendalam" OR "deep learning") AND ("keterampilan kolaborasi" OR "gotong royong") AND ("sekolah dasar" OR "SD").

To maintain the rigor and timeliness of the analyzed data, strict eligibility criteria were established prior to the literature screening process (Febrianto & Siroj, 2024). The inclusion criteria mandated that selected sources must be peer-reviewed journal articles or official curriculum policy documents published within a ten-year window between 2016 and 2026, written in either English or Bahasa Indonesia, and specifically focused on pedagogical deep learning principles (mindful, meaningful, joyful) tied to 21st-century collaboration skills in elementary education settings. Conversely, the exclusion criteria filtered out literature published prior to 2016, textbooks, undergraduate theses (*skripsi*), popular articles, blogs, conference abstracts, and any articles focusing on deep learning within the context of computer science (artificial intelligence/algorithms) or secondary and higher education levels.

The literature selection process followed a four-stage systematic pipeline inspired by the PRISMA framework to ensure absolute transparency. The initial database search yielded a total of 54 records during the identification stage. During the subsequent screening stage, 12 duplicate articles were removed, and the titles and abstracts of the remaining 42 records were evaluated for general relevance, resulting in the exclusion of 20 records that did not match the elementary education context. In the eligibility stage, the full texts of the remaining 22 articles were rigorously assessed against the predetermined inclusion and exclusion criteria, which led to the exclusion of 10 articles that discussed computational deep learning rather than educational pedagogy. Ultimately, a final total of 12 high quality peer-reviewed journal articles along with 2 ministerial regulation documents were selected for final qualitative analysis.

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The 12 selected articles were examined using qualitative content analysis, which proceeded through three systematic stages: categorization, synthesis, and interpretation. During the categorization stage, data from the literature were extracted and coded into distinct thematic nodes, including conceptual definitions of 21st-century collaboration, pedagogical elements of deep learning, and empirical barriers in schools. In the synthesis stage, findings across different authors, publication years, and regional contexts were cross-examined and integrated to uncover patterns, contradictions, and consensus regarding the variables. The final stage, interpretation, involved a critical evaluation of the synthesized data against the macro-policies of the Merdeka Curriculum and Indonesian ministerial regulations specifically No. 12 of 2024 and No. 13 of 2025 to formulate conclusions regarding the structural, cultural, and pedagogical challenges and opportunities associated with the implementation of deep learning in elementary education.

FINDINGS AND DISCUSSION

Integration of Deep Learning into the Elementary School Curriculum

The implementation of deep learning within the elementary school curriculum continues to face a range of complex challenges. These obstacles include limitations in educational facilities and infrastructure, such as inadequate access to technology and instructional materials that do not yet fully support the implementation of deep learning. In addition, the lack of professional training and mentoring for teachers in understanding and applying this approach effectively remains a major challenge. Such conditions may hinder the development of contextual, reflective, and meaningful learning processes, which are the core characteristics of deep learning.

Table 1. Literature Review: Deep Learning Integration

No	Source	Focus of finding	Important information
1.	(Maulana et al., 2025)	The impact of deep learning implementation on classroom climate transformation.	The teacher successfully integrated the three main pedagogical elements of deep learning.
2.	(Raja et al., 2026)	Examining an objective picture of teachers' understanding, application and perceptions of the deep learning approach.	*Deep learning is considered to have the potential to improve critical thinking skills, but is still hampered by curriculum restructuring, the urgency of massive teacher training, and limited supporting facilities in schools.*
3.	(Khafizah & Sayekti, 2026)	Problems faced by teachers when integrating the three main elements of deep learning.	The importance of policy interventions in the form of reducing the administrative burden on teachers, providing adequate laboratory/media facilities, and ongoing mentoring.

Based on the analysis of the three scientific articles in the table 1, the integration of deep learning into the primary education curriculum marks a paradigm shift from traditional, rote-memorization instructional method toward holistic, student centered knowledge construction. Synthesizing the current literature reveals that this approach relies heavily on the balanced operationalization of three core pedagogical pillars: mindful, meaningful, and joyful learning. Analysis across multiple recent studies demonstrates that when teachers succesfully align these three elements, the classroom climate transforms into an active learning ecosystem that stimulates early metacognitive awareness and higher order thinking skills (Khafizah & Sayekti, 2026; Maulana et al., 2025; Raja et al., 2026). This conceptual shift is strongly anchored in constructivist learning theories, where knowledge is not merely transmitted but actively negotiated by learners.

However, a critical cross-examination of the literature exposes a substantial gap between these ideal theoretical frameworks and the practical realities of primary schools. While theoretical models suggest that deep learning possesses a tactical flexibility that allows is to be implemented via low tech instructional adjustments, such as targeted trigger questions and contextual project-based learning (Fullan, 2021), comtemporary field studies present a more constrained reality. Empirical evidence points to systemic vulnerabilities, most notably the severe disparities in regional educational infrastructure, limited digital facilities, and rigid curriculum structures that restrict spontaneous pedagogical innovation (Khafizah & Sayekti, 2026; Raja et al., 2026). Furthermore, the literature highlights a profound tension between the cognitive demands of deep learning and the current operational capacity of educators. Teachers face overwhelming pedagogical planning requirements and heavy administrative tasks that directly reduce the time needed for essential classroom reflection (Khafizah & Sayekti, 2026). Consequently, the successful institutionalization of deep learning cannot rely solely on classroom level adjustment,

it demands systemic policy interventions, including targeted bureaucratic relief, infrastructure equalization, and sustained professional mentoring.

Collaboration Skills in Elementary School

In 21st century education, collaboration skills are no longer viewed merely as a secondary social trait, but as a core cognitive and behavioral competence. Within the structural framework of the Indonesian Merdeka Curriculum, this competences is tied directly to the mutual cooperation (gotong royong) dimension of the Pancasila Student Profile. The literature consistently defines collaboration as a highly coordinated process where students work toward share objectives through active individual contributuins, open communication, and share accountability (Nordin et al., 2021). Primary education represents a critical socio-developmental milestone during this operational phase, children transition into broader peer interactions, where they must learn to navigate diverse viewpoints, resolve cognitive conflict, and practice mutual respect (Sunbanu et al., 2019). Because collaborative dispositions do not develop in a vacuum, they require deliberately structured, interactive, and reflective learning environments.

Table 2. Literature Review: Collaboration Skills in Elementary School

No	Source	Focus of finding	Important information
1.	(Khanifah et al., 2019)	Student collaboration skills.	There is a significant positive influence of collaboration skills on learning outcomes; students who have high collaboration skills consistently show better and more mature learning outcomes.
2.	(Husaeni et al., 2025)	The effectiveness of the social interaction learning model (especially in the context of social studies) to mitigate the decline in social-emotional competencies (collaboration and empathy) of elementary school students post-pandemic.	The elementary school phase is identified as a critical period of children's social development, where the cultivation of collaboration skills during this period will be the foundation of their future professional competence.
3.	(Zahra et al., 2026)	Integration of deep learning combined with religious practices and literacy activities to strengthen 21st century competencies (4C) and minimize the weaknesses of the traditional memorization system in elementary schools.	The deep learning approach, which synergizes with the Independent Curriculum, can facilitate cognitive, emotional, and behavioral transformation by emphasizing comprehensive understanding of the material, critical analysis, and meaningful learning.

Synthesizing findings across different studies highlights a strong consensus regarding the positive correlation between highly developed collaboration skills and overall academic achievement. Students who exhibit advanced collaborative abilities consistently demonstrate superior learning outcomes, deeper conceptual retention, and more adaptive social behaviors

(Khanifah et al., 2019). Furthermore, recent post-pandemic literature emphasizes that structured social-interaction models are vital for mitigating the widespread decline in young learners' social-emotional competencies (Husaeni et al., 2025). Interestingly, the literature reveals an important conceptual convergence: when deep learning is paired with local cultural, literacy, or religious practices, it acts as a powerful catalyst for cognitive and behavioral transformation (Zahra et al., 2026). Therefore, the collaboration dimension in 21st Century Learning Design measures students' ability to work together with others in learning activities (Kamal et al., 2022; Satria et al., 2024). By moving away from superficial memorization and focusing instead on deep, collaborative problem-solving, this integrated approach helps students build the essential indicators of modern teamwork, which include productive flexibility, active compromise, and collective responsibility (Rigawati et al., 2024; Rosita et al., 2022). Thus, the development of collaborative competence serves as the baseline foundation for preparing young learners to function effectively in an increasingly interconnected global society.

Challenges of Deep Learning Implementation

Table 3. Literature Review: Challenges of Deep Learning Implementation

No	Source	Focus Of Finding	Important Information
1.	(Izzudin et al., 2026)	The successful implementation of the Independent Curriculum based on deep learning	The main challenges faced are the limited readiness of human resources (teachers) in adopting the deep learning paradigm and the heterogeneity of students' academic backgrounds which triggers competency gaps.
2.	(Ulya et al., 2026)	Deep learning at the elementary education level has the potential to optimize meaningful learning and holistic development of children, provided that it is contextually aligned with the child's cognitive development stage (concrete operational phase) and psychosocial stage.	Systemic barriers identified include teachers' low reflective ability and philosophical understanding of the curriculum, unequal access to technology in remote areas, and limited contextual teaching aids.
3.	(Rodhiyah et al., 2025)	Concrete activities based on real experiences, field practice, and group discussions have proven effective in stimulating students' abilities to understand, apply, and reflect on the material, as well as increasing their self-confidence.	Teachers face significant operational constraints in the form of limited digital infrastructure (such as the availability of LCD/projectors), insufficient time management for final reflection sessions due to the density of the material, and high time demands in designing creative-contextual teaching modules.

A cross-study analysis of the hurdles facing deep learning implementation reveals a complex matrix of structural, cultural, and psychological challenges. Methodologically, these constraints can be divided into macro-systemic issues and micro-instructional barriers. At the classroom level, the primary obstacle stems from a widespread deficit in teachers' philosophical understanding of deep learning paradigms and their limited reflective capacity to design complex, contextual teaching modules (Izzudin et al., 2026; Ulya et al., 2026). This instructional limitation is severely aggravated by practical operational bottlenecks, such as a lack of basic digital infrastructure (e.g., projectors and reliable internet access) and poor time management within crowded school schedules, which often forces teachers to abbreviate or omit crucial reflection phases (Rodhiyah et al., 2025).

From a student-centered perspective, the literature warns of significant psychological risks if deep learning strategies are implemented carelessly. Primary school students are in a concrete operational phase, meaning that instructional materials must be rigidly aligned with their specific cognitive and psychosocial development stages (Ulya et al., 2026). When schools impose deep learning demands without considering the high heterogeneity of student academic backgrounds, it creates a wide competency gap. This mismatch risks causing severe cognitive overload, heightened student anxiety, and digital fatigue, which ultimately undermines the meaningfulness of the learning experience (Izzudin et al., 2026; Rodhiyah et al., 2025).

To counter these systemic challenges, current research argues against isolated classroom interventions, advocating instead for a combination of institutional support and targeted digital tools. The literature shows that long-term teacher adjustment relies heavily on strong school governance, which includes active principal mentorship, regular supervisory feedback, and the revitalization of local teacher communities, such as the Teachers' Working Group (KKG). Furthermore, integrating accessible digital technologies (e.g., Canva, Wordwall, and generative AI tools like ChatGPT) alongside differentiated instruction acts as an important equalizer that bridges student learning gaps, protects psychological well-being, and builds student self-confidence (Paramita et al., 2025).

Deep Learning Opportunities in Strengthening Collaborative Skills

Table 4. Literature Review: Opportunities for Deep Learning in Strengthening Collaborative Skills

No	Source	Focus Of Finding	Important Information
1.	(Paramita et al., 2025)	Its empirical implementation in the field faces significant systemic and operational obstacles.	The main challenges identified include unpreparedness of regulations and systems, lack of comprehensive teacher training, limited infrastructure, limited time management due to administrative burdens, and the complexity of learning outcome evaluation/assessment instruments.

2.	(Salilah et al., 2025)	Deep learning offers opportunities for educational reconstruction through personalized and adaptive learning.	Opportunities: significant potential in leveraging data to analyze student learning behavior in real-time, facilitate personalized learning, and enhance critical and collaborative thinking skills. Challenges: infrastructure gaps, limited digital literacy, and teacher competency..
3.	(Isnayanti et al., 2025)	Integration of deep learning at the elementary school level requires curriculum restructuring that is oriented towards direct experience (experiential learning) and character strengthening..	Deep learning at the elementary level requires conditioning an exploratory and reflective learning environment by integrating mindfulness elements to maintain student concentration.

When evaluating the opportunities that deep learning offers for strengthening collaboration skills, a comparative analysis of the literature reveals a clear tension between optimistic theoretical projections and cautious empirical reporting. On one hand, deep learning provides a valuable opportunity to restructure modern primary education by moving toward personalized, adaptive, and highly interactive learning experiences. By utilizing real-time learning data, teachers can theoretically analyze student behaviors to design collaborative activities that match individual student capacities, thereby improving both logical reasoning and collective problem-solving skills (Salilah et al., 2025). This exploratory model encourages young learners to move past passive consumption and engage in authentic knowledge co-construction, which extends their attention span and deepens social interaction (Isnayanti et al., 2025).

On the other hand, this optimistic view is strictly qualified by widespread operational warnings across the literature. The practical implementation of these collaborative spaces faces deep systemic barriers, including a massive digital divide across different regions, low digital literacy among educators, and rigid evaluation instruments that fail to accurately measure collaborative and affective growth (Paramita et al., 2025; Salilah et al., 2025). Additionally, institutional instability such as changing curriculum policies and deeply ingrained cultural resistance to student-centered methods frequently disrupts the continuity needed to establish an exploratory and reflective classroom environment (Isnayanti et al., 2025; Paramita et al., 2025).

Ultimately, the synthesis of the literature indicates that deep learning cannot successfully foster collaboration through purely theoretical changes. Its success depends entirely on a balanced approach: combining macro-level changes, such as adaptive public regulations and multisectoral infrastructure support, with micro-level capacity building, ensuring that teachers are pedagogically equipped to guide collaborative, mindful, and inclusive learning experiences.

CONCLUSION

This study concludes that developing 21st-century collaboration skills in primary education is a critical necessity for children's cognitive and psychosocial growth, which can be effectively facilitated through the mindful, meaningful, and joyful pillars of deep learning. While this approach successfully transforms traditional classrooms into exploratory, student-centered ecosystems, its optimization faces complex challenges, including gaps in teacher pedagogical capacity, regional infrastructure disparities, and the risk of student cognitive overload. Therefore, a successful transition requires robust systemic support, including bureaucratic reduction, continuous teacher mentoring, and the formulation of authentic assessment instruments.

However, a key limitation of this study is its exclusive reliance on a qualitative review of secondary literature, which means the synthesized conceptual framework has not been empirically validated in live classroom settings across diverse socio-economic regions. To address this gap, future research should transition from theoretical synthesis to empirical execution by conducting longitudinal or mixed-methods action research in primary schools to evaluate the field-level effectiveness of deep learning on collaborative outcomes. Additionally, future investigations should focus on developing practical, low-cost affective assessment tools to help educators monitor collaborative dynamics in resource-constrained schools.

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