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DEEP LEARNING IMPLEMENTATION IN ELEMENTARY SCHOOLS: ENHANCING CRITICAL THINKING AND MEANINGFUL LEARNING THROUGH CONTEXTUAL PEDAGOGY

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Abstract

Elementary education in Indonesia remains predominantly characterized by rote learning and teacher-centered practices, which constrain students' critical thinking and meaningful engagement. This participatory action research investigated the implementation of deep learning pedagogy in a rural elementary school (SD Negeri 019 Bonan Dolok, Mandailing Natal, Sept–Oct 2025), involving 50 teachers, 75 students (grades 3–5), and three university researchers through six collaborative cycles. Multiple qualitative instruments—observations, reflective journals, interviews, and artifact analyses—were employed to capture pedagogical and behavioral transformations. Findings indicate a progressive shift from transmissive to inquiry-oriented teaching. Teachers increasingly used open-ended questioning, extended wait time, and authentic local contexts. Students demonstrated higher participation, analytical reasoning, and collaboration, although progress varied across ability levels. Key challenges included limited instructional time, assessment misalignment, and teachers' initial discomfort with shared authority. Collaborative reflection and peer learning communities emerged as pivotal for sustaining innovation. Deep learning proved attainable in resource-constrained environments when supported by reflective professional development and school leadership. Theoretically, this study extends deep learning and contextual teaching frameworks into underexplored elementary contexts, identifying reflective collaboration as a critical mechanism for pedagogical transformation. Practically, it proposes a scalable, context-sensitive model for implementing deep learning in rural schools through participatory teacher development, offering actionable guidance for educators and policymakers seeking to foster critical, creative, and collaborative learning.

Keywords: ***Deep learning, contextual learning, critical thinking, reflective pedagogy, elementary education, participatory action research, teacher professional development, rural education, Indonesia***

1. Introduction

The landscape of twenty-first-century education demands learners who think critically, solve complex problems, and adapt to rapidly shifting contexts. Yet many elementary classrooms in rural Indonesia remain anchored in surface learning; memorization and teacher-centered lectures where students recite facts without understanding their meaning or relevance. During preliminary visits to schools in Mandailing Natal Regency, we witnessed this pattern repeatedly: students recited formulas flawlessly but struggled to apply concepts to real situations or explain them in their own words. Teachers expressed frustration with these limitations yet felt constrained by time pressures, curriculum mandates, and a lack of concrete guidance for teaching differently. Deep learning offers a compelling alternative. Rather than merely knowing facts, students develop the capacity to understand relationships between ideas, create novel solutions, and apply knowledge meaningfully (Fullan, Quinn, & McEachen, 2018). When academic content connects to students' lived experiences, learning transforms from externally imposed obligation into personally and socially relevant inquiry. However, implementing deep learning in elementary settings is not simply a technical challenge of adopting new strategies; it requires fundamental shifts in how teachers perceive their roles and how students understand learning itself. While substantial literature demonstrates deep learning's effectiveness in well-resourced secondary and tertiary contexts, far less research

examines implementation in resource-constrained rural elementary schools in developing nations. Existing studies focus predominantly on outcomes rather than processes, describing what changed without adequately illuminating how those changes occurred or what enabled them. Most critically, limited research addresses the practical challenges teachers face when transitioning from traditional to student-centered approaches with large classes, minimal materials, and students whose home environments may not support extended learning projects. The Indonesian educational context exemplifies these challenges, despite curriculum reforms promoting student-centered learning, classroom practice in many rural regions remains heavily transmission-oriented.

This participatory action research investigated how deep learning principles could be implemented effectively in a rural Indonesian elementary school and examined effects on teaching practices and student learning engagement. Specifically, we addressed two questions: (1) How can deep learning be adapted for implementation in resource-constrained primary school settings? (2) What changes occur in teachers' pedagogical practices and students' learning dispositions during implementation? Between September and October 2025, we conducted six collaborative sessions at SD Negeri 019 Bonan Dolok with fifty teachers, seventy-five students (grades 3-5), and three university researchers. Our approach deliberately positioned teachers as collaborative partners rather than research subjects, recognizing that sustainable change emerges from within school communities. We structured sessions to progressively build capacity: introducing deep learning concepts, designing contextually relevant lessons, exploring Problem-Based and Project-Based Learning models, implementing approaches in actual classrooms, engaging in collective reflection, and planning for sustainability.

This study contributes to scholarship and practice in several ways. First, it provides empirical evidence that deep learning can succeed in challenging contexts when implementation respects local realities and builds on existing strengths. Second, it documents the messy, nonlinear reality of pedagogical transformation through detailed qualitative analysis, offering practical guidance for educators attempting similar changes. Third, it illuminates collaborative reflection and professional learning communities as crucial mechanisms for sustaining innovation, insights applicable across diverse educational improvement efforts. Finally, by focusing on rural Indonesian elementary education, we address geographic and developmental gaps in the deep learning literature, demonstrating that transformative pedagogies need not remain exclusive to privileged contexts.

2. Literature Review

2.1 Deep Learning: From Theory to Practice

Deep learning in education transcends simple pedagogical techniques, it represents a philosophical departure from surface-level knowledge engagement. While definitions vary across the literature (Chen & Singh, 2024), consensus centers on learning that integrates cognitive, emotional, and social dimensions, moving beyond memorization toward understanding, creating, and applying knowledge (Fullan, Quinn, & McEachen, 2018). Biggs and Tang's (2011) constructive alignment framework and their influential 3P model (Presage-Process-Product) provide a theoretical architecture, emphasizing coordination between teaching activities, assessment methods, and higher-order learning objectives. This model proves particularly valuable for acknowledging how student backgrounds, institutional contexts, pedagogical choices, and assessment practices interweave to facilitate or constrain deeper engagement. Constructivist foundations from Piaget (1972) and Vygotsky (1978) establish deep learning as inherently active, reflective, and socially situated. However, translating these theoretical principles into classroom practice, particularly in contexts where transmission models dominate, presents substantial challenges. Recent bibliometric analyses tracking deep learning research evolution demonstrate transformative effects on conceptualizing student engagement and critical thinking development (Weng, Chen, & Ai, 2023), yet reveal geographic concentration in North America, Europe, and East Asia, with limited attention to South and Southeast Asian contexts, despite these regions representing enormous student populations.

Key Gap: Existing literature predominantly addresses deep learning in secondary and tertiary education within well-resourced settings. Elementary contexts in developing nations remain understudied, particularly regarding practical implementation processes rather than merely outcomes.

2.2 Deep Learning in Elementary Education

Applying deep learning principles to elementary education presents distinct challenges and opportunities. Young learners bring tremendous curiosity yet require structured support for developing metacognitive awareness and self-regulation. A comprehensive bibliometric review of educational technology in elementary education (1986-2023) reveals increasing research attention to interactive learning environments supporting deeper cognitive engagement, with emphasis on ubiquitous learning, technology

integration, and collaborative approaches (Marfo et al., 2024). International research demonstrates that properly implemented deep learning approaches significantly enhance critical thinking skills and intrinsic motivation among elementary students, with meta-analyses confirming substantial positive effects from student-centered environments incorporating feedback loops and visible learning strategies (Hattie, 2022). However, most evidence originates from well-resourced systems in developed nations. Research examining how deep learning principles adapt for contexts characterized by large classes, limited materials, minimal technology, and teachers with primarily traditional educational backgrounds remains scarce. The Indonesian educational landscape exemplifies these challenges. Despite curriculum reforms promoting student-centered learning, classroom practice in many regions (particularly rural areas) remains transmission-oriented. Teachers face pressure to cover extensive content, prepare students for standardized assessments, and maintain order with limited support, making deep learning invitations feel like additional burdens rather than opportunities.

Key Gap: Limited research addresses practical implementation challenges in resource-constrained settings or documents the gradual, nonlinear transformation process teachers undergo when transitioning to deep learning approaches.

2.3 Contextual Teaching and Learning as Implementation Bridge

Contextual Teaching and Learning (CTL) emerges as a particularly accessible approach for introducing deep learning principles within challenging environments. CTL systematically connects academic concepts to real-world applications and students' daily lives, recognizing that learning proves most effective when contextualized and when students actively construct understanding (Johnson, 2017). This philosophical orientation aligns closely with deep learning while offering more concrete, practical entry points for teachers transitioning from traditional methods. CTL's theoretical foundations rest on brain research and constructivist learning theory, encompassing key components: meaningful connections between new knowledge and prior experiences, self-regulated learning, collaboration, critical and creative thinking, individual learner support, high standards, and authentic assessment. Empirical research on CTL implementation in elementary contexts yields encouraging findings, with studies demonstrating enhanced critical thinking abilities across diverse student populations when teachers provide simple yet progressively advanced explanations with appropriate support (Usman, Murdani, & Hasanah, 2021). The relationship between CTL and critical thinking development has received particular scholarly attention, with research confirming that CTL methods can enhance thinking abilities even among students with special needs through appropriate scaffolding (Glynn & Winter, 2004). This challenges deficit-oriented assumptions about which students benefit from intellectually demanding instruction, suggesting that virtually all students can engage in higher-order thinking when teachers create supportive conditions.

Key Gap: While CTL shows promise, limited research examines its integration with broader deep learning frameworks in elementary settings, particularly in non-Western contexts where cultural adaptation proves essential.

2.4 Teacher Professional Development and Reflective Practice

Pedagogical innovation ultimately depends on teachers' capacity and willingness to modify practice, which relies heavily on professional development quality. Reflective practice has emerged as dynamic, participatory, and cyclical, contributing significantly to educators' professional development and personal growth (Ferraro, 2000). Contemporary frameworks like Gibbs' (1988) reflective cycle and Korthagen and Vasalos' (2005) 5R approach provide concrete structures encompassing situation description, feelings exploration, outcome evaluation, contributing factor analysis, new understanding development, and future practice reconstruction based on insights. Research on teacher change confirms that meaningful transformation requires more than brief workshops or intellectual conviction. Teachers need sustained opportunities to develop practices, receive supportive feedback, reflect on experiences, and build confidence in approaches initially feeling risky and unfamiliar (Guskey, 2002). The nonlinear change process involves reciprocal interaction between beliefs, practices, and student outcomes rather than simple sequential change. Professional learning communities (PLCs) have gained traction as frameworks for supporting teacher learning. When educators collectively examine practice, share challenges and successes, and collaboratively develop solutions, they create professional learning ecosystems far more powerful than individual reflection alone (Wenger, 1998). Effective professional development provides adequate time for learning, practice,

implementation, and reflection over extended periods with opportunities for feedback, modeling, and supported practice rather than brief, isolated workshops (Darling-Hammond & Oakes, 2021).

Key Gap: Most research positions university researchers as external experts studying schools rather than collaborative partners learning alongside practitioners. Limited scholarship documents how sustained university-school partnerships can cultivate professional learning communities supporting deep learning implementation in challenging contexts.

2.5 Synthesis and Study Positioning

This review reveals several critical gaps our research addresses. First, deep learning scholarship concentrates on secondary and tertiary education in well-resourced settings, with elementary contexts in developing nations substantially underrepresented. Second, existing research emphasizes outcomes over processes, describing changes without adequately illuminating how transformations occurred or what enabled them. Third, insufficient attention is paid to emotional, cultural, and relational dimensions of pedagogical change; how teachers experience uncertainty, how students respond to increased responsibility, how communities negotiate competing pressures. Fourth, literature tends to treat deep learning implementation as primarily technical (acquiring new strategies) with inadequate attention to beliefs, relationships, and classroom culture transformation. Fifth, the intersection of university-school partnerships, collaborative action research, and capacity building for deep learning remains underexplored, with researchers typically positioned as external experts rather than collaborative partners. Our study's unique contributions: We examine deep learning implementation in a rural Indonesian elementary school, documenting both processes and outcomes through detailed qualitative analysis. We employ participatory action research, positioning teachers as collaborative partners rather than research subjects. We attend explicitly to collaborative reflection and professional learning community development as change mechanisms. We provide a thick description of the gradual, messy transformation process across multiple levels, teacher beliefs and practices, student engagement and dispositions, classroom cultures, and institutional structures. Finally, we demonstrate that deep learning principles can be adapted successfully across cultural and economic contexts when implementation respects local realities and builds on existing strengths, contributing empirical evidence from an underrepresented geographic region and educational level to the global deep learning discourse. This study is novel in both its conceptual and methodological orientation. It uniquely integrates Contextual Teaching and Learning (CTL) and deep learning pedagogy within a participatory action research framework—an approach rarely applied in elementary education, particularly in rural, resource-constrained Indonesian settings. While previous research has examined deep learning primarily in secondary or tertiary contexts of developed nations, this study advances the discourse by illuminating how reflective collaboration and locally grounded practice can operationalize deep learning principles in early education. By positioning teachers as co-researchers and emphasizing contextual adaptation rather than replication of Western models, the study contributes new empirical and theoretical insights into how transformative pedagogies can emerge within developing-world educational ecologies.

3. Methodology

3.1 Research Design and Context

This study employed qualitative participatory action research, positioning teachers as collaborative partners rather than research subjects. Conducted between September and October 2025 at SD Negeri 019 Bonan Dolok, Mandailing Natal Regency, North Sumatra, this rural elementary school serves an agricultural community with typical resource constraints: limited technology infrastructure, government-issued textbooks as primary materials, class sizes of 30-40 students, and teachers with varied experience levels (ranging from novice to 20+ years). The school's conditions reflect broader patterns in rural Indonesian elementary education, making findings potentially transferable to similar contexts.

3.2 Participants

Teachers (n=50): All grade levels (1-6) participated, representing diverse teaching experience and prior pedagogical training. Participation was voluntary following purposive sampling principles, with overwhelmingly positive responses reflecting genuine interest in professional growth. Students (n=75): Grades 3-5 students participated directly in learning activities and research processes. These intermediate grades were selected because students possessed sufficient literacy and communication skills to articulate learning experiences while remaining at crucial cognitive development stages.

University Researchers (n=3): Faculty from UIN Syekh Ali Hasan Ahmad Addary's Elementary Education program served as facilitators and co-learners, bringing complementary expertise in curriculum design, classroom management, and reflective practice. School Principal: Participated actively throughout, providing crucial administrative support and legitimizing the initiative among teachers.

3.3 Ethical Procedures

We secured formal approval from the university research ethics committee and the district education authorities. Teachers received comprehensive information about the study purposes, the voluntary nature, and withdrawal rights. For student participants, we employed dual consent, securing written parental permission and students' own assent through age-appropriate discussions. Confidentiality was addressed by distinguishing between internal project discussions (identities known) and external reporting (pseudonyms and aggregated data).

3.4 Participatory Action Research Cycles

The six-session implementation followed iterative action research cycles. Session 1 (Week 1) began with orientation, ice-breaking activities, and experiential exploration to distinguish surface from deep learning, culminating in a collaboratively created "Characteristics of Deep Learning" concept map. Session 2 (Week 2) introduced Contextual Teaching and Learning (CTL) principles through mini-workshops where teachers collaboratively designed lesson plans integrating authentic, locally relevant contexts. Session 3 (Week 3) focused on Problem-Based and Project-Based Learning models through theory and practice, producing a mini-project on energy conservation. Session 4 (Weeks 4–5) involved classroom implementation, with researchers acting as supportive colleagues rather than evaluators. Session 5 (Week 6) emphasized reflection through journals, group discussions, and student focus groups, alongside the introduction of authentic assessment tools such as rubrics and portfolios. Session 6 (Week 7) concluded with student project exhibitions, teacher reflections, and sustainability planning through the establishment of teacher learning communities and mentor roles. The six-session implementation was organized as iterative action research cycles combining exploration, experimentation, and reflection. Table 1 summarizes the sequential focus, core activities, and major outcomes of each cycle, illustrating how capacity building and pedagogical transformation unfolded progressively across the seven-week process.

Overview of Participatory Action Research Cycles

Session	Focus	Core Activities	Key Outcomes
1. Orientation and Exploration	Distinguishing surface vs. deep learning	Ice-breaking activities, collaborative discussions, and creation of a "Characteristics of Deep Learning" concept map	Shared understanding of deep learning principles and commitment to collaborative inquiry
2. Contextual Teaching and Learning (CTL) Workshop	Linking deep learning with contextual pedagogy	Mini-workshops, lesson plan co-design using authentic local contexts	Contextually relevant lesson prototypes emphasizing real-world connections
3. Inquiry Models: PBL and Project-Based Learning	Applying deep learning strategies through inquiry	Introduction to Problem-Based and Project-Based Learning, design of mini-projects on local issues (e.g., energy conservation)	Teacher-designed inquiry projects integrating deep learning components
4. Classroom Implementation	Translating plans into classroom practice	Teachers implement designed lessons; researchers observe	Evident pedagogical shifts toward inquiry

		and provide supportive feedback	facilitation and student engagement
5. Reflective Dialogue and Assessment	Deepening reflection and refining practice	Reflective journals, group discussions, introduction of authentic assessment tools (rubrics, portfolios)	Increased teacher self-awareness, improved questioning and assessment alignment
6. Consolidation and Sustainability	Institutionalizing reflective practice	Student exhibitions, peer sharing, establishment of teacher learning communities	Sustained professional learning culture and continued collaborative reflection

3.5 Data Collection

We employed methodological triangulation through five complementary data sources:

Method	Description	Purpose
Classroom Observations	Detailed field notes across all six sessions; minimum two researchers per observation	Document teaching strategies, student responses, and classroom interactions
Teacher Reflective Journals	Written/audio reflections after each session using guided prompts	Capture internal experiences, planning decisions, insights, and challenges
Student Focus Groups	Two sessions (after Sessions 3 & 6); age-appropriate facilitation with concrete prompts	Understand student perceptions, learning experiences, and attitude shifts
Teacher Interviews	Semi-structured, 45-60 minutes post-intervention	Explore overall experiences, noticed changes, unresolved challenges, and future intentions
Artifact Collection	Lesson plans, student work samples, assessment rubrics, and classroom displays	Provide tangible evidence of pedagogical practices and learning processes

3.6 Data Analysis

The data analysis followed Miles and Huberman's (1994) interactive model, encompassing three concurrent processes. Data reduction involved multiple readings using both predetermined and emergent codes derived from theoretical and contextual patterns. Initial categories, such as pedagogical strategies, student engagement, teacher beliefs, collaborative dynamics, challenges, and reflective insights, were progressively refined into detailed subcodes like questioning techniques and scaffolding methods. Data display was conducted through visual tools, including matrices comparing sessions, network diagrams connecting themes, and descriptive vignettes illustrating key classroom moments. Conclusion drawing entailed continuous testing of emerging interpretations against the evidence, intentionally seeking both confirming and contradictory cases to uncover the nuanced complexities of pedagogical transformation and learning engagement.

3.7 Trustworthiness

The study ensured research quality through several complementary strategies. Credibility was strengthened by prolonged engagement, persistent observation, data triangulation, peer debriefing among researchers, and member checking with participants to verify interpretations. Transferability was achieved through rich, contextual descriptions of the setting, participants, and procedures, allowing readers to determine relevance to their own contexts. Dependability and confirmability were maintained through detailed audit trails documenting research decisions, data collection, analysis, and interpretation processes. Finally, authenticity was upheld by recognizing power dynamics, providing space for diverse and dissenting perspectives, and ensuring that the collaborative process meaningfully benefited all participants.

3.8 Researcher Positionality

As university-based researchers, we occupied positions of relative privilege, shaping how participants related to us. We mitigated these dynamics by positioning ourselves as learners, acknowledging teachers' practical wisdom, and demonstrating genuine curiosity. Our belief in deep learning's value (based on personal transformative experiences) motivated passionate commitment while creating risks of overlooking limitations. We addressed this through deliberately seeking disconfirming evidence, discussing assumptions openly, and maintaining reflexive journals documenting not just observations but emotional responses and evolving thinking.

3.9 Limitations

The study's qualitative nature in a specific context limits generalizability. The six-session timeframe captures only initial implementation, not long-term sustainability. The researcher's presence likely influenced outcomes significantly. Voluntary participation may have attracted teachers already open to innovation. Measurement relied on qualitative evidence rather than standardized assessments. Cultural and linguistic factors in translating Indonesian into English may have affected interpretation nuances.

4. Results and Discussion

Analysis of classroom observations, reflective journals, focus groups, interviews, and artifacts across six sessions revealed three overarching findings: (1) significant teacher pedagogical transformation from transmission to facilitation, (2) enhanced student engagement and critical thinking despite uneven manifestation, and (3) collaborative reflection as a crucial change mechanism. We present integrated findings with immediate theoretical and practical implications.

4.1 Teacher Pedagogical Transformation: From Transmission to Facilitation

Teachers progressively shifted from lecture-based instruction toward inquiry-based facilitation, though facing persistent challenges with time, control, and assessment alignment.

Initial State (Pre-Intervention): Observations revealed teaching dominated by direct instruction, textbook exercises, and teacher-controlled pacing. Teachers positioned themselves as knowledge transmitters: *"My job is to make sure students learn what they need to know from the curriculum. I explain things clearly, give them practice, and check if they remember"* (4th-grade teacher, initial journal).

Key Changes Observed:

Pedagogical Dimension	Before	After	Evidence
Questioning	Closed, single-answer	Open-ended, analytical	82% of teachers use "Why?" "How might?" by Session 6
Wait Time	<1 second	5-15 seconds	Documented in 78% of observed lessons
Discourse Pattern	Teacher-student (IRE)	Student-to-student dialogue	45% increase in peer-to-peer exchanges
Context Integration	Abstract, textbook-based	Authentic, locally relevant	All Session 4-6 lessons incorporated real-world problems
Student Autonomy	Minimal choice	Structured choice in tasks	Observed in 68% of lessons by Session 5

Representative Teacher Voice: *"Before, I thought good questions had clear right answers. Now I see that questions making students think deeply often don't have one correct response... My role became helping them evaluate ideas together, not telling them which answer was correct"* (5th-grade teacher, Session 5 reflection).

Persistent Challenges:

- Time pressure: 88% of teachers cited anxiety about curriculum coverage
- Control discomfort: 34% struggled with the productive messiness of inquiry
- Assessment misalignment: 72% defaulted to recall-based tests despite inquiry instruction
- Differentiation: Variable success supporting struggling learners in less-structured tasks

Theoretical Implications: These findings align with constructivist learning theory, positioning teachers as learners constructing pedagogical understanding through experimentation and reflection (Piaget, 1972; Vygotsky, 1978). The variation in change trajectories confirms Guskey's (2002) nonlinear change model, where beliefs, practices, and outcomes interact reciprocally. Our evidence extends this literature by documenting specific pedagogical shifts in rural elementary contexts, a substantially underrepresented setting in teacher change research.The persistent challenges reveal systemic tensions between deep learning aspirations and institutional structures (standardized testing, coverage mandates) that individual teacher effort alone cannot resolve. This finding has critical policy implications: sustainable deep learning implementation requires not just teacher professional development but fundamental realignment of curriculum expectations and assessment systems.

4.2 Student Engagement and Critical Thinking: Enhanced but Uneven Development

Throughout the learning sessions, students exhibited a gradual yet meaningful transformation in their engagement and learning behavior. Their participation became more active, their curiosity more visible through frequent questioning, and their ability to think analytically and work collaboratively developed significantly. Although the pace of change differed among individuals, these improvements emerged as the result of consistent guidance and structured support provided during the process. In earlier, more traditional lessons, only a small portion of the class (around 8 to 12 students out of 30 to 40) actively took part in discussions. However, as the sessions progressed, especially by the fifth and sixth meetings, active participation expanded remarkably, with 22 to 28 students regularly contributing. This marked an overall increase of approximately 45% in class engagement. A similar pattern was seen in how students initiated questions. At the beginning, their curiosity appeared limited, with only two to three questions emerging per lesson. By the later sessions, the classroom dynamic shifted noticeably, as students began to pose around 15 to 20 substantial questions each time. Their inquiries reflected deeper thinking and genuine curiosity, such as “Why do some plants need more water?” and “How can we measure if our conservation campaign is actually effective?” Collaboration among students also evolved. Initially, group work was largely procedural; members merely divided tasks without much interaction or shared reasoning. Over time, this changed into more authentic teamwork. By the later stages, about 68% of groups demonstrated true interdependence, showing active listening, idea exchange, and even constructive disagreement. These shifts illustrated not only

a rise in academic engagement but also the growth of essential 21st-century learning skills within the classroom environment. Critical Thinking Evidence: Portfolio analysis comparing student work from Session 2 vs. Session 5 revealed notable sophistication increases:

Dimension	Session 2	Session 5
Reasoning	Circular ("conserve because important")	Evidence-based ("calculated 400L daily waste from toilets")
Argumentation	Opinion stated as fact	Claims supported with investigation data
Problem-solving	Immediate "too hard" responses	Multiple strategy attempts, persistence
Creativity	Generic solutions	Diverse, context-specific innovations

Representative Student Voice: *"Before, studying was just memorizing information from books. Now I understand that learning means solving real problems and making things better. We learned about water and energy, not just to know facts but to actually help our school waste less"* (4th-grade student, focus group). Uneven Development: Not all students experienced equal transformation. High-achieving students thrived immediately with increased autonomy. Struggling students showed mixed responses; some flourished with hands-on, contextual approaches; others found decreased structure overwhelming and required substantial additional scaffolding. Students who previously remained "invisible" (neither excelling nor struggling) showed perhaps the most striking growth, with contextual learning unlocking previously dormant engagement.

Metacognitive Awareness: Focus groups revealed developing sophistication. Early responses about learning strategies: *"when the teacher explains clearly," "when it's easy."* Later responses: *"when I try to connect new information with things I already know," "when I explain my thinking to others and they ask me questions that make me think harder."* Theoretical Implications: These findings challenge deficit-oriented assumptions about young learners' intellectual capacities, confirming research demonstrating elementary students' substantial critical thinking potential when provided with cognitively demanding tasks with appropriate support (Hattie, 2022). The uneven development across student populations underscores that deep learning is not a pedagogical panacea; effective implementation requires attending to diverse learner needs through differentiated support while maintaining high expectations for all. Our evidence extends international deep learning research, predominantly from well-resourced Western contexts, into rural developing nation settings, demonstrating that contextual adaptation enables successful implementation across diverse circumstances. The crucial role of authentic, locally relevant problems in engaging students has particular significance for resource-constrained settings where technological tools may be limited but community connections can be leveraged powerfully.

4.3 Classroom Culture Evolution: Psychological Safety and Collaborative Norms

Over the course of the study, classroom culture underwent a meaningful transformation toward greater psychological safety, stronger collaborative responsibility, and a redefinition of traditional authority dynamics. These changes, however, did not occur naturally; they required deliberate effort, consistent modeling, and explicit cultivation by teachers. A noticeable shift emerged in the dimension of psychological safety. Mistakes, once seen as failures to avoid, gradually became recognized as valuable opportunities for learning. Teachers began responding to student errors with curiosity instead of immediate correction, often saying, “Interesting! Tell me more about your thinking.” This subtle change fostered a climate where students felt safer to take intellectual risks. As one student expressed during a focus group, “Now when I’m wrong, we just think together about why, and that helps me understand better.” Such attitudes signified a move toward an environment where learning was viewed as an exploratory process rather than a performance test. The establishment of collaborative norms also marked an essential cultural evolution. Teachers explicitly encouraged students to take shared responsibility for each other’s learning. The emphasis gradually shifted from individual achievement to collective success, with students beginning to value group progress over personal recognition. By the fifth and sixth sessions, many students openly expressed pride in their group’s accomplishments, demonstrating an emerging sense of community

ownership in the learning process. Equally transformative was the reconfiguration of authority within the classroom. A telling example occurred when students, during an investigation on water usage, reached conclusions that contradicted the textbook. Instead of dismissing their findings, the teacher guided a critical comparison between the students' data and the textbook information. This moment communicated a powerful message, that knowledge should be examined through evidence and reasoning, not accepted uncritically based on authority. Theoretically, these shifts resonate with Wenger's (1998) communities of practice framework, which views learning as active participation within social contexts. The findings highlight that such cultural change requires intentional, sustained attention. Professional development, therefore, must go beyond technical instruction to include a focus on teachers' beliefs, interpersonal relationships, and the social norms shaping classroom life.

4.4 Collaborative Reflection: The Critical Change Mechanism

Structured collaborative reflection emerged as the most valued and sustainable component of the intervention. Ninety-four percent of participating teachers identified reflection opportunities as "most valuable" or "very valuable." These sessions enabled shared problem-solving and fostered a community of practice that persisted beyond the formal research period. Teachers' reflective depth evolved notably, from early descriptive notes (e.g., "Students seemed interested") to later analytical entries emphasizing improvement (e.g., "Next time, I need to clarify expectations and model evidence-based arguments"). By Session 6, teachers had institutionalized sustainability practices, including monthly reflection meetings, peer observations, co-planning, and mentoring systems. Theoretically, these outcomes reinforce frameworks that view reflection as central to professional learning (Schön, 1983; Korthagen & Vasalos, 2005). The findings demonstrate that reflective orientation can be effectively cultivated through structured support, creating accountability and sustaining change even after external assistance ends. Ultimately, this approach built internal teacher capacity for ongoing improvement, offering a practical model for enduring educational innovation

4.5 Contextual Factors: Enablers and Constraints

Several key enablers supported the success of the initiative, while notable constraints shaped its implementation dynamics. Administrative support played a crucial role, the principal's visible endorsement legitimized the program, resulting in full teacher participation. Teacher motivation also proved vital, as genuine curiosity persisted even amid early skepticism. The partnership model between university researchers and teachers fostered collaboration rather than top-down evaluation, while the rural community context enabled authentic, locally relevant learning projects that resonated with students' daily lives. However, several critical constraints emerged. Time pressure was the most frequently reported challenge (88% of teachers), alongside misalignment between deep learning goals and standardized recall assessments. Limited resources restricted the sophistication of inquiry-based projects, and cultural norms initially caused discomfort as teachers adapted to reduced authority and increased student agency. These elements interacted in complex ways. Administrative flexibility occasionally alleviated time constraints but could not fully resolve systemic workload tensions. Teacher motivation helped sustain progress, though enthusiasm waned when challenges felt insurmountable. Theoretically, the findings align with ecological perspectives on educational change (Fullan, 2021), emphasizing that successful implementation cannot rely on universal models. Instead, meaningful and lasting reform must be context-sensitive, balancing enabling and constraining forces while adapting to the unique ecological realities of each educational environment.

4.6 Research Limitations and Future Directions

This study has several limitations affecting the scope and generalizability of its findings. As a qualitative single-site inquiry, results may not represent broader contexts. The six-session timeframe captures only early implementation, leaving sustainability unverified. Researcher presence may have influenced behavior, while voluntary participation likely drew more innovation-oriented teachers. The absence of standardized assessments limits measurable outcome claims. Consequently, conclusions should be viewed as context-specific rather than universally applicable. Findings illuminate deep learning implementation in a rural Indonesian school but require longitudinal validation for sustained impact. Future research should prioritize: (1) multi-year longitudinal studies; (2) urban–rural and regional comparisons; (3) standardized outcome evaluations; (4) micro-level analysis of effective pedagogical strategies; (5) equity-focused inquiry; and (6) system-level scaling research. Despite its limits, the study fills a critical research gap by offering

empirical evidence from rural elementary education in a developing nation, employing participatory approaches that position teachers as partners, and identifying collaborative reflection as a core driver of lasting educational change (cf. Schön, 1983; Fullan, 2021)..

4.7 Practical Implications for Multiple Stakeholders

The study highlights practical insights for multiple stakeholders in advancing deep learning. Teachers are encouraged to begin with small-scale experiments, embrace discomfort as a natural sign of growth, collaborate with peers, and remain patient with gradual progress. School leaders play a pivotal role by providing visible support, allocating time for reflection, minimizing competing demands, celebrating progress, and ensuring alignment between instruction and assessment. For professional development providers, the findings emphasize the need for sustained, job-embedded programs that address not only teaching techniques but also underlying beliefs and school culture. Building professional learning communities and offering ongoing feedback opportunities are essential for lasting growth. Meanwhile, policymakers must align curriculum and assessment systems with deep learning goals, invest in long-term teacher development, and promote innovation through supportive (not prescriptive) measures, recognizing that genuine change stems from teacher conviction rather than compliance. Overall, the research demonstrates that implementing deep learning in resource-constrained elementary contexts is achievable when supported by structured professional development, continuous collaborative reflection, and strong administrative commitment. Yet, its full realization depends on addressing systemic misalignments—particularly standardized assessments emphasizing recall, curriculum mandates focused on coverage, and accountability systems prioritizing efficiency. Sustainable transformation, therefore, requires policy-level reform that enables and protects pedagogical innovation (cf. Fullan, 2021).

5. Conclusion

5.1 Summary of Key Findings

This participatory action research explored the implementation of deep learning pedagogy in a rural Indonesian elementary school through six collaborative sessions (September–October 2025) involving fifty teachers, seventy-five students, and three university researchers. The study revealed three main findings. First, teachers transformed their instructional practices from transmission-based methods toward inquiry-oriented, facilitative approaches. Observable progress included greater use of open-ended questions (82% by Session 6), longer wait times (5–15 seconds), and a 45% rise in student-to-student interaction. Despite gains, challenges persisted, particularly time constraints (88%), assessment misalignment (72%), and discomfort with reduced authority (34%).

Second, students' engagement increased notably, reflected in a 45% rise in participation and a leap in substantive questions from 2–3 to 15–20 per lesson. Their analytical thinking and collaboration improved, as portfolios showed shifts from simple reasoning to evidence-based argumentation. However, progress varied; high achievers adapted faster, while struggling students required more scaffolding. Third, structured collaborative reflection proved the most valuable and sustainable component (94% of teachers), fostering professional learning communities that continued beyond the formal intervention. Contextual enablers such as administrative support, teacher motivation, and community relevance facilitated change, while time pressure, limited resources, and systemic misalignment constrained progress.

5.2 Contributions to Literature and Practice

This study offers five key contributions. (1) It extends deep learning research into rural, underrepresented settings, demonstrating adaptability across cultural and economic contexts. (2) It documents implementation processes, highlighting the nonlinear nature of pedagogical change. (3) It identifies collaborative reflection as a core mechanism sustaining innovation, extending reflective practice theory (Schön, 1983; Korthagen & Vasalos, 2005). (4) It models participatory research, positioning teachers as partners, not subjects. (5) It integrates Contextual Teaching and Learning (CTL) as a practical bridge to deep learning in resource-limited schools. Practically, teachers are advised to begin with small experiments and seek collaboration; school leaders should ensure reflective time and align assessments; professional development providers must design sustained, culture-sensitive programs; and policymakers need to align curricula and assessments with deeper learning goals while fostering supportive, not prescriptive, environments.

5.3 Limitations and Future Research Directions

As a qualitative single-site study, findings are context-specific and not broadly generalizable. The six-session timeframe captures only early implementation, while researcher presence and voluntary participation may have influenced results. Without standardized measures, learning gains remain interpretive rather than definitive. Future research should include longitudinal tracking, comparative urban–rural analyses, rigorous outcome assessments, micro-level pedagogical studies, equity-focused investigations, and scaling research on systemic adoption.

5.4 Final Reflection

At its core, this study reflects a vision of education that nurtures critical, creative, and collaborative learners. Evidence from SD Negeri 019 Bonan Dolok shows that deep learning is achievable even in limited-resource contexts through structured support, reflective collaboration, and sustained commitment. However, full realization requires systemic reform, aligning assessments with higher-order thinking, granting curricular flexibility for depth, and investing in long-term professional growth. Meaningful educational transformation arises not from extraordinary conditions but from ordinary educators working collaboratively with shared purpose. Deep learning, therefore, stands as a promising pathway toward education that honors every child's potential and prepares them to build a more just and sustainable future.

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