

Deep learning approach implementation in natural and social science learning at an outstanding Primary School: A case study

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ABSTRACT

The implementation of deep learning in Indonesia's curriculum remains underexplored in non-urban outstanding primary schools. This study aimed to analyse the characteristics of natural and social sciences deep learning practice and the ecosystem factors supporting its implementation in an outstanding primary school. Three upper-grade teachers (Grades IV, V, VI) served as primary participants, with 10 to 29 years of teaching experience. Data were collected through in-depth interviews, a focus group discussion (FGD), classroom observations conducted three times per teacher using a four-dimension rubric adapted from the framework for teaching, and analysis of instructional planning documents. Analysis employed Braun and Clarke's thematic analysis with source and method triangulation. Findings revealed three consistently occurring pedagogical strategies: contextual phenomenon-based trigger questions, distributed collaborative role structures within learning groups, and metacognitive reflection rituals at the close of instruction. The mean observation score was 3.50 on a 4-point scale, indicating transformative practice, while document completeness reached 16 of the 16 required document types. These three strategies were supported by two ecosystem factors: transformational principal leadership and an active internal learning community. The theoretical implication is a redefinition of teacher readiness as a collective capacity emerging from multilevel interactions, rather than a static individual attribute. The practical implication is the need for professional development interventions targeting the school ecosystem holistically.

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1. Introduction

Twenty-first-century education demands a paradigm shift from surface learning — which emphasises memorisation — toward deep learning, which prioritises deep conceptual understanding, the ability to connect ideas, and the transfer of knowledge to novel contexts (Hattie, 2023; Hjardemaal, 2023). This demand arises from the reality that contemporary knowledge evolves rapidly, while future occupations require adaptive, problem-solving, and collaborative skills that conventional instructional approaches cannot adequately develop. Program for International Student Assessment (PISA) 2022 results indicate that Indonesian students' science literacy scores remained in the 380–400 range, well below the Organisation for Economic Co-operation and Development (OECD) average of 485 (Bilad et al., 2024). This gap underscores the urgency of transforming science instruction at the primary level to build the foundations of scientific reasoning more robustly from an early age.

Within the Indonesian context, the deep learning paradigm has been institutionalised through the Indonesian curriculum, which places meaningful learning at the centre of schooling (Aditiya & Fatonah, 2023; Hendrianty et al., 2024). The subject of Natural and Social Science is an integrated

science and social studies course. It has become one of the primary sites for implementing this approach because it demands higher-order thinking from the earliest grades of primary school (Luthfiyah et al., 2025). Deep learning in primary education is not merely an instructional approach but an axiological transformation that positions conceptual understanding, contextual sensitivity, and intellectual independence as the central goals of learning (Gufron & Suryahadikusumah, 2024). This framing places teachers as the pivotal agents who translate policy vision into classroom practice. Teacher readiness has accordingly become a central concern in evaluations of Merdeka Curriculum implementation (Al Arsyadhi & Kurniawan, 2023).

Prior studies have identified several determinants of successful deep learning implementation. In a study of primary schools in Bekasi, successful implementation depended on teachers' cognitive readiness, the availability of interactive media, and school leadership support (Hasanah & Pujiati, 2025). In a mathematics context, teachers' understanding of meaningful, mindful, and joyful learning principles correlated positively with implementation quality (Mutmainnah et al., 2025). Deep learning in primary schools also requires the integration of three elements: reflective planning, phenomenon-based instructional strategies, and authentic assessment (Nurul et al., 2025). Internationally, transformational principal leadership has been shown to enable pedagogical innovation (Bao, 2024), while teachers have been emphasised as change agents who translate curriculum directives into contextually appropriate practice (Brown et al., 2023). Taken together, these determinants operate across the macro level of curriculum policy, the meso level of the school, and the micro level of classroom practice; how they interact within a single outstanding school, however, remains underexplored.

Despite the rapidly growing literature on deep learning in Indonesian primary education, four gaps remain inadequately addressed. First, the majority of existing studies rely on surveys or literature reviews (Isnayanti et al., 2025; Suwandi et al., 2024), providing limited insight into actual classroom pedagogical practice. Second, qualitative studies tend to select urban elite schools as cases, leaving the dynamics of outstanding schools in non-urban sub-districts — positioned at the intersection of centralised national policy and contextual local practice — largely undocumented (Sasmita et al., 2025). Third, existing scholarship tends to focus on individual teacher factors without explicitly exploring the role of the school ecosystem in sustaining practice (Sariakin et al., 2025). Fourth, field-observation-based narratives of good practice remain scarce, despite their value for enriching the professional development repertoire of teachers in comparable contexts (Rasmitadila et al., 2025). Detailed, observation-grounded illustrations of how exemplary teachers enact deep learning day to day, and of the conditions that keep such practice alive, are therefore especially needed.

This study addresses these gaps through a single-case study design that integrates four data sources — interviews, focus group discussion, classroom observations, and document analysis — to reconstruct deep learning practice holistically. The proposed solution is a conceptual model of three pedagogical strategies supported by two ecosystem factors, generated from fieldwork synthesis rather than purely theoretical deduction. The model draws on the ecological framework (Bronfenbrenner, 1979) and change-agent theory (Brown et al., 2023), both of which locate instructional practice as a product of multilevel interactions.

Two specific research questions guide the study: (RQ1) What are the characteristics of natural and social sciences deep learning practice demonstrated by three upper-grade teachers at Pajaran 04 State Elementary School? (RQ2) What ecosystem factors support this practice, and how do their support mechanisms operate? The study contributes to the literature on teacher readiness in outstanding primary schools with a detailed narrative and a testable conceptual model, and offers a replicable implementation model for professional development in comparable school contexts.

2. Method

2.1. Research design

This study employed a qualitative approach with a single-case study design (Yin, 2018). A single-case design was chosen because the aim was to provide an in-depth description of one informationally rich school context that illuminates the phenomenon of deep learning in natural and social sciences instruction. The qualitative approach creates space to understand the meanings that

teachers construct from their teaching experiences — a dimension inaccessible to quantitative methods (Creswell & Poth, 2018; Merriam & Tisdell, 2016). Fieldwork was conducted from March to May 2026 over nine site visits, comprising three observation sessions per teacher, two interview sessions per teacher, one collective FGD session, and one document analysis session at the school.

2.2. Research site and participants

The research site was Pajaran 04 State Elementary School, a Grade-A accredited public primary school located in the centre of Saradan Sub-district, Madiun Regency, East Java Province. The school enrolls 145 students taught by 13 educators, yielding a teacher-to-student ratio of 1:11. The school was selected through purposive sampling on three criteria: (a) Grade-A accreditation, (b) at least two years of Indonesian curriculum implementation, and (c) a documented track record of natural and social sciences achievement at the regency level.

Three upper-grade teachers were selected as the primary participants, because Grades IV, V, and VI span the developmental range from concrete-operational to formal-operational thinking — the range most relevant for applying deep learning strategies. Participant identities were anonymised with initials to protect confidentiality. The school principal also participated in the FGD to provide a managerial perspective. Participant profiles are presented in Table 1.

Table 1. Demographic profile of three teacher participants

Initial	Grade	Gender	Age (yrs)	Experience (yrs)	Education
ASw	IV	Female	37	10	B.Ed. Primary Education
DYK	V	Male	44	20	B.Ed. + M.Ed.
SM	VI	Female	52	29	B.Ed. Primary Education

Source: Participant demographic data, April 2026

2.3. Data collection techniques

Four data collection techniques were used to ensure source and method triangulation (Nowell et al., 2017). First, semi-structured in-depth interviews were conducted twice per participant, each lasting 60–90 minutes, covering four thematic clusters: conceptual understanding of deep learning, concrete instructional practices, professional reflection, and perceptions of ecosystem support. Second, one FGD was held with all three teachers and the principal for 120 minutes to explore collective dynamics inaccessible through individual interviews. Third, classroom observations were conducted three times per teacher using a four-dimension rubric adapted from the framework for teaching: planning, strategy, interaction, and assessment, each scored on a 1–4 scale with specific behavioural descriptors (Praetorius & Charalambous, 2018). Fourth, document analysis was performed on 16 types of instructional planning documents, including teaching modules, diagnostic-formative-summative assessments, project rubrics, differentiated worksheets, digital media, teacher reflection notes, and student portfolios.

2.4. Data analysis

Data were analysed using a six-phase thematic analysis (Braun & Clarke, 2021), supported by a three-stage coding procedure (Miles et al., 2014). Phase one involved familiarisation through verbatim transcription of all interviews and the FGD. Phase two involved open coding to identify units of meaning in transcripts and observation notes. Phase three involved axial coding to construct categories by grouping related codes. Phase four involved theme searching by clustering categories into broader themes. Phase five involved theme review to ensure internal coherence and external distinctiveness between themes. Phase six involved reporting, constructing a narrative that integrates the main themes. Source triangulation compared the accounts of the three teachers, the principal, and the documents. Method triangulation compared interview, observation, FGD, and document data. Member checking was conducted by sharing a summary of findings with participants for verification, following established trustworthiness criteria for thematic analysis (Nowell et al., 2017).

2.5. Ethical considerations

This study obtained approval from the Madiun Regency Education Office and the school principal. Written informed consent was obtained from each participant before data collection, with a detailed explanation of the study's aims, participants' rights, and confidentiality guarantees. Participant identities were anonymised, and all data were stored in encrypted form. Participants had the right to withdraw at any time without consequence.

3. Results and Discussion

This section is organised into five sub-sections. Section 3.1 presents the quantitative observation scores as an overview of instructional quality. Section 3.2 presents three pedagogical strategies as the main qualitative findings answering RQ1. Section 3.3 presents two ecosystem factors addressing RQ2. Section 3.4 presents document analysis as supporting evidence. Section 3.5 synthesises across findings to draw theoretical and practical conclusions.

3.1. Observation score profile

Observation data collected across nine site visits revealed a highly consistent score profile among the three teachers. Mean scores across all four practice dimensions — planning, strategy, interaction, and assessment — uniformly reached 3.50 on a maximum scale of 4.0. Each dimension was measured using specific behavioural descriptors adapted from established classroom-observation frameworks for instructional quality (Praetorius & Charalambous, 2018), where a score of 3 indicates competent practice and a score of 4 indicates distinguished practice. Figure 1 explains the results of the observation scores across four practice dimensions.

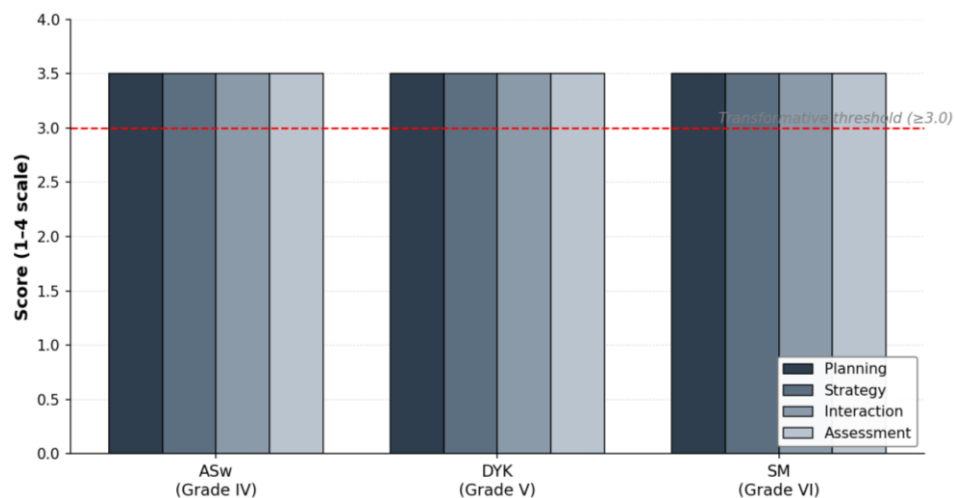


Fig. 1. Observation scores of teachers across four practice dimensions

The consistency of scores at 3.50 across all teachers warrants two observations. First, instructional quality is evenly distributed among the three teachers despite considerable variation in age, years of experience, and educational background — ASw (37 years old, 10 years of experience, B.Ed.), DYK (44, 20 years, M.Ed.), and SM (52, 29 years, B.Ed.). Such demographic diversity would ordinarily yield significant variation in practice, yet this was not detected at the dimension level at Pajaran 04 State Elementary School. Second, the mean score of 3.50 sits at the boundary between competent and distinguished, indicating that practice has surpassed the minimum threshold but has not yet fully reached a level of comprehensive pedagogical innovation.

These findings interact with two prior meta-analyses. A meta-analysis synthesising 56 large-scale studies found that school-level characteristics significantly influence teacher practice beyond individual variation (Holzberger et al., 2020), a proposition supported by the even quality distribution observed here. Teacher competence has further been shown to influence student outcomes through instructional quality as a mediator (Fauth et al., 2019). The uniform score of 3.50 is therefore not a statistical coincidence but a reflection of an internal school mechanism explored in subsequent sub-sections.

3.2. Three consistently occurring pedagogical strategies

The six-phase thematic analysis (Braun & Clarke, 2021) identified three pedagogical strategies that emerged consistently across all observation sessions, corroborated by interview and FGD data. To assess theme strength, the researchers counted each theme's occurrence across four data sources and applied a convergence criterion: a theme was considered strong if it appeared in at least three data sources with a total of at least 25 instances. Occurrence distributions are presented in Table 2.

Table 2. Theme occurrence distribution across four data sources

Theme	Interviews	FGD	Observations	Documents	Total Convergence
Contextual trigger questions	9	3	9	9	30 (strong)
Distributed collaborative roles	8	3	9	8	28 (strong)
Metacognitive reflection ritual	9	3	9	9	30 (strong)

Source: Cross-source coding results, April 2026

Table 2 shows that all three themes meet the strong convergence criterion. The trigger-question and reflection-ritual themes display the highest occurrence (30 instances each), meaning they were present in every observation session and every interview. The collaborative-roles theme is slightly lower (28 instances) because it appeared in eight of nine interview sessions and eight of nine document sets. The three themes are complementary and can be read as a cycle of meaningful learning: trigger questions open the cycle, collaborative role structures sustain it, and reflection rituals close it with formative assessment.

The first strategy is contextual phenomenon-based trigger questions. All three teachers began each lesson with trigger questions linking natural and social sciences content to students' everyday experiences. In one observation of Grade IV on 10 April 2026, ASw opened a lesson on the water cycle with the open question: "Why does laundry dry on the line even though it has not been wrung out?" This question functioned as a catalyst by opening a pathway toward conceptual exploration without demanding a single correct answer. Student responses varied, including conjectures about wind, solar heat, and gravity. ASw then wove these responses into an introduction to the concept of evaporation.

"I don't want the children just to memorise the word evaporation. I want them to feel that this phenomenon is all around them. If the children are curious, they will keep seeking answers without being told to." (ASw, Interview, 12 April 2026)

Trigger questions at Pajaran 04 State Elementary School share two distinctive characteristics: they are anchored in everyday life — rooted in student experience rather than formal texts — and they are open-ended, allowing varied responses without immediate evaluation. Both features are identified by Hattie (2023) as strong predictors of students' cognitive engagement, with effect sizes above 0.40 considered meaningful. This practice also aligns with the cognitive activation model, which positions initial stimulation as the key to deep learning (Xu et al., 2025). Hasanah and Pujiati's (2025) study in urban Bekasi found that contextual trigger questions are a key indicator of teacher readiness for deep learning, so the findings from Pajaran 04 State Elementary School reinforce this phenomenon beyond an urban setting.

A critical note is warranted. The trigger-question strategy did not always succeed equally in every session. During the 17 April 2026 observation, a trigger question about solar eclipses in Grade VI elicited little student response because the topic was perceived as too abstract. SM adapted by using a torch-and-ball analogy to visualise the phenomenon. This real-time adaptation demonstrates that the strategy's strength lies not only in the initial question but also in the teacher's sensitivity to reading student responses and adjusting approach on the fly — consistent with the concept of responsive teaching in contemporary literature.

The second strategy is distributed collaborative role structures. All three teachers integrated small-group work with clearly defined role assignments. DYK, the Grade V teacher, consistently applied a four-role structure within learning groups: a recorder who documented discussions, a presenter who reported results to the class, a researcher who sought additional sources, and a moderator who managed speaking turns. Roles were rotated weekly so that every student experienced all four roles over the course of one semester. This practice aligns with cooperative learning principles, which remain prominent in contemporary literature for their effectiveness in building twenty-first-century skills (AL-Zboun, 2021).

"Each child has a different role in the group. Nobody is allowed to just sit quietly. If you're the recorder, you record. If you're the moderator, you manage the discussion. That way, every child is learning." (DYK, Interview, 14 April 2026)

DYK's practice transforms group dynamics that have traditionally been dominated by high-achieving students. By distributing roles, mid- and low-achieving students gain an equal space to contribute. This approach also cultivates social-emotional learning, an increasingly important theme in contemporary primary education, especially when integrated with local cultural contexts (Niman, 2025). The role structure can further be read as a concrete expression of Vygotsky's zone of proximal development: students perform roles slightly above their independent capacity, but within the safety of group support.

A reflective note regarding this strategy concerns the need for adequate initial training. ASw and DYK acknowledged that in the early weeks of implementation, students were unfamiliar with their assigned roles. Some refused to present because they felt shy; others declined the moderator role because they felt they lacked authority. Both teachers responded by explaining the purpose of each role and modelling expected behaviours. After two to three weeks, students accepted role rotation as a class routine. This experience underscores that collaborative structures cannot be implemented instantly; they require a patient scaffolding period.

The third strategy is metacognitive reflection rituals. All three teachers consistently closed each lesson with a reflection ritual. SM, the Grade VI teacher with the longest experience, routinely asked students to write three sentences at the end of each class: what they learned, what still confused them, and what they wanted to know more about. This practice, known in the literature as an exit ticket, provides the teacher with formative feedback while simultaneously promoting students' metacognitive awareness.

"Three sentences might look simple, but reading the children's writing every day tells me who is still confused and who has understood. The next day I can immediately adjust my teaching strategy." (SM, Interview, 16 April 2026)

This consistent reflection practice aligns with the reflective-practitioner perspective, which positions reflection as the core of professional growth (Tobin et al., 2024). More specifically, metacognitive reflection rituals align with the mindful learning philosophy that underpins the deep learning approach (Mutmainnah, Adrias, & Zulkarnaini, 2025). In a blended-learning context, metacognitive reflection has been shown to correlate with deeper learning outcomes (Shi & Lan, 2024). The reflection ritual at Pajaran 04 State Elementary School is therefore not a formality but a sustained instrument of pedagogical development.

The reflection ritual serves a dual function. For students, it supports the consolidation of understanding and builds metacognitive awareness of their own learning processes. For teachers, student reflections serve as formative data used to adjust subsequent instruction. SM reported routinely taking student reflection sheets home to read in the evening and designing the next session's strategy based on detected patterns of confusion — concretely realising the data-driven instruction cycle that the literature endorses (Hattie, 2023).

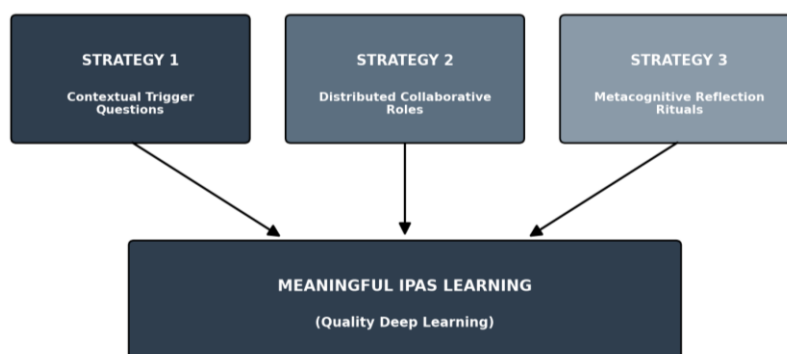


Fig. 2. Conceptual model of three pedagogical strategies and intended outcomes

3.3. Supporting ecosystem factors

The three consistent pedagogical strategies did not emerge organically. Analysis of interview, FGD, and document data identified two ecosystem factors sustaining these practices: transformational principal leadership and an active internal learning community. Both factors operate synergistically and constitute a prerequisite for the continuity of good practice. This sub-section addresses RQ2 by detailing the mechanisms through which each factor operates.

The first section is transformational principal leadership. The principal of Pajaran 04 State Elementary School displayed transformational leadership as described by Bao (2024). Three indicators were consistently observed: first, active encouragement of pedagogical experimentation within a psychologically safe space for failure; second, substantive involvement in pedagogical discussions as an equal discussant rather than an authority figure; and third, concrete resource support, including facilitating teacher access to additional learning resources and allocating dedicated time for professional development (Darling-Hammond et al., 2020). FGD data revealed that teachers perceived these three indicators as granting psychological permission to innovate.

"The principal always encourages us to try new things. Even if we fail, there is no scolding. That is what makes us brave enough to innovate." (FGD, April 2026)

This statement reflects what has been described as psychological safety in a school context (Sariakin et al., 2025). Without psychological safety, teachers tend to choose already-mastered practices to minimise risk, making innovation difficult. The principal's role in managing the deep learning approach is key to shaping the character of Generation Alpha students, particularly in navigating the challenges of new curriculum implementation (Hidayat & Lyesmaya, 2024). The principal's leadership at Pajaran 04 State Elementary School extended well beyond administrative management to include substantive engagement with pedagogical discourse — a feature that distinguishes transformational from transactional leadership.

The second section is an active internal learning community. The second ecosystem factor is the active internal learning community. All three teachers described a regular Friday-afternoon meeting as their primary space for professional development. Unlike formal meetings often experienced as burdensome, these gatherings were informal and reflective in character. Teachers shared experiences, discussed successes and failures, and planned strategies together. There was no rigid agenda, yet full participation occurred every week. This phenomenon has been described as an organic professional learning community, one that grows from internal need rather than top-down instruction (Kariuki et al., 2024).

The learning community's character at Pajaran 04 State Elementary School aligns with the professional learning community model that positions reflective collaboration as the engine of professional growth. Key characteristics observed include sustained regularity, a focus on concrete practice, and a non-hierarchical climate. Teacher professional development in Indonesia is most effective when it occurs in communities that combine formal training with informal peer collaboration (Rasmitadila et al., 2025). The Friday-afternoon community at Pajaran 04 State Elementary School concretely exemplifies this principle and constitutes the transmission mechanism for practices across teachers.

The knowledge transmission mechanism within this learning community may be described as follows: a pedagogical strategy that succeeds in one classroom is shared in the Friday meeting and adopted by other teachers with modifications suited to their own classroom contexts. This pattern explains the convergence of observation scores at 3.50 — a question raised in Section 3.1. The learning community functions as a homogenisation mechanism for practice without erasing each teacher's individual stylistic variation.

3.4. Completeness of instructional planning documents

Analysis of the 16 types of instructional planning documents revealed full completeness at Pajaran 04 State Elementary School. This profile is not merely administrative formality but a reflection of a strong professional documentation culture (Bentri et al., 2022). Comprehensive documentation provides a systematic foundation for implementing learning activities consistently and monitoring their quality throughout the instructional process. Moreover, the availability of all required planning documents indicates institutional readiness to support the implementation of

pedagogical innovations in classroom practice. The completeness breakdown is presented in Table 3.

Table 3. Completeness of 16 instructional planning document types

No.	Document Type	Status	No.	Document Type	Status
1	Natural and Social Sciences Teaching Module	Complete	9	Teacher Reflection Notes	Complete
2	Learning Objectives Map (CP-ATP)	Complete	10	Learning Community Records	Complete
3	Diagnostic Assessment	Complete	11	Narrative Student Report	Complete
4	Formative Assessment	Complete	12	Student Portfolios	Complete
5	Summative Assessment	Complete	13	Enrichment Schedule	Complete
6	Project Scoring Rubric	Complete	14	Teacher Training Records	Complete
7	Differentiated Worksheets (LKPD)	Complete	15	Supervision Notes	Complete
8	Digital Learning Media	Complete	16	School Self-Evaluation	Complete

Source: Field document analysis results, April 2026 (16/16 = 100% complete)

Full document completeness reflects a professional documentation culture in which documentation is an integral part of learning rather than an additional burden (Bentri et al., 2022). Teacher reflection notes — frequently absent at other schools — have become a routine at Pajaran 04 State Elementary School, as have well-documented student portfolios. This enables authentic, continuous assessment and generates formative feedback for ongoing practice improvement. The technological, pedagogical, and content knowledge (TPACK) framework positions documentation as an important component linking content, pedagogical, and technological knowledge (Jiménez Sierra et al., 2023). Full document completeness at Pajaran 04 State Elementary School demonstrates that this framework is well actualised at the school level.

3.5. Cross-Finding Synthesis and Theoretical Implications

A synthesis of all findings shows that the success of Pajaran 04 State Elementary School cannot be explained by individual teacher competence alone. The three consistent pedagogical strategies — trigger questions, collaborative role structures, and reflection rituals — are sustained by two ecosystem factors — transformational leadership and an internal learning community — that work synergistically and mutually reinforce one another. This pattern aligns with an ecological systems perspective, which locates instructional practice as a product of multilevel interactions between the teacher, the school, and broader systems (Spear & Kirkman, 2024). Building a deep learning mindset among primary school teachers requires a consistently supportive ecosystem, not one-time, sporadic training (Hendrianty et al., 2024).

The relationship between findings and the theoretical framework can be articulated across three levels. At the micro level (classroom), the three pedagogical strategies serve as the operational mechanisms producing meaningful learning. At the meso level (school), the two ecosystem factors provide the conditions enabling micro-level strategies to grow and be sustained. At the macro level (policy), the Merdeka Curriculum provides the flexibility that the school ecosystem exploits effectively. These three-level relationships answer the implicit question in Section 3.1 about why observation scores are evenly distributed: even distribution is produced by a consistent meso-level ecosystem, which is in turn enabled by an accommodating macro-level policy.

The theoretical implication of these findings is the need to redefine teacher readiness. Readiness is not merely a static individual attribute — knowledge, skill, or motivation — but a collective capacity that emerges from teachers' interactions within a supportive ecosystem. The practical implication is that professional development interventions must target not only individual teachers but the entire school ecosystem, including the principal and the internal collaborative culture (Zainil et al., 2025).

A note of epistemic caution is required. This is a single-case study of one Grade-A accredited outstanding primary school. The claims that can be drawn are descriptive and analytical, not statistical generalisations. The typology of three strategies and two ecosystem factors constitutes a working model requiring further testing in school contexts that differ in accreditation level, geographic location, and resource capacity. This study does not claim that these five elements represent the only model of success but rather one among several possible models, consistent with analytic generalisation, as distinct from statistical generalisation (Yin, 2018).

4. Conclusion

This single-case study described and analysed natural and social sciences deep learning practice at Pajaran 04 State Elementary School, a Grade-A accredited outstanding public primary school in Saradan Sub-district, Madiun Regency. Three main findings were formulated in response to the two research questions. First, addressing RQ1, instructional practice was marked by three consistent pedagogical strategies: contextual phenomenon-based trigger questions, distributed collaborative role structures, and metacognitive reflection rituals. A mean observation score of 3.50 on a 4.0 scale indicates transformative practice consolidated at the school level, not merely at the individual level. Second, addressing RQ2, this practice was sustained by two synergistic ecosystem factors: transformational principal leadership that provides psychological safety for innovation, and a Friday-afternoon internal learning community that serves as the engine of collaborative professional growth. Third, 100% completeness of instructional planning documents (16/16) reflects a strong professional documentation culture constituting an infrastructure supporting meaningful practice.

The theoretical implication of this study is the redefinition of teacher readiness as a collective capacity emerging from multilevel interactions rather than a static individual attribute. The practical implication is the need for professional development interventions that target the school ecosystem holistically — including the principal and the internal collaborative culture. Future research is recommended through multi-site case studies to test the identified typology in school contexts differing in accreditation level, geographic location, and resource capacity. Larger-scale quantitative studies may also statistically test the propositions of the conceptual model generated here.

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Declarations

- Author contribution** : The first author designed the study, collected and analysed data, and wrote the manuscript. The second and third authors provided methodological guidance and conceptual revision.
- Funding statement** : This study received no external funding.
- Conflict of interest** : The authors declare no conflict of interest.
- Additional information** : The study obtained approval from the Madiun Regency Education Office and written informed consent from all participants.

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