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Transforming Problem-Based Learning through CIPROPAD to Enhance Elementary Students' Reasoning Skills

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Article Info

Abstract

Strengthening critical reasoning skills is essential in elementary education, as students are expected to identify information, analyze cause–effect relationships, and draw logical conclusions. However, classroom implementation of Problem-Based Learning (PBL) has not fully supported the development of these skills. This study represents the preliminary phase of Design Research (DR), aimed at mapping classroom conditions and students' reasoning competence prior to developing a transformation model called CIPROPAD. Data were collected from 78 fourth-grade students in an elementary school in Bandung, West Java, Indonesia, through classroom observations using a Likert-scale instrument, document analysis (lesson plans, worksheets, and assessments), and interviews with the teacher and students. The findings indicate that instruction remains largely teacher-centered, authentic problem use is not systematic, and student collaboration is insufficiently facilitated. Students' reasoning skills are predominantly at the remembering and understanding levels, with notable difficulties in analyzing information and providing logical justification. These findings highlight the urgency of transforming PBL into a more contextual, collaborative, and reasoning-oriented learning design supported by a circuit-based structure using Padlet, aligned with elementary learners' characteristics and 21st-century learning demands.

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INTRODUCTION

Reasoning has increasingly been recognized as a core competency in elementary education, particularly within the broader discourse of twenty-first century learning. Contemporary educational frameworks emphasize not only the acquisition of factual knowledge but also the capacity to analyze information, construct logical arguments, evaluate evidence, and reflect upon the validity of conclusions. In the context of elementary schooling, reasoning development is foundational rather than supplementary. It shapes how students approach unfamiliar problems, regulate their thinking, and engage in collaborative meaning-making. Early

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experiences with reasoning influence students' epistemic beliefs about knowledge, their persistence in problem solving, and their capacity to transfer understanding across contexts. Consequently, reasoning should not be treated as an advanced cognitive outcome reserved for higher grades, but as a developmental process that must be intentionally cultivated from the primary level.

From a cognitive perspective, reasoning involves a sequence of coordinated processes: identifying relevant information, establishing causal or relational links, generating hypotheses, justifying claims with evidence, and revising ideas when confronted with alternative perspectives. These processes are inherently iterative and socially mediated. Research suggests that reasoning flourishes in learning environments where students encounter authentic problems, engage in dialogic interaction, and receive structured opportunities to articulate and refine their thinking (Hačatrjana & Namsone, 2024; Hmelo-Silver, 2004). However, reasoning does not emerge automatically from exposure to problems. It requires deliberate instructional orchestration that aligns epistemic purpose, cognitive regulation, and formative assessment.

Problem Based Learning (PBL) has long been advocated as a pedagogical approach capable of fostering reasoning. By situating learning within authentic and ill-structured problems, PBL positions students as active inquirers who must define the problem, explore possible explanations, and collaboratively generate solutions (Hung et al., 2004; Torp & Sage, 2002). The epistemic strength of PBL lies in its emphasis on purposeful inquiry. Students are encouraged to engage with problems that mirror real-life complexity, thereby grounding reasoning in meaningful contexts. Empirical studies have demonstrated that PBL can enhance conceptual understanding, promote higher-order thinking, and support collaborative learning when properly scaffolded (Hmelo-Silver, 2004; Kim et al., 2019).

Despite its theoretical promise, the implementation of PBL in elementary classrooms often remains partial and procedural. Teachers may adopt the terminology of PBL while maintaining traditional instructional control over problem interpretation and solution pathways. Problems may be contextualized, yet students' reasoning processes remain underdeveloped because opportunities for systematic justification, peer critique, and iterative refinement are limited. In many cases, classroom interactions focus on arriving at correct answers rather than examining the quality of reasoning behind them. Consequently, reasoning becomes incidental rather than structurally embedded within the learning process.

A further limitation concerns cognitive regulation. While PBL provides authentic contexts, it does not inherently guarantee that students engage in structured cycles of reflection and refinement. Students may generate initial ideas but lack explicit mechanisms for revisiting, comparing, and improving them. Without iterative cognitive loops, reasoning may stagnate at superficial levels such as recall or simple explanation. Moreover, reasoning trajectories often remain ephemeral. Once discussion ends, the evolution of ideas is rarely documented or revisited. This invisibility of thinking constrains formative assessment and reduces opportunities for metacognitive awareness.

The increasing integration of educational technology offers potential solutions to this limitation. Digital platforms can function as cognitive artifacts that externalize students' thinking, preserve learning traces, and facilitate asynchronous reflection. Tools that allow multimodal representation and peer feedback can strengthen engagement and provide structured opportunities

for justification and revision (Zafeer et al., 2025). However, digital integration in many elementary settings remains additive rather than systemic. Technology is frequently used for presentation or submission purposes rather than as a mediating structure that regulates reasoning processes. When technology is detached from pedagogical design, its impact on deep learning remains limited.

These conditions reveal a significant design gap in elementary reasoning instruction. Existing approaches tend to emphasize one dimension of learning while underrepresenting others. PBL prioritizes problem authenticity but may understructure cognitive refinement. Circuit Learning emphasizes structured rotation and active engagement but may lack explicit epistemic grounding in authentic problems. Digital collaboration platforms support documentation and interaction but may not be embedded within coherent instructional syntax. The absence of systemic integration among these dimensions results in fragmented reasoning experiences.

To address this gap, a coherent instructional system must simultaneously fulfill three interdependent functions: establishing meaningful epistemic contexts, regulating iterative cognitive processes, and externalizing reasoning for collaborative evaluation and assessment. Without authentic problems, reasoning lacks purpose. Without iterative regulation, reasoning lacks depth and refinement. Without visible documentation, reasoning lacks accessibility for feedback and metacognitive reflection. These dimensions cannot function effectively in isolation; they require structural alignment within a unified learning framework.

The CIPROPAD framework (Circuit Learning–Problem Based Learning–Padlet) is conceptualized as a triadic integration designed to achieve this alignment. Within this system, PBL functions as the epistemic context generator, positioning learning within authentic and meaningful problems that define the purpose of inquiry. Circuit Learning operates as the cognitive regulation mechanism, embedding iterative cycles of idea generation, articulation, peer feedback, and refinement within each problem-solving phase. Padlet serves as a mediating cognitive artifact that externalizes reasoning processes, preserves revision trajectories, and supports formative assessment through visible documentation. The integration is not additive but systemic; each component performs a distinct theoretical role that cannot be substituted without compromising coherence.

From a theoretical standpoint, CIPROPAD aligns constructivist principles of knowledge construction with socially shared regulation and distributed cognition. Reasoning development emerges as a system-level outcome of contextual engagement, iterative cognitive refinement, and representational mediation. In this sense, CIPROPAD moves beyond viewing reasoning as a discrete skill to conceptualizing it as a dynamic process shaped by instructional design architecture.

This study represents the preliminary phase of a Design Research approach aimed at diagnosing existing classroom practices and identifying instructional gaps related to reasoning development in elementary settings. Design Research is particularly appropriate because it seeks not only to evaluate existing practices but to generate design principles grounded in empirical classroom realities. By mapping current patterns of PBL implementation, collaboration dynamics, reasoning performance, and digital utilization, this research establishes an evidence-based foundation for refining and validating the CIPROPAD framework.

The contribution of this study is threefold. First, it articulates an empirically grounded diagnosis of reasoning-related gaps within elementary PBL practice. Second, it advances a

theoretically integrated instructional framework that aligns epistemic authenticity, cognitive regulation, and technological mediation. Third, it positions reasoning development as a visible, assessable, and iterative process rather than as an implicit outcome of problem exposure. Through this integrated design orientation, the study responds to the growing demand for elementary instructional models that support deep, regulated, and transparent reasoning processes aligned with contemporary educational expectations.

METHOD

This study constitutes the preliminary phase of a Design Research (DR) approach aimed at diagnosing instructional practices and identifying design requirements for strengthening elementary students' reasoning ability. Design Research, also known as Educational Design Research, is characterized by its systematic investigation of educational problems in authentic contexts with the goal of generating theoretically grounded and practically relevant design principles (McKenney & Reeves, 2012; Plomp, 2013).

Unlike traditional experimental studies that test the effectiveness of a predetermined intervention, Design Research begins with a thorough exploration of contextual challenges. According to McKenney and Reeves (2012), the preliminary research phase focuses on needs analysis, contextual investigation, and literature grounding before any prototyping occurs. In alignment with this framework, the present study exclusively addresses the diagnostic phase and does not aim to evaluate the effectiveness of the CIPROPAD framework. Instead, it identifies gaps in reasoning-oriented instruction that will inform subsequent design and prototyping phases.

The study was conducted in a fourth-grade setting at a public elementary school in Bandung, West Java, Indonesia. The school was selected purposively based on the following criteria:

1. The implementation of contextual or problem-based instructional approaches.
2. Availability of limited but functional digital infrastructure.
3. Administrative approval for systematic classroom observation and document review.

Participants consisted of 78 fourth-grade students distributed across parallel classes and one classroom teacher responsible for coordinating instruction. Students ranged in age from 9 to 10 years. The larger sample size allowed for more stable descriptive analysis of baseline reasoning tendencies across a broader cohort, while still maintaining contextual depth characteristic of Design Research.

To ensure triangulation and obtain a comprehensive understanding of the instructional context, four complementary data sources were used: structured classroom observation, document analysis of lesson plans and worksheets, an open-ended reasoning pretest, and semi-structured interviews with the teacher and selected students. These data sources were selected to capture instructional practices, baseline reasoning performance, and perceived learning challenges from multiple perspectives. The details of each instrument are described below.\

To identify instructional gaps related to reasoning development, three primary data sources were employed: classroom observation, an open-ended reasoning pretest, and semi-structured interviews. These instruments were selected to capture instructional practices, baseline reasoning performance, and participants' perceptions in a focused and manageable manner.

1. Classroom Observation

   Structured observation was conducted to examine how problem-based instruction was implemented and how students' reasoning was facilitated. The observation focused on three core aspects: student participation, structure of the problem-solving process, and evidence of analytical explanation and justification.

Table 1. Classroom Observation Indicators

Domain	Indicator	Operational Description
Student Participation	Active engagement	Students contribute ideas during discussion and problem solving
Student Participation	Balanced interaction	Participation is not dominated by a few students
Problem-Solving Structure	Problem identification	Students identify known and unknown information in the task
Problem-Solving Structure	Strategy exploration	Students discuss alternative strategies before concluding
Reasoning Evidence	Analytical explanation	Students explain relationships between concepts logically
Reasoning Evidence	Justification	Students provide reasons or evidence to support their answers

2. Reasoning Pretest

   An open-ended pretest was administered to all 78 students to measure baseline reasoning ability. Students were required to identify key information, explain solution strategies, and justify their answers.

Table 2. Reasoning Pretest Indicators

Dimension	Indicator	Assessment Focus
Problem Identification	Identifies relevant information	Accuracy in recognizing key elements of the problem
Analytical Reasoning	Explains solution process logically	Coherence and clarity of explanation
Justification	Provides evidence-based reasoning	Strength and relevance of supporting arguments
Conclusion	Draws logical conclusion	Consistency between reasoning and final answer

3. Semi-Structured Interviews

   Interviews with the teacher and selected students were conducted to clarify observed patterns and identify perceived challenges in reasoning and collaboration.

Table 3. Semi-Structured Interview Focus Areas

Interview Domain	Guiding Focus	Purpose
Reasoning Difficulty	Difficulty explaining answers	Identify barriers in analytical explanation
Collaboration	Experience working in groups	Examine participation and interaction challenges
Instructional Support	Perception of teacher guidance	Understand scaffolding needs
Confidence	Comfort in expressing ideas	Explore affective dimension of reasoning
Digital Use	Experience using technology in learning	Identify digital mediation gaps

Through the integration of classroom observation, reasoning pretest, and semi-structured interviews, this preliminary phase provided a focused yet comprehensive diagnosis of instructional practices and students' baseline reasoning performance. The triangulation of quantitative and qualitative data allowed the identification of consistent patterns related to limited analytical explanation, insufficient justification, and uneven participation during problem-based activities. Rather than aiming to test the effectiveness of an intervention, this methodological approach was designed to clarify contextual needs and derive evidence-based design considerations. The findings from this phase therefore function as the empirical foundation for the subsequent development and refinement of the CIPROPAD instructional framework within the broader Design Research cycle.

RESULTS AND DISCUSSION

Results

The findings of this preliminary phase are presented across three domains: classroom observation, reasoning pretest performance, and interview analysis. The results aim to describe existing instructional conditions and identify reasoning-related gaps that inform subsequent design development.

1. Classroom Observation Results

Classroom observation was conducted to examine how problem-based instruction was enacted and to what extent reasoning behaviors were supported during classroom interaction. The descriptive results are presented in Table 1.
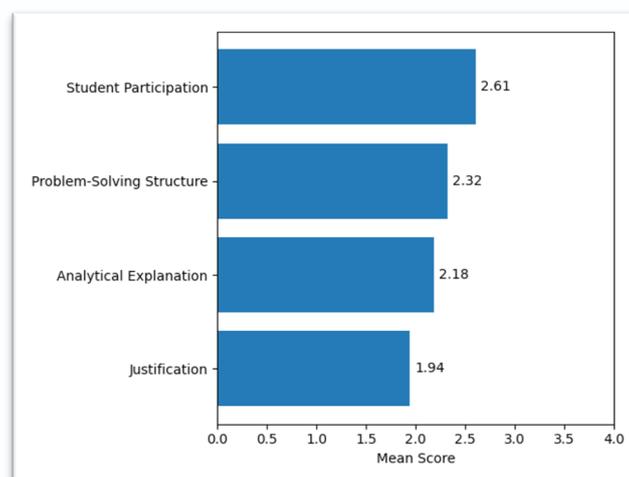

Figure 1. Classroom Observation Summary

The observation findings indicate that although student engagement was visible, reasoning-oriented interaction was not systematically structured. Students participated in tasks, yet analytical explanation and especially justification were not consistently embedded within instructional routines. This suggests that reasoning processes were present in fragmented forms rather than as deliberate learning targets.

2. Reasoning Pretest Results

To examine students' baseline reasoning ability, an open-ended pretest was administered to all 78 students. The summary of students' performance across reasoning dimensions is presented in Table 2.
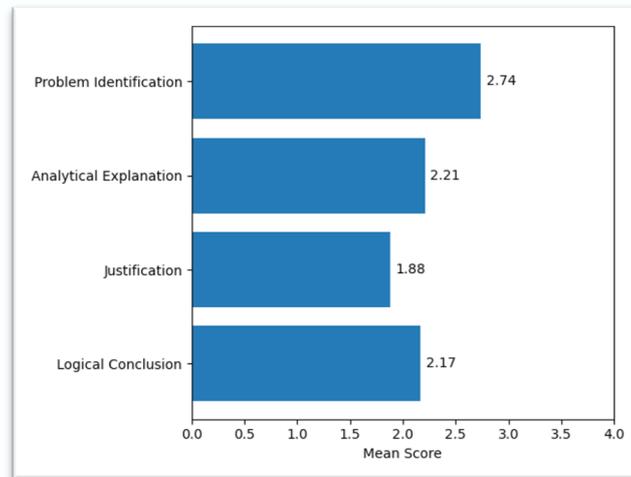

Figure 2. Reasoning Pretest Results

The results reveal a gap between recognizing problem information and constructing coherent reasoning. While students were able to identify relevant elements, their explanations tended to lack depth and structured justification. The relatively weak performance in justification reinforces the observation findings that evidence-based reasoning has not yet become an established classroom norm.

3. Interview Findings

To deepen the understanding of patterns observed in classroom observation and pretest performance, semi-structured interviews were conducted with the classroom teacher and eight students representing varied reasoning levels. The interviews aimed to explore perceived challenges in explanation, collaboration, and instructional support. The thematic analysis yielded several recurring patterns, as summarized in Table 3.

Table 3. Summary of Interview Findings

Theme	Description of Pattern	Representative Excerpt
Difficulty in Articulating Reasoning	Students could produce answers but struggled to explain the logical steps behind them.	"I know the answer, but I don't know how to explain it step by step."
Limited Justification Practice	Classroom activities emphasized correctness rather than evidence-based explanation.	"Usually we just write the answer. The teacher checks if it is correct."
Uneven Participation in Groups	Collaborative tasks were often dominated by confident students.	"I usually follow my friend if they are sure."
Time Constraints in Discussion	Extended reasoning discussions were limited by lesson time.	"Sometimes we need to finish the lesson, so discussion cannot be too long."

Minimal Digital Mediation	Technology was used mainly to submit answers rather than document reasoning.	"We use technology to submit answers, not to show our thinking."

The interview findings indicate that reasoning challenges were not merely individual cognitive limitations but were closely related to instructional structure. Students' difficulty in articulating reasoning suggests limited opportunities to practice structured explanation. The absence of routine justification requirements reflects a classroom culture oriented toward task completion rather than analytical defense of ideas. Additionally, uneven participation during group work indicates that collaborative settings did not automatically ensure distributed cognitive engagement. Finally, the limited use of digital tools for documenting thinking reveals that reasoning processes remained largely invisible and unregulated.

Taken together, these qualitative insights complement the quantitative results and reinforce the conclusion that reasoning development has not yet been systematically embedded within instructional design. This diagnostic understanding provides a clear foundation for developing an integrated framework that explicitly supports explanation, justification, collaborative regulation, and digital mediation of thinking processes.

Discussion

The findings of this study reveal a set of interconnected instructional gaps that collectively impede the development of reasoning skills among fourth-grade elementary students. These gaps—concerning instructional orientation, collaborative structure, justification practice, and digital mediation—are not isolated phenomena; they reflect systemic patterns that have been widely documented in educational research on elementary problem-based learning environments. The following discussion situates these findings within the broader literature, examines their theoretical implications, and articulates the rationale for the CIPROPAD framework as an integrated design response.

Teacher-Centered Instruction as a Barrier to Reasoning Development

The classroom observation data consistently indicated that instruction remained largely teacher-centered, with students occupying a predominantly passive role during problem-solving activities. This finding aligns with a growing body of literature demonstrating that teacher-centered pedagogical approaches significantly constrain students' opportunities for analytical reasoning and critical engagement (Ennis, 2018; Mat & Jamaludin, 2024). Romdhon et al. (2024) similarly found that constructivist approaches only produce meaningful reasoning gains when teachers actively engineer inquiry conditions rather than defaulting to information-delivery routines, a shift that requires not only instructional strategy change but a fundamental reorientation of epistemic authority in the classroom. When instructional control is concentrated in the teacher, students rarely experience the epistemic agency necessary for reasoning development: the opportunity to identify problems independently, propose alternative strategies, and defend their conclusions with evidence.

Studies on PBL implementation in elementary settings have consistently found that the quality of student reasoning is mediated not only by the presence of problem contexts but by the degree to which teachers deliberately relinquish instructional control and scaffold independent inquiry (Wandiraa et al., 2024; Rahmawati & Suryanto, 2020). Ismail et al. (2024) demonstrated

that pairing PBL with higher-order thinking skills (HOTS)-oriented formative assessment produced significantly greater gains in critical thinking than PBL alone, precisely because the assessment component made the quality of reasoning—not merely answer correctness—an explicit and observable learning target. In many classrooms, PBL is implemented procedurally rather than epistemically: problems are presented, but the reasoning process behind their exploration is not systematically cultivated. The current findings reflect this pattern. Students participated in learning tasks but were not systematically guided to examine the logic of their reasoning, compare alternative interpretations, or justify their conclusions. As a result, reasoning remained incidental rather than structurally embedded within the learning design.

Limitations in Justification Practice and Analytical Explanation

The pretest results demonstrated that while students were able to identify relevant problem information at a relatively higher level, their performance in justification and analytical explanation was considerably weaker. This pattern, corroborated by the interview data in which students explicitly reported knowing the answer but being unable to explain their reasoning step by step, reflects a well-documented gap between procedural knowledge and conceptual articulation in elementary mathematics education (Mata-Pereira & da Ponte, 2017; Haçatrạna & Namsone, 2024). Romdhon et al. (2024) noted that this gap is especially persistent in classrooms where students have been socialized to demonstrate knowledge through correct answers rather than through explanatory discourse, making the explicit teaching of justification routines a prerequisite for reasoning development rather than an optional enrichment.

The emphasis on answer correctness over the quality of reasoning processes, as revealed through both observation and interview, mirrors findings by Lelapary (2022), who documented that classrooms prioritizing task completion rather than explanatory depth consistently produce students with superficial reasoning trajectories. Students in the present study described a classroom culture in which writing the correct answer was sufficient, and where the teacher's feedback was oriented toward answer verification rather than reasoning elaboration. This instructional orientation is particularly concerning given research indicating that structured justification practice is essential for progressing from lower-order remembering and understanding toward higher-order analysis and evaluation (Hmelo-Silver, 2004; Kim et al., 2019). Banihashem et al. (2025) characterize this pervasive emphasis on outcome verification as a "conformative" rather than genuinely formative assessment orientation—one that systematically forecloses the deliberate reasoning elaboration students need to progress to higher cognitive levels.

The finding that students' reasoning was predominantly situated at the remembering and understanding levels resonates with research on the developmental trajectory of reasoning in elementary settings. Sarwanto et al. (2021) argued that without explicit instructional mechanisms for generalization, argumentation, and justification, elementary students tend to plateau at lower cognitive levels regardless of their exposure to problem-based contexts. This reinforces the need for a design framework that not only presents authentic problems but also provides structured opportunities for students to articulate, compare, and refine their reasoning across iterative cycles. Huang et al. (2024) confirmed this in an inquiry-based flipped classroom context where technology-enhanced formative assessment prompts caused students to advance more rapidly from recall-level performance toward analytical and evaluative responses—precisely because the prompts made reasoning visible and addressable in real time.

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Uneven Collaborative Participation and the Absence of Distributed Cognitive Engagement

Both the observation and interview data revealed that collaborative group activities were frequently dominated by confident or academically stronger students, with less assertive peers adopting a follower role rather than contributing independently reasoned perspectives. This pattern of uneven participation is consistent with broader research on collaborative learning dynamics, which has found that without structured facilitation mechanisms, group work tends to reproduce rather than disrupt pre-existing participation hierarchies (Chi et al., 2018; Zheng et al., 2024). From the perspective of 21st-century learning competencies, Dafit et al. (2024) identified collaboration and communication as the two dimensions of the 4Cs framework most frequently underdeveloped in elementary instructional settings, largely because teachers tend to equate grouping students with collaboration rather than engineering the epistemic conditions that enable genuine collaborative reasoning.

Collaborative learning, in its theoretically optimal form, generates reasoning gains through the mutual articulation of ideas, the cognitive pressure of reconciling divergent perspectives, and the iterative refinement of shared understanding. However, as the current findings demonstrate, collaborative settings in which participation is unequally distributed fail to produce these benefits for all learners. Research by Mahmud et al. (2024) on collaborative inquiry-based approaches in elementary mathematics classrooms found that structural regulation of student roles was a critical moderator of reasoning quality: when students were assigned complementary roles requiring them to explain, question, and evaluate, reasoning depth improved significantly compared to unstructured group conditions.

This has direct implications for the Circuit Learning component of the CIPROPAD framework. Circuit Learning, as conceptualized in this study, operates not merely as a rotational activity structure but as a mechanism for ensuring distributed cognitive engagement. By embedding structured problem stations within an iterative circuit, each student is required to engage with the problem independently before contributing to a shared elaboration. This design addresses the participation imbalance identified in the current findings by structurally imposing individual accountability within a collaborative context.

Digital Tools as Peripheral Rather Than Mediating Structures

The interview findings consistently indicated that technology in the observed classroom was employed primarily for answer submission and content delivery rather than as a mediating structure that preserves and externalizes students' reasoning processes. Students described using technology to "submit answers" rather than to document or share their thinking. This additive rather than systemic use of digital tools represents a missed opportunity for cognitive externalization, a process that has been identified as central to both metacognitive awareness and formative assessment (Zafeer et al., 2025). Michalsky (2024) demonstrated that metacognitive scaffolding embedded within digital environments—tools that prompt students to reflect on and make their thinking visible—led to significantly higher-order task performance compared to unscaffolded conditions, underscoring that it is not the technology itself but its structural integration with reflective prompts that drives cognitive depth.

Research on digital platforms in collaborative learning environments has demonstrated that tools enabling multimodal documentation of student thinking can significantly enhance engagement, peer feedback quality, and the visibility of reasoning trajectories (Naamati-Schneider

& Alt, 2023; Rath, 2024). Padlet, as an asynchronous digital pinboard, has been shown to support collaborative knowledge construction by allowing students to post, respond to, and revise their contributions in a preserved and visible format. Naamati-Schneider and Alt (2023) demonstrated that Padlet-mediated collaborative learning fostered deeper cognitive engagement and feedback literacy, as students were able to reflect on their peers' contributions before formulating responses. Similarly, Rath (2024) found that Padlet's asynchronous and anonymous features promoted broader participation and more constructive peer feedback in professional education settings.

The absence of such a platform in the observed classroom meant that reasoning processes remained largely invisible and ephemeral. Once classroom discussion ended, the evolution of students' ideas was not preserved, revisited, or used as a basis for formative assessment. This invisibility of thinking, as the interview data confirmed, also reduced metacognitive opportunities for students themselves: with no record of their reasoning trajectory, students had limited capacity to reflect on the quality of their own thinking over time. The CIPROPAD framework addresses this limitation by positioning Padlet as a cognitive artifact that externalizes reasoning, preserves revision history, and creates a visible record accessible for both teacher assessment and student reflection.

Theoretical and Design Implications: Toward CIPROPAD

Taken together, the diagnostic findings of this study point to a design gap that cannot be addressed by isolated instructional modifications. The challenges observed—teacher-centeredness, absent justification norms, uneven collaborative participation, and peripheral digital use—are interdependent. Addressing one without the others risks reproducing the same fragmentation that characterizes the current instructional landscape. This systemic diagnosis aligns with McKenney and Reeves' (2018) argument that educational design research should not produce incremental fixes but rather principled frameworks that address the structural conditions underlying persistent learning challenges. Rezki and Yetri (2025) reinforced this view in the PBL context, showing that interventions attending only to problem authenticity without addressing collaborative regulation or assessment visibility produced inconsistent reasoning gains, precisely because the absence of structural supports allowed passive engagement to persist despite meaningful problem contexts.

The CIPROPAD framework responds to this imperative by conceptualizing an instructional system in which PBL provides the epistemic context, Circuit Learning supplies the iterative cognitive regulation structure, and Padlet serves as the representational and communicative scaffold for visible reasoning. Each component addresses a distinct but interrelated dimension of the gap identified in this study. PBL positions learning within authentic problems that motivate reasoning by providing purposeful context (Hmelo-Silver, 2004; Hung et al., 2004). Circuit Learning introduces iterative engagement cycles that require students to revisit, compare, and refine their thinking across multiple encounters with the same problem (Mahmud et al., 2024). Padlet externalizes and preserves these reasoning cycles, enabling formative assessment, peer feedback, and metacognitive reflection (Naamati-Schneider & Alt, 2023; Beltrán-Martín, 2019).

This triadic design is consistent with constructivist principles of knowledge construction (Hmelo-Silver, 2004) and socially shared regulation of learning, which emphasizes the importance of structured collaborative environments in which learners co-monitor, co-regulate, and collectively refine their understanding. Gonida et al. (2023) argued that when critical thinking,

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communication, collaboration, and creativity are structured as interdependent rather than parallel competencies—each reinforcing the others through deliberate design—students develop more integrated and transferable cognitive capabilities than when these skills are addressed in isolation. From a distributed cognition perspective, Padlet functions as an external memory system that offloads cognitive burden while simultaneously enriching the shared knowledge space available for collaborative elaboration. This integration of tool-mediated cognition with structured collaborative routines reflects an alignment between the theoretical foundations of the CIPROPAD framework and empirically grounded principles of effective elementary learning design.

Methodological Considerations and Limitations

As a preliminary phase of Design Research, this study was explicitly oriented toward diagnosis rather than intervention evaluation. The triangulation of classroom observation, open-ended pretest, and semi-structured interviews provided complementary perspectives on instructional practices and reasoning performance, consistent with the methodological requirements of the preliminary phase as outlined by McKenney and Reeves (2018) and Plomp (2013). Slingerland et al. (2024) demonstrated that teacher-researcher co-design approaches to formative assessment, in which teachers actively map instructional gaps before designing interventions, yield greater pedagogical coherence and classroom ownership than top-down implementation models—an orientation reflected in the present study's participatory diagnostic approach. The use of Likert-scale observation instruments alongside qualitative interview analysis enabled both systematic pattern identification and contextual nuance.

Several limitations, however, warrant acknowledgment. The study was conducted in a single elementary school in Bandung, West Java, limiting the generalizability of findings to other institutional and cultural contexts. The purposive sampling approach, while appropriate for the Design Research methodology, introduces selection bias that should be addressed in subsequent phases through broader sampling strategies. Furthermore, as this phase preceded any prototype development, the findings describe existing conditions rather than causal relationships. Future research phases should employ experimental or quasi-experimental designs to evaluate the effectiveness of the CIPROPAD framework under controlled conditions across diverse elementary settings.

Despite these limitations, the diagnostic richness of this study provides a theoretically grounded and empirically situated foundation for the subsequent design and prototyping phases of the CIPROPAD framework. By systematically mapping the instructional gaps related to reasoning development in an elementary PBL context, this research contributes both to the empirical understanding of reasoning instruction challenges and to the theoretical development of integrated instructional design frameworks for twenty-first-century elementary learning.

CONCLUSION

This preliminary Design Research phase reveals that the development of elementary students' reasoning skills is constrained not by the absence of instructional models, but by their fragmented implementation. Although elements of problem-based learning, collaboration, and digital technology were present, they were not systematically aligned to support analytical explanation and justification. Instruction remained largely teacher-centered, classroom discourse

prioritized answer correctness over reasoning quality, and students demonstrated difficulty articulating and defending their ideas. Consequently, reasoning processes tended to remain superficial and insufficiently regulated.

The findings highlight four interconnected gaps: limited justification practice, uneven collaborative participation, minimal cognitive regulation during problem solving, and peripheral use of digital tools. These conditions prevented reasoning from becoming an explicit and assessable learning objective. Without structured opportunities for students to articulate, compare, and refine their thinking, exposure to authentic problems alone was insufficient to promote higher-order reasoning.

In response, the CIPROPAD framework is positioned as an integrated instructional design that aligns Problem-Based Learning as the epistemic driver, Circuit Learning as the iterative regulatory structure, and Padlet as a digital medium for externalizing and preserving reasoning processes. This study provides a theoretically grounded and empirically supported foundation for subsequent prototyping and validation phases aimed at systematically strengthening reasoning-oriented learning in elementary education.

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