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REENGINEERING PROJECT-BASED LEARNING: EMBEDDING DEEP LEARNING MECHANISMS TO FOSTER COGNITIVE DEPTH

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ABSTRACT
The growing emphasis on educational innovation has led to the widespread adoption of Project Based Learning as a student centered approach aimed at enhancing engagement and real world problem solving. However, its implementation often remains focused on activity and product completion rather than on the development of meaningful cognitive depth. At the same time, deep learning theory highlights the importance of conceptual understanding, critical thinking, and knowledge transfer, yet it lacks clear instructional pathways for systematic classroom application. This study addresses this gap by proposing a reengineering of Project Based Learning through the integration of deep learning mechanisms. Using a conceptual research design, this study synthesizes theoretical perspectives from constructivism, deep learning, and cognitive development to develop a structured instructional framework. The analysis identifies key mechanisms, including cognitive conflict, iterative meaning making, conceptual transfer, and metacognitive regulation, and systematically embeds them within the phases of Project Based Learning. The resulting model transforms Project Based Learning from an activity oriented approach into a cognitively structured system that aligns instructional processes with higher order thinking outcomes. The proposed framework contributes to the field by reconceptualizing Project Based Learning as a mechanism driven learning model, operationalizing deep learning principles into actionable instructional design, and establishing clear indicators of cognitive depth. This study offers both theoretical and practical implications by bridging the gap between pedagogical innovation and cognitive processes, thereby providing a foundation for more meaningful and transformative learning experiences. Future research is recommended to empirically validate the effectiveness of the model across diverse educational contexts.

Kata Kunci: *Project Based Learning, Deep Learning in Education, Cognitive Depth, Higher Order Thinking Skills*

INTRODUCTION
Contemporary education systems are under increasing pressure to move beyond surface level learning and to cultivate higher order cognitive abilities such as critical thinking, conceptual understanding, and knowledge transfer. Although these goals are widely acknowledged in policy and practice, many instructional approaches still emphasize procedural engagement rather than meaningful intellectual transformation. Project Based Learning has emerged as one of the most widely adopted pedagogical innovations intended to address this issue, as it encourages active inquiry, collaboration, and authentic problem solving (Hendrawati et al., 2024; Napitupulu et al., 2024). However, the expanding implementation of Project Based Learning has not consistently resulted in deeper learning outcomes, which raises important questions about whether project based activities genuinely promote cognitive depth or merely increase levels of student participation (Doyan et al., 2024; Safitri, 2024).

A fundamental limitation of conventional Project Based Learning lies in its tendency to prioritize product completion and visible activity over the internal processes of knowledge construction and conceptual restructuring (Alhayat et al., 2023; Safitri, 2024). Students often demonstrate high engagement through the production of artifacts and presentations, yet such

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engagement does not necessarily indicate deep understanding or the ability to transfer knowledge across contexts. This condition reveals a persistent gap between pedagogical intention and cognitive outcome, where innovation in instructional format is not matched by innovation in cognitive design. As a consequence, Project Based Learning can become an approach that is rich in activity but limited in its capacity to foster meaningful learning (Kongkhen & Chatwattana, 2023; Safitri, 2024).

At the same time, the concept of deep learning within educational theory offers a powerful lens for understanding how learners construct meaning, integrate new knowledge with prior understanding, and apply concepts in novel situations. Deep learning emphasizes processes such as critical analysis, metacognitive regulation, and conceptual transfer, all of which are essential for achieving genuine cognitive development (Rosário-Ferreira et al., 2021; Song, 2022). Despite its strong theoretical foundation, deep learning remains insufficiently translated into classroom practice. Much of the existing literature highlights its importance but does not provide clear and structured instructional models that educators can readily implement (Calderaro et al., 2023; Shorten et al., 2021). This creates a second gap, in which cognitive theory remains disconnected from practical pedagogical design.

The coexistence of these two gaps highlights a critical limitation in current educational innovation. On one hand, Project Based Learning provides a flexible and engaging structure but lacks embedded mechanisms that ensure cognitive depth. On the other hand, deep learning offers a clear conceptualization of meaningful learning but lacks operational pathways for systematic implementation in authentic classroom environments. Addressing this limitation requires a shift from activity oriented instructional models toward learning designs that are explicitly grounded in cognitive processes.

In response to this challenge, the present study proposes a reengineering of Project Based Learning through the systematic embedding of deep learning mechanisms within its instructional structure. In this perspective, projects are not treated as final products but as structured processes through which learners engage in knowledge construction, metacognitive reflection, and conceptual transfer. Each phase of Project Based Learning is intentionally redesigned to incorporate mechanisms such as cognitive conflict induction, iterative meaning making, reflective regulation, and evidence based reasoning. Through this approach, project based activities are transformed into a coherent system that actively supports the development of cognitive depth.

This study contributes to the field of educational innovation in three important ways. First, it reconceptualizes Project Based Learning as a cognitively structured model rather than an activity driven approach, thereby addressing concerns regarding its effectiveness in fostering higher order thinking. Second, it translates deep learning theory into clearly defined instructional mechanisms that can be systematically applied in classroom practice. Third, it offers an integrated framework that bridges the gap between pedagogical design and cognitive outcomes, providing educators with a practical and theoretically grounded model for enhancing the quality of learning.

By placing cognitive depth at the center of instructional design, this study advances the discourse on educational innovation beyond surface level changes in method and format. It emphasizes the importance of aligning pedagogical approaches with the fundamental processes through which learners construct understanding. In doing so, it establishes a foundation for a renewed form of Project Based Learning that is not only engaging and authentic but also capable of producing meaningful and transformative learning experiences.

LITERATURE REVIEW

1. Project Based Learning

Project Based Learning has been widely recognized as a student centered instructional approach that situates learning within authentic tasks and real world problem solving. Rooted in constructivist theory, this approach emphasizes active engagement, collaboration, and the production of meaningful artifacts as evidence of learning. Early conceptualizations of Project Based Learning highlighted its potential to bridge the gap between theoretical knowledge and practical application by allowing learners to investigate complex questions over an extended period of time (Pratiwi et al., 2025; Wulandari et al., 2024). Through this process, students are expected to develop not only content knowledge but also a range of transversal skills such as communication, collaboration, and problem solving.

Despite these strengths, a growing body of research has identified critical limitations in the implementation of Project Based Learning (Diana et al., 2021; Fawaas et al., 2024). One recurring issue is the tendency of classroom practice to focus on task completion and product creation rather than on the depth of understanding achieved during the learning process. In many cases, projects become ends in themselves, with success measured by the quality of the final artifact rather than by the sophistication of students' thinking (Berliana et al., 2024; Diana et al., 2021). This condition reflects a misalignment between the intended goals of Project Based Learning and its practical execution, where engagement is prioritized but cognitive development is not systematically ensured.

Furthermore, the instructional design of Project Based Learning often lacks explicit mechanisms to guide students toward higher order thinking. While the approach provides opportunities for inquiry and exploration, it does not inherently guarantee that learners will engage in analysis, evaluation, or knowledge transfer. Without structured scaffolding, students may remain at a surface level of understanding, relying on procedural strategies rather than constructing deep conceptual insights. This limitation suggests that Project Based Learning, in its conventional form, requires further refinement to function as a model that consistently promotes cognitive depth rather than mere activity.

2. Deep Learning in Education

Deep learning in education refers to a mode of learning in which individuals actively construct meaning, connect new information with prior knowledge, and apply understanding in novel contexts. Unlike surface learning, which is characterized by memorization and procedural reproduction, deep learning involves critical engagement with content, reflective thinking, and the integration of ideas into coherent conceptual frameworks. Theoretical perspectives on deep learning emphasize its role in fostering durable understanding and transferable knowledge, both of which are essential for addressing complex and dynamic problems (Shorten et al., 2021; Song, 2022).

A central feature of deep learning is the emphasis on cognitive processes such as analysis, synthesis, and evaluation. Learners are encouraged to question assumptions, explore relationships between concepts, and develop reasoned arguments based on evidence. In addition, metacognitive regulation plays a crucial role, as students must monitor their own understanding, identify gaps in knowledge, and adjust their learning strategies accordingly. These processes enable learners to move beyond passive reception of information toward active and self directed knowledge construction (Calderaro et al., 2023; Shorten et al., 2021).

However, while the conceptual foundations of deep learning are well established, its practical implementation in classroom settings remains limited. Many educational contexts continue to rely on instructional methods that prioritize content coverage and standardized assessment, leaving little room for the iterative and reflective processes required for deep learning. Moreover, existing frameworks often describe the characteristics of deep learning without providing detailed guidance on how these processes can be systematically embedded within specific pedagogical models. This gap highlights the need for instructional designs that translate deep learning principles into concrete and actionable teaching practices.

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3. Cognitive Depth

Cognitive depth refers to the level of intellectual engagement and complexity involved in the learning process. It encompasses the extent to which learners are able to analyze information, synthesize ideas, evaluate arguments, and apply knowledge in new and unfamiliar situations. Cognitive depth is closely associated with higher order thinking skills, which are essential for meaningful learning and long term knowledge retention (Karn, 2022; Tan et al., 2022). Rather than focusing on the quantity of information acquired, cognitive depth emphasizes the quality of understanding and the ability to use knowledge flexibly.

The development of cognitive depth requires learning environments that challenge students to move beyond surface level engagement. This involves the use of tasks that provoke inquiry, encourage critical reflection, and demand the integration of multiple perspectives. Instructional strategies that support cognitive depth often include open ended questions, problem based scenarios, and opportunities for argumentation and justification (Rachman et al., 2022; Youngs et al., 2022). These approaches enable learners to engage with content in a more sophisticated manner, leading to deeper and more durable learning outcomes.

Despite its importance, cognitive depth is not consistently achieved in many educational settings. One reason for this is the lack of alignment between instructional activities and assessment practices. When evaluation focuses primarily on factual recall or procedural accuracy, students are less likely to engage in deeper forms of thinking. Additionally, without explicit guidance and scaffolding, learners may struggle to navigate complex tasks that require higher order cognitive processes. This underscores the need for pedagogical models that not only promote engagement but also systematically support the development of cognitive depth through clearly defined mechanisms and structured learning experiences.

RESEARCH METHOD

1. Research Design

This study adopts a conceptual research design aimed at developing a theoretically grounded and pedagogically applicable model for reengineering Project Based Learning through the integration of deep learning mechanisms. Conceptual research is appropriate for this study because the primary objective is not to test hypotheses through empirical data, but to construct a coherent framework that synthesizes existing theories and addresses identified gaps in current educational practices. The study is positioned within a design oriented paradigm, where theoretical analysis is used to inform the development of an instructional model that can guide future empirical investigation and classroom implementation.

2. Analytical Approach

The study employs a systematic conceptual analysis to examine and integrate three core domains, namely Project Based Learning, deep learning in education, and cognitive depth. The analysis is conducted through an iterative process of comparison, abstraction, and synthesis. First, key characteristics, principles, and limitations of each domain are identified based on relevant scholarly literature. Second, points of convergence and divergence among these domains are critically examined to reveal conceptual gaps and misalignments. Third, these insights are used to construct a unified framework that embeds deep learning mechanisms within the structural phases of Project Based Learning.

This analytical process is guided by a deductive logic, where established theories serve as the foundation for model development. At the same time, an inductive element is incorporated to allow new conceptual relationships to emerge from the synthesis of the reviewed literature. This dual approach ensures that the proposed model is both theoretically grounded and innovative in its design.

3. Framework Development Procedure

The development of the proposed model follows a structured multi stage procedure. In the first stage, the foundational elements of Project Based Learning are mapped to identify its standard instructional phases, including problem orientation, inquiry, creation, presentation, and reflection. In the second stage, core mechanisms of deep learning are identified, such as cognitive conflict, iterative knowledge construction, metacognitive regulation, and conceptual transfer. In the third stage, these mechanisms are systematically embedded into each phase of Project Based Learning to create a redesigned instructional structure.

The fourth stage involves the alignment of the redesigned structure with indicators of cognitive depth, ensuring that each embedded mechanism contributes to higher order thinking processes such as analysis, evaluation, and synthesis. In the final stage, the overall framework is refined to ensure internal coherence, logical consistency, and practical applicability within classroom contexts.

4. Theoretical Validation

To ensure the rigor of the proposed framework, the study employs theoretical validation through triangulation of perspectives. This involves aligning the model with established theories in constructivism, experiential learning, and self regulated learning. Each component of the framework is examined to ensure consistency with these theoretical foundations, thereby strengthening its conceptual validity. In addition, the model is evaluated based on three criteria. The first is coherence, which refers to the logical integration of its components. The second is relevance, which considers its applicability to contemporary educational challenges. The third is potential effectiveness, which reflects its capacity to foster cognitive depth as indicated by higher order thinking processes.

5. Scope and Limitations

As a conceptual study, this research does not include empirical testing or statistical validation. The proposed framework is intended as a theoretical contribution that provides a foundation for future experimental and applied research. While the model is designed to be adaptable across educational contexts, its practical effectiveness will depend on factors such as teacher expertise, classroom conditions, and institutional support. Therefore, further studies are recommended to empirically examine the impact of the proposed model on learning outcomes and to refine its implementation in diverse educational settings.

FINDINGS AND DISCUSSION

1. Reengineering Project Based Learning into a Cognitive Architecture

The analysis reveals that conventional Project Based Learning operates primarily as an activity oriented instructional model in which student engagement is emphasized through project completion, collaboration, and presentation. However, such engagement does not inherently ensure cognitive depth, as the internal processes of knowledge construction, conceptual restructuring, and reflective thinking are often not explicitly structured. This creates a disconnect between what learners do and how they think, resulting in outcomes that may appear productive but remain cognitively superficial.

The reengineered model addresses this limitation by transforming Project Based Learning into a cognitively structured architecture. In this model, each instructional phase is intentionally aligned with specific deep learning mechanisms that guide learners toward higher order thinking. This transformation establishes a direct relationship between pedagogical design and cognitive processes, ensuring that engagement leads to meaningful intellectual development rather than surface level participation.

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2. Identification of Core Deep Learning Mechanisms

The findings identify four core mechanisms that function as the foundation for fostering cognitive depth. These mechanisms are derived from the synthesis of deep learning theory and are positioned as integral components of instructional design. Cognitive conflict functions as the entry point of learning by challenging prior knowledge and stimulating inquiry. Iterative meaning making supports continuous knowledge construction through cycles of exploration and reflection. Conceptual transfer ensures that learners apply understanding beyond immediate tasks, enabling flexibility of knowledge. Metacognitive regulation allows learners to monitor, evaluate, and refine their thinking processes. These mechanisms operate as an interconnected system that sustains cognitive engagement across all phases of learning rather than as isolated instructional elements.

3. Embedding Mechanisms within Instructional Phases

The analysis indicates that conventional Project Based Learning is predominantly implemented as an activity oriented instructional approach in which student engagement is reflected through project completion, collaboration, and presentation. While such practices successfully increase participation and visible learning outputs, they do not automatically lead to cognitive depth. The processes of knowledge construction, conceptual restructuring, and reflective thinking are frequently implicit rather than systematically designed. Consequently, a gap emerges between learners' observable actions and their internal cognitive development, producing learning outcomes that appear productive but remain limited in intellectual depth.

Table 1. Alignment of Project Based Learning Phases with Deep Learning Mechanisms and Cognitive Outcomes

PjBL Phase	Embedded Mechanism	Instructional Focus	Expected Cognitive Outcome
Problem Framing	Cognitive Conflict	Challenging assumptions through complex questions	Activation of prior knowledge and critical questioning
Inquiry and Exploration	Iterative Meaning Making	Cycles of investigation and reflection	Conceptual understanding and knowledge construction
Design and Creation	Conceptual Transfer	Application of knowledge in new contexts	Ability to transfer and adapt knowledge
Presentation and Defense	Evidence Based Reasoning	Argumentation and justification of ideas	Analytical thinking and reasoning skills
Reflection and Regulation	Metacognitive Regulation	Self monitoring and evaluation of learning	Awareness and control of cognitive processes

To address this limitation, the present study reconceptualizes Project Based Learning as a cognitively structured architecture. In this reengineered model, each instructional phase is deliberately aligned with specific deep learning mechanisms that function as drivers of higher order thinking. This alignment ensures that learning activities are not merely procedural but are cognitively purposeful, guiding learners through processes of analysis, integration, and reflection. As a result, the model establishes a clear and systematic relationship between pedagogical design and cognitive processes, transforming Project Based Learning from an activity centered approach into a framework that actively fosters meaningful and sustained intellectual development.

4. Emergence of Cognitive Depth Indicators

The integration of deep learning mechanisms within the reengineered Project Based Learning model leads to the emergence of clearly identifiable indicators of cognitive depth. Unlike conventional approaches that rely primarily on observable engagement or product quality, the proposed model emphasizes internal cognitive processes that can be systematically observed through learners' reasoning, articulation, and application of knowledge. This shift allows cognitive depth to be understood not as an abstract construct but as a set of measurable intellectual behaviors (Castro-Hostetler et al., 2021).

The analysis reveals that cognitive depth manifests through several interconnected indicators. Learners demonstrate analytical thinking when they are able to deconstruct complex problems, identify relationships among concepts, and evaluate alternative perspectives. Cognitive depth is further reflected in knowledge synthesis, where learners integrate information from multiple sources into coherent and meaningful frameworks. In addition, the ability to construct evidence based arguments indicates a higher level of reasoning, as learners justify their ideas through logical explanation and supporting evidence rather than relying on superficial responses.

Another critical indicator is conceptual transfer, which refers to the ability to apply learned knowledge in new and unfamiliar contexts. This reflects a shift from rote understanding to flexible and adaptive thinking. Alongside this, metacognitive awareness emerges as a defining characteristic of cognitive depth, as learners actively monitor their own understanding, recognize limitations, and adjust their learning strategies accordingly. This self regulatory capacity ensures that learning is not only deep but also sustainable over time (Efklides & Tsiora, 2002).

Taken together, these indicators demonstrate that cognitive depth is a multidimensional construct that encompasses analysis, synthesis, reasoning, transfer, and reflection. By embedding deep learning mechanisms within each instructional phase, the reengineered model provides a structured pathway through which these indicators can consistently develop. As a result, cognitive depth becomes an intentional outcome of instructional design rather than an incidental byproduct of learning activities.

5. Development of the Reengineered PjBL Framework

The culmination of this study is the development of a reengineered Project Based Learning framework that systematically integrates deep learning mechanisms into its instructional structure. This framework is not presented as a linear sequence of activities, but as a coherent cognitive system in which each phase is intentionally designed to stimulate and sustain higher order thinking. The development process is grounded in the alignment between pedagogical stages, embedded mechanisms, and expected cognitive outcomes, ensuring that learning is both structured and intellectually meaningful.

The framework consists of five interconnected phases, namely problem framing, inquiry and exploration, design and creation, presentation and defense, and reflection and regulation. Each phase is redefined to serve a distinct cognitive function. The problem framing phase initiates learning through cognitive conflict, encouraging learners to question assumptions and activate prior knowledge. The inquiry and exploration phase facilitates iterative meaning making, where learners engage in cycles of investigation, interpretation, and refinement of ideas. The design and creation phase emphasizes conceptual transfer by requiring learners to apply knowledge in new and authentic contexts.

The presentation and defense phase introduces evidence based reasoning as learners articulate, justify, and defend their ideas through structured argumentation. Finally, the reflection and regulation phase focuses on metacognitive processes, enabling learners to evaluate their understanding and regulate their learning strategies. These phases are not isolated; rather, they function as a continuous and recursive system in which reflection informs subsequent inquiry and conceptual development. A key feature of the framework is its cyclical nature, which reinforces the iterative process of learning. Learners are encouraged to revisit earlier stages based on feedback and reflection, allowing for continuous refinement of understanding. This dynamic structure ensures that knowledge construction is progressive and adaptive rather than static.

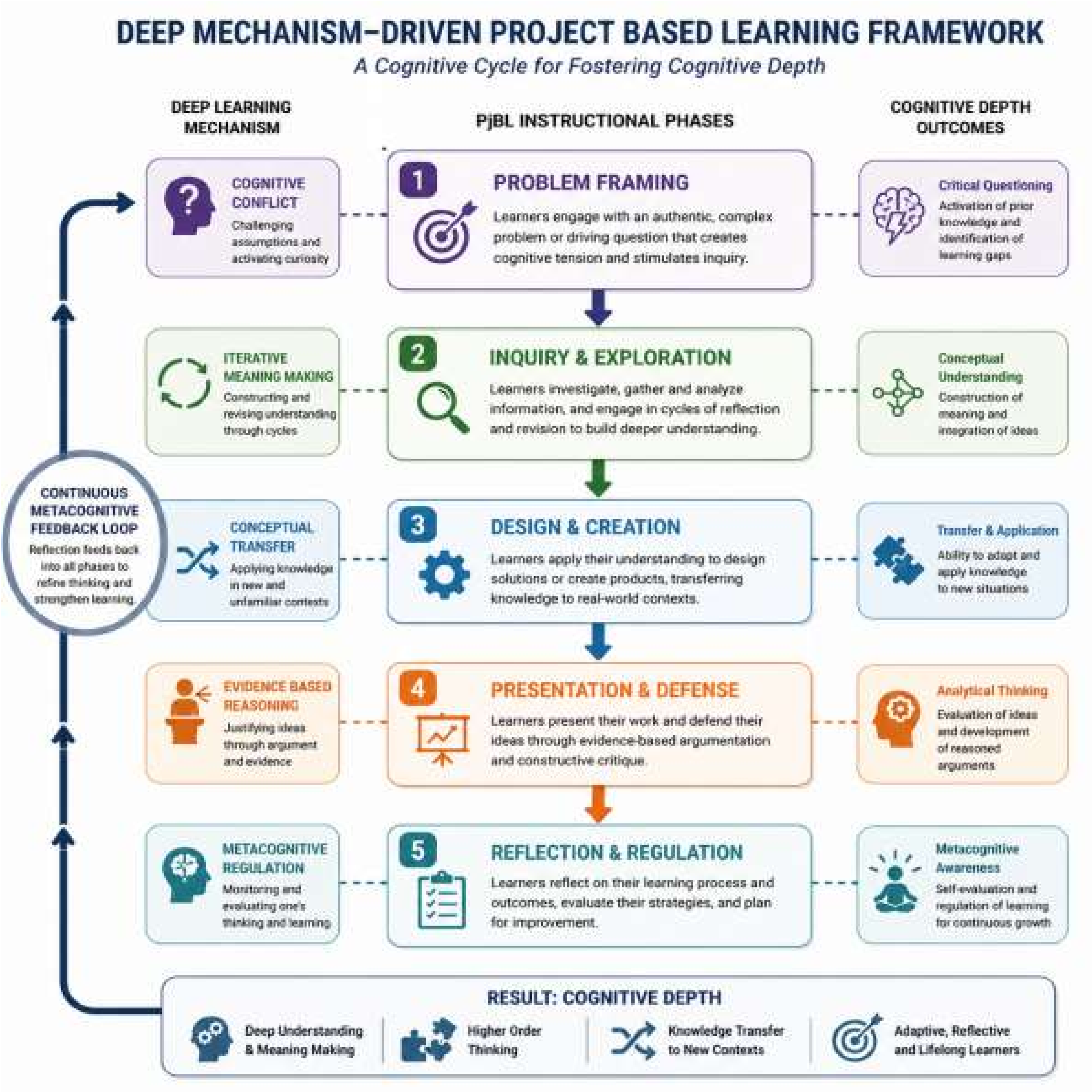

Figure 1. Deep Mechanism Driven Project Based Learning Framework

Overall, the reengineered framework represents a shift from procedural implementation to cognitive orchestration. By embedding deep learning mechanisms within each instructional phase, the model transforms Project Based Learning into a structured environment that consistently promotes cognitive depth. This framework provides a clear and actionable foundation for educators seeking to align instructional practices with the development of meaningful and transferable knowledge.

CONCLUSION

This study addressed a persistent challenge in contemporary education, namely the limited integration of meaningful cognitive development within Project-Based Learning (PBL). While PBL is widely recognized for promoting active learning, its implementation often

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emphasizes student engagement and product completion rather than deep conceptual understanding. To address this gap, the study proposed a reengineered PBL model that systematically embeds deep learning mechanisms throughout each instructional phase, thereby linking pedagogical activities with meaningful cognitive processes.

The proposed model demonstrates that integrating cognitive conflict, iterative meaning-making, conceptual transfer, and metacognitive regulation transforms PBL into a cognitively structured learning system that promotes higher-order thinking and conceptual understanding. This study contributes theoretically by extending constructivist learning through an explicit integration of deep learning principles into instructional design, while also providing a practical framework that educators can adopt to foster analytical reasoning, knowledge transfer, and metacognitive awareness.

Although the proposed model offers significant conceptual and practical contributions, it remains theoretical and requires empirical validation across diverse educational settings and disciplines. Future studies are encouraged to evaluate its effectiveness using experimental or quasi-experimental designs and to explore the integration of digital technologies and learning analytics. Overall, the reengineered PBL model provides a promising framework for shifting educational practice from activity-oriented instruction toward cognitively meaningful and intellectually transformative learning.

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