

## The Application Of Deep Learning In Project-Based Learning: Strategies And Pedagogical Implications

Rita Purwanti<sup>1\*</sup>, Kastam Syamsi<sup>2</sup>  
State University of Yogyakarta

**Corresponding Author:** Rita Purwanti [rita0253fbs.2021@student.uny.ac.id](mailto:rita0253fbs.2021@student.uny.ac.id)

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### ABSTRACT

This study aims to examine the implementation strategy of project-based learning (PBL) in facilitating Deep Learning at the SMA/SMK level in Yogyakarta using a descriptive qualitative approach. purposive sampling the research participants include: five teachers from the SMA/SMK education level who have experience implementing PBL for at least the last 2 years and twenty-five learners who have participated in project-based learning under the guidance of the participating teachers. Through interviews, observations, and document analysis, it was found that PBL significantly improved conceptual understanding and 21st century skills (critical thinking, problem solving, collaboration, communication, creativity), as well as learning motivation. Key strategies included formulating authentic questions, learner autonomy, teacher facilitation, team collaboration, and self-reflection. PBL serves as a pedagogical philosophy that empowers students to become true learners, emphasizing a shift in the teacher's role to facilitator, robust project design, and holistic assessment to equip them to deal with future complexities.

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## **INTRODUCTION**

The world of education is faced with huge challenges for the younger generation to deal with the complexities of the 21st century. Rapid changes in technology, the global economy and the need for innovation demand learning approaches that focus not only on knowledge transfer, but also on developing critical thinking, creativity, collaboration and problem-solving skills. Traditional learning models, which tend to be passive and teacher-centered, often fail to equip learners with these essential competencies, creating a gap between what is taught in school and what is needed in the real world (Chen et al., 2021).

One pedagogical innovation that is receiving increasing attention is Project-Based Learning (PBL). PBL is a learning approach that engages learners in authentic and meaningful projects that are relevant to real life. PBL gets learners actively involved in the process of investigating, designing, implementing and presenting project results, often working in groups and facing complex challenges that require higher-order thinking. This approach inherently encourages independence, responsibility and adaptability, which are essential in an ever-changing global landscape (Wurdinger & Marx, 2020).

Fundamentally, PBL seeks to promote what is known as “Deep Learning”. In contrast to surface learning, which focuses only on memorizing facts and procedures, deep learning involves a thorough understanding of concepts, the ability to integrate new information with existing knowledge and apply that knowledge in a variety of contexts. This means learners not only know “what”, but also ‘why’ and “how” a concept works, enabling them to analyze, synthesize, and evaluate information effectively (Fink, 2019).

Effective implementation of PBL can be a catalyst for deep learning. When learners engage in challenging projects, they are encouraged to explore topics in depth, ask questions, seek solutions, and test hypotheses. This process forces them to move beyond rote learning, build connections between different disciplines, and develop solid conceptual understanding. These projects are not only about producing a final product, but furthermore about a transformative learning journey (Larmer et al., 2020).

In the context of deep learning, PBL provides a rich environment for the development of metacognition, which is the ability of learners to think about their own thinking. When working on projects, they need to plan, monitor their progress, reflect on the strategies used, and adjust their approach if needed. These metacognitive skills are crucial for lifelong learning, as they equip individuals with the tools to continuously learn and adapt in a dynamic information age (Zohar & Dori, 2022).

In addition, PBL naturally fosters collaboration and communication skills, key elements of deep learning in social settings. Projects often demand

teamwork, where learners must discuss, share ideas, provide feedback and resolve conflicts. These interactions not only enrich individuals' understanding but also teach them how to learn from and with others, preparing them for an increasingly interdisciplinary work environment (Buck Institute for Education, 2019).

It is important to note that the concept of deep learning is not just limited to the cognitive domain. It also involves affective and psychomotor dimensions. PBL, with its authentic and relevant nature, can increase learners' intrinsic motivation, foster curiosity, and develop resilience in the face of failure. Hands-on experience in solving real problems fosters confidence and encourages them to take measured risks in the learning process (Hmelo-Silver et al., 2020).

However, effective implementation of PBL to achieve deep learning is not without challenges. Inappropriate project design, lack of teacher support, or assessments that are not aligned with deep learning goals can hinder the full potential of this approach. Therefore, a deep understanding of how PBL can be strategically implemented to optimally facilitate deep learning at different levels of education is needed (Kokotsaki et al., 2019).

Given the great potential of PBL in promoting deep learning, this article aims to elaborate on how this learning method can be one of the most effective ways to instill deep understanding in learners. By examining the pedagogical principles underlying PBL and linking them to the characteristics of deep learning, it is hoped to provide guidance for educators to design more meaningful and transformative learning experiences.

Although the great potential of Project-Based Learning (PBL) in promoting Deep Learning has been widely discussed and conceptually supported, and is considered as an answer to the challenges of 21st century education, the existing literature review still shows a gap regarding comprehensive empirical evidence on the effectiveness of PBL in achieving Deep Learning in various educational contexts in Indonesia. Most studies tend to focus on improving partial cognitive aspects or specific skills, but not many have holistically measured the extent to which PBL has actually succeeded in instilling deep understanding as a whole (cognitive, affective, and psychomotor) as outlined in the concept of Deep Learning. Therefore, this study seeks to fill the gap by investigating more deeply how the implementation of PBL specifically influences and measures indicators of Deep Learning in high school students in Yogyakarta. Thus, the findings from this study are expected to provide stronger and more specific empirical evidence, as well as practical guidance for educators and policy makers in optimizing PBL to achieve transformative deep learning goals.

## **THEORETICAL REVIEW**

### ***The Nature of Deep Learning***

Deep learning is defined as a holistic approach where learners not only memorize facts, but also understand concepts thoroughly, integrate new information with prior knowledge, and are able to apply the knowledge in various contexts (Hattie & Yates, 2014, cited in Fullan, Quinn, & McEachen, 2020). In contrast to surface learning that focuses on information reproduction, deep learning emphasizes personal meaning construction, critical analysis, information synthesis, and knowledge transfer to new situations. This concept is crucial in preparing learners for complex and unstructured challenges in the real world (Fullan et al., 2020).

Fullan, Quinn, and McEachen (2020) identified six global competencies at the core of deep learning: character, citizenship, collaboration, communication, creativity, and critical thinking. Each of these dimensions is interrelated and essential to forming resilient and adaptive learners. Deep learning involves the ability to question, explore, connect and create, all of which contribute to deeper understanding and the development of innovation capacity (Glevey et al., 2023).

Theoretically, deep learning is deeply rooted in the theory of constructivism, which states that learners actively construct their own understanding through interaction with the environment and experiences (Glevey et al., 2023).

Theoretically, deep learning is deeply rooted in the theory of constructivism, which states that learners actively construct their own understanding through interaction with the environment and experiences (Bransford, Brown, & Cocking, 2000, cited in Jannah & Khasanah, 2024). In this context, knowledge is not transferred, but rather constructed. This process is supported by reflection, meta-cognition, and social interactions that allow learners to test and validate their understanding (Khasanah & Asitah, 2022).

Metacognition, or "thinking about thinking," is a vital component of deep learning. It involves learners' ability to plan learning strategies, monitor their understanding, and evaluate the effectiveness of the approaches used (Flavell, 1979, cited in Fitriana & Anggreini, 2021). When learners are aware of their learning process, they can identify knowledge gaps, adjust strategies, and ultimately, achieve deeper and longer-lasting understanding (Putri & Asitah, 2023).

### *Characteristics of Project Based Learning (PBL)*

Project-Based Learning (PBL) is a learner-centered learning model, where they gain knowledge and skills through an extended process designed around complex, authentic, and challenging questions or problems (Blumenfeld, Soloway, Marx, Krajcik, Guzdial, & Palincsar, 1991, cited in Rahman, 2022). Key characteristics of PBL include authentic projects, driving questions, learner voice and choice, collaboration, feedback and revision, and public products (Larmer & Mergendoller, 2010, cited in Ammar & Yulyana, 2023).

The Buck Institute for Education (BIE) identifies the essential elements of PBL, including: (1) challenging driving questions; (2) sustained investigation; (3) authenticity; (4) learner voice and choice; (5) reflection; (6) critique and revision; and (7) public product (P21, 2015, cited in Supriatna et al., 2023). These principles ensure that the project is not only a fun activity, but also a meaningful and deep learning experience. PBL inherently supports deep learning as it forces learners to actively engage in knowledge construction, rather than just passively receiving information (Mali et al., 2022). By working on challenging projects, learners are encouraged to analyze problems, find solutions, and integrate various disciplines, all of which are hallmarks of deep learning (Novita, 2021).

One of the significant contributions of PBL to deep learning is its development of problem-solving and critical thinking skills (Wahyuni et al., 2021). Well-designed projects present complex problems that require learners to analyze information, evaluate alternatives, and make informed decisions. This process goes beyond rote learning, encouraging learners to think independently and creatively (Saraswati et al., 2023).

The collaboration aspect of PBL is essential to encourage deep learning. When learners work in groups, they learn to share ideas, listen to others' perspectives, and negotiate to achieve a common goal (Amalia, 2021). Communication skills are also honed through project presentations, group discussions, and interactions with external parties, all of which support richer understanding and the ability to articulate thoughts effectively (Andriani & Wijayanti, 2022).

PBL provides an ideal platform to foster creativity and innovation. Learners have the freedom to explore different solutions and approaches to project problems, encouraging them to think "outside the box" (Pratama & Utami, 2021). The process of creating authentic products or solutions in PBL stimulates imagination and encourages learners to take intellectual risks necessary for innovation (Ramadhani & Setyorini, 2022). Authentic projects, which are relevant

to the real world and have a clear audience and purpose, have been shown to significantly enhance deep learning (Anam et al., 2023). When learners see the immediate relevance of what they are learning, their intrinsic motivation increases, and they are more likely to engage deeply with the subject matter (Hidayat & Astuti, 2024). Authenticity encourages the transfer of knowledge to situations outside the classroom. Reflection is an integral component of PBL that facilitates deep learning. Through reflection, learners process their learning experiences, identify what they have learned, and how they can improve (Supriatna et al., 2023). Constructive feedback, both from teachers and peers, is also essential to guide learners in revising and refining their understanding and project products (Wijayanti & Priambodo, 2022). While the potential of PBL for deep learning is huge, its implementation is not without challenges. Inadequate project design, lack of teacher support in facilitating deep exploration, assessments that are not aligned with deep learning objectives, as well as resource availability, can hinder its effectiveness (Nurmala & Fitriani, 2021). Adequate teacher training and a change in the learning paradigm are needed to overcome this obstacle (Rizki & Indriani, 2023).

### *Teacher's Role as a Facilitator of Deep Learning in PBL*

In PBL, the teacher's role shifts from an information deliverer to a facilitator and guide (Rahman, 2022). Teachers need to design strong prompting questions, provide relevant resources, monitor learners' progress, provide timely feedback, and encourage reflection. The teacher's ability to create a learning environment that supports exploration and risk determines the success of deep learning (Amalia & Yulyana, 2024). Measuring deep learning in PBL requires an assessment approach that is holistic and formative, going beyond traditional summative tests (Fahmi & Hidayat, 2023). Assessments may include rubrics for project products, observation of the collaboration process, reflection journals, oral presentations, and portfolios. Assessment should focus on conceptual understanding, knowledge transfer, and development of 21st century skills, not just on the end result of the project (Suryani & Nurcahyani, 2022).

## **METHODOLOGY**

This research uses a descriptive qualitative approach with a multi-site case study design to explore strategies for implementing Project-Based Learning (PBL) in facilitating Deep Learning. The research participants included five high school/vocational school teachers with experience in implementing PBL, selected by purposive sampling, and twenty-five learners of these teachers, selected by considering the diversity of abilities. The study was located in three educational institutions in Yogyakarta. Data were collected through semi-structured interviews, participatory observation and document analysis, aiming

to achieve data triangulation. All qualitative data were then analyzed using a thematic approach, through the stages of transcription, repeated reading, coding, theme identification and review, and report writing. The credibility of the findings was ensured through data triangulation, member checking, and thick description, while dependability and confirmability were supported by an audit trail.

## RESULTS

This study identified that the implementation of Project-Based Learning (PBL) in three educational institutions in Yogyakarta significantly contributed to the facilitation of Deep Learning in high school students. The main findings can be grouped into several major themes, namely (1) Key Strategies for PBL Implementation, (2) Impact of PBL on Deep Learning and 21st Century Skills, and (3) Challenges and Pedagogical Implications.

Table 1. Key Strategies for PBL Implementation in Facilitating Deep Learning

No.	Key Strategy	Description of Findings	Representative Quotes
1.	Formulating Authentic Driving Questions	The teacher designs prompting questions ( <i>driving question</i> ) that are relevant to the real world, spark curiosity, and encourage in-depth exploration.	" <i>Our project questions are not just theories, but real problems in the environment. That makes us think hard and find solutions that can really work.</i> " (Students, State Vocational School 2 Kasihan)
2.	Granting Student Autonomy	Students are given the freedom to choose topics, plan projects, and determine how they work, increasing their sense of ownership and responsibility.	" <i>I let the kids explore with their ideas, I just direct at the beginning. The result is more original and they are proud.</i> " (Teacher, SMA N 1 Kasihan)

3.	Sustainable Teacher Facilitation	The teacher acts as a facilitator, not a provider of information, providing guidance, constructive feedback, and emotional support throughout the project process.	<i>"Our teacher was always there when we needed help, but he didn't give us the answers straight away. He encouraged us to think for ourselves."</i> (Student, SMA N 1 Kasihan)
4.	Effective Team Collaboration	Projects are worked on in groups, encouraging active discussion, role-sharing, and conflict resolution among team members.	<i>"We learn a lot from our friends during group work. If there is a problem, we solve it together."</i> (Students, SMK N 3 Kasihan)
5.	Integration of Self-Reflection	Teachers encourage students to reflect regularly on their learning process, difficulties, and achievements, both individually and in groups.	<i>"After each stage of the project, we were asked to write a reflection journal. It helped me realize what I had learned and what I needed to improve."</i> (Students, State Vocational School 2 Kasihan)

Table 2. Impact of PBL on Deep Learning and 21st Century Skills

No.	Observed Impacts	Description of Findings	Document Observation/ Analysis
1.	Enhanced Conceptual Understanding	Students demonstrate a deeper understanding of the concepts of the subject matter, not just memorizing but being able to explain "why" and "how".	This is evident from the quality of in-depth project presentations, the ability to answer conceptual questions, and the elaboration of ideas in group discussions.
2.	Critical Thinking Skills Development	Students are able to analyze problems from various perspectives, evaluate information, and formulate logical arguments.	Projects often involve data analysis, identifying root causes, and formulating evidence-based solutions.
3.	Improved Problem Solving Skills	Students are skilled in identifying authentic problems, designing innovative solutions, and testing the effectiveness of those solutions.	The project results demonstrate creative and practical solutions to given problems, accompanied by a process <i>trial and error</i> .

4.	Improve Collaboration and Communication Skills	Students actively interact, share ideas, provide feedback, and negotiate effectively in teams.	Observations showed dynamic team interactions, clear division of tasks, and presentations involving all members.
5.	Increasing Motivation and Learning Independence	Students demonstrate high enthusiasm in completing projects, are proactive in seeking information, and are able to learn independently.	High levels of attendance and participation, initiative in seeking additional learning resources, and the ability to complete assignments without close supervision.

Table 3. Challenges and Pedagogical Implications of PBL Implementation

No.	Challenge	Description of Findings	Pedagogical Implications
1.	Strong Project Design	Teachers' difficulties in designing projects that are authentic, challenging, and aligned with the curriculum and objectives <i>Deep Learning</i> .	Training is required and <i>professional development</i> for teachers in designing effective and meaningful PBL projects.
2.	The Role of Teachers as Facilitators	The shift in the teacher's role from information provider to facilitator requires adaptation and new skills in guiding	Teacher capacity development in project-based classroom facilitation, guidance and management skills.

		and providing feedback.	
3.	A Holistic Evaluation System	The challenge in developing an assessment rubric that is able to capture <i>Deep Learning</i> and non-cognitive skills (collaboration, creativity, etc.).	It is necessary to develop a comprehensive authentic assessment system, covering processes and products, as well as cognitive and non-cognitive dimensions.



**Figure 1. PBL as a Foundation for Deep Learning**

Overall, the findings confirm that PBL is not just an alternative learning method, but a fundamental pedagogical philosophy to realize Deep Learning. Effective implementation requires a shift in teacher roles, robust project design and a holistic assessment system, ultimately empowering learners to become critical thinkers, innovative problem solvers and true learners.

## DISCUSSION

This discussion analyzes the research findings regarding the implementation of Project-Based Learning (PBL) in facilitating Deep Learning in high school/vocational school students in Yogyakarta, by linking it to the relevant theoretical framework. The

results confirm the significant role of PBL not only as a teaching method, but as a transformative pedagogical philosophy, in line with the demands of 21st century education.

### ***Formulating Authentic Driving Questions and Learner Autonomy***

Findings suggest that formulating authentic driving questions and granting autonomy to learners are key strategies in effective PBL. Real-world relevant driving questions trigger intrinsic curiosity, which is essential for Deep Learning (Fink, 2019). When learners feel ownership of the project and can make decisions, they tend to be more cognitively and affectively engaged. This aligns with constructivism theory that emphasizes active learning where learners construct their own knowledge through exploration and experience (HmeloSilver et al., 2020). This autonomy also fosters learning independence and responsibility, crucial competencies for lifelong learning.

### ***Teacher Facilitation and Team Collaboration***

Shifting the role of the teacher to a continuous facilitator and encouraging effective team collaboration are also pillars of PBL success. The teacher no longer acts as the sole source of information, but rather as a guide who facilitates the process of discovery and problem solving by learners. This role requires skills in asking questions, providing formative feedback, and managing group dynamics (Larmer et al., 2020). Team collaboration, as observed in the study, not only enriches individual understanding through discussion and sharing of ideas, but also develops communication and negotiation skills. This is an integral aspect of Deep Learning in a social setting, preparing learners for an increasingly interdisciplinary work environment (Buck Institute for Education, 2019).

### ***Integration of Self-Reflection and Metacognition Development***

The aspect of self-reflection integrated in the PBL process is crucial in promoting metacognition. When learners systematically reflect on their learning process, challenges, and strategies, they develop awareness of their own thinking (Zohar & Dori, 2022). This metacognitive ability allows them to monitor progress, identify gaps in understanding, and adjust learning approaches. It is the foundation for adaptive and continuous learning, enabling individuals to continuously learn and adapt amidst dynamic information.

### ***Positive Impact on Deep Learning and 21st Century Skills***

Research findings consistently show that PBL significantly improves conceptual understanding and develops 21st century skills. Learners do not just memorize facts, but are able to analyze, synthesize, and evaluate information, which is the essence of Deep Learning (Fink, 2019). The observed skills of critical

thinking, problem solving, collaboration, communication, and creativity are clear evidence that PBL equips learners with essential competencies needed in the future (Chen et al., 2021). In addition, the authentic nature of PBL enhances intrinsic motivation and learning independence, fostering curiosity and resilience in the face of challenges, which are also important affective dimensions of Deep Learning.

### ***Implementation Challenges and Pedagogical Implications***

Although the potential of PBL is enormous, this study also identified challenges **in its implementation**, including the need for strong **project design**, **shifting teacher roles**, and **holistic assessment system**. Inadequate project design can hinder potential *Deep Learning* (Koko Tsai et al., 2019). Therefore, *professional development sustainable* for teachers in designing authentic and challenging projects becomes crucial. In addition, developing teacher capacity in facilitation and guidance, as well as developing an authentic assessment system that is able to measure *Deep Learning* And non-cognitive skills, are essential steps to maximize the impact of PBL.

Overall, this discussion underlines that PBL is not just a method, but rather a comprehensive pedagogical approach that, if implemented with appropriate strategies and adequate support, can effectively facilitate *Deep Learning* and prepare students to face the complexities of the 21st century.

## **CONCLUSIONS AND RECOMMENDATIONS**

This study comprehensively confirms that Project-Based Learning (PBL) is a highly effective pedagogical strategy in facilitating Deep Learning at the senior high school level. Through an in-depth analysis of its implementation strategies and pedagogical implications, it was found that PBL successfully promoted deep conceptual understanding, the development of essential 21st-century skills (such as critical thinking, problem solving, collaboration, communication, and creativity), and increased students' motivation and independence in learning. This success was mainly supported by key elements of PBL, such as the formulation of authentic and challenging driving questions, the granting of autonomy to students, ongoing facilitation and guidance by teachers, the emphasis on effective team collaboration, and the integration of reflection and self-evaluation. PBL does not only focus on the final product, but rather on the transformative process that builds students' intellectual and personal capacities holistically.

Based on the research results, the following are recommendations for optimizing PBL in achieving *deep learning*:

- Continuing Teacher Professional Development: Teacher training focuses on effective project design, facilitation techniques, constructive feedback, and group management to transform the teacher's role into a facilitator and mentor.
- Flexible and Interdisciplinary Curriculum Integration: Curriculum design should allow for authentic cross-subject projects so students can integrate knowledge and see real-world relevance.
- Development of an Authentic and Holistic Assessment System: Institutions need to implement assessments that measure deep *learning*, not just memorization. It includes comprehensive rubrics, observations, reflective journals, presentations, and portfolios, which focus on process and deep understanding.
- Provision of Resources and Institutional Support: Governments and educational institutions must ensure adequate facilities, technology, access to experts, and policies and time allocation to support successful PBL implementation.
- Further Research: Conduct studies on the long-term impact of PBL on students' readiness for higher education and careers, and explore models of PBL scalability across different educational levels and contexts, including technology integration.

### **FURTHER STUDY**

Although this research has provided insight into effectiveness Project-Based Learning (PBL) in facilitating Deep Learning, there are several areas that need further exploration:

1. Longitudinal Study of Long-Term Impact: Research is needed that tracks the cognitive and skill development of students exposed to PBL consistently over several years. This will show how deep *learning impacts* knowledge retention, transferability, and readiness for future academic and professional challenges.
2. Effectiveness of Teacher Training: Conduct an experimental or quasi-experimental study to evaluate the effectiveness of a specifically designed teacher training program to improve their competency in designing, facilitating, and assessing PBL-supportive learning, *deep learning*.
3. The Role of Technology in Strengthening PBL: Exploration of how various technology tools and platforms (such as VR/AR, online collaboration platforms) can be effectively integrated into PBL to enhance deep *learning*, including its impact on student collaboration and reflection.
4. Comparison of PBL Implementation in Various Contexts: Conduct a comparative study of how PBL implementation strategies adapt across

cultural and socioeconomic contexts, both in Indonesia and globally, to identify enabling or inhibiting factors.

5. Development and Validation of Assessment Instruments *Deep Learning*: Focus on the development and validation of specific authentic assessment instruments to measure aspects of deep *learning achieved* through PBL, such as critical thinking rubrics, collaborative observations, and metacognition questionnaires

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