ANALYSIS OF PROJECT BASED LEARNING WITH THE INTEGRATION OF ARTIFICIAL INTELLIGENCE IN CLASS

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ARTICLE INFO	ABSTRACT

Phenomenon/Issue: The integration of Artificial Intelligence (AI) into education, particularly in Project-Based Learning (PjBL), is emerging as a strategy to enhance student engagement and 21st-century skills. However, its implementation in elementary schools faces challenges, including teacher preparedness, infrastructure limitations, and ethical considerations.

Purpose: This study aims to explore the implementation of AI-supported PjBL in a fifth-grade classroom at UPT SD Negeri 060937 Medan Johor. It seeks to identify the benefits, challenges, and strategies for effective integration of AI in elementary education.

Novelty: The research contributes to the relatively limited body of knowledge on how AI can enhance PjBL at the elementary level in Indonesia, particularly in resource-constrained environments. It provides a localized understanding of integrating advanced technologies into foundational education systems.

Research Methods: A qualitative case study approach was employed, using interviews, classroom observations, and document analysis. Data were analyzed thematically to identify patterns and insights related to AI integration.

Results: The study found that AI integration in PjBL increased student engagement, critical thinking, and collaboration. However, challenges such as technical barriers, teacher adaptation, and ethical concerns were evident.

Research Contributions: This study offers practical recommendations for educators and policymakers on leveraging AI in elementary education. It highlights the importance of teacher training, robust infrastructure, and ethical guidelines to ensure AI enhances, rather than hinders, learning outcomes.

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INTRODUCTION

Primary education serves as a critical foundation in shaping the competencies of future generations. In the context of an increasingly dynamic era, especially with the advent of the Fourth Industrial Revolution and Society 5.0, education must integrate modern technologies to deliver relevant and innovative learning processes. One approach that has gained traction is project-based learning (PjBL), which is recognized for its potential to enhance students' problem-solving skills, critical thinking, and collaboration key competencies for the 21st century(Chiu et al., 2023; Haefner et al., 2021; Nuseir et al., 2020). However, implementing PjBL in classrooms often faces challenges, particularly in leveraging advanced technologies like Artificial Intelligence (AI) to support the learning process.

UPT SD Negeri 060937 in Medan Johor is one of the elementary schools striving to enhance the quality of its education through innovation. Recognizing the growing importance of integrating technology in education, the school has begun exploring the use of AI in project- based learning for fifth-grade students. The application of AI in education holds great potential to create personalized, interactive, and more effective learning experiences(Ahmad et al., 2022; Ameen et al., 2023; Bhuiyan et al., 2024; L. Chen et al., 2025; Sharma et al., 2024). AI can assist students in understanding content through tailored approaches, provide real-time feedback, and support teachers in designing engaging and meaningful projects. Despite its potential, the integration of AI in PjBL at the elementary school level remains relatively new, especially in Indonesia. Several challenges arise, including limited infrastructure, insufficient teacher knowledge of AI, and resistance to change. Furthermore, the cognitive development stage of elementary school students requires a careful approach to ensure technology serves as a facilitator rather than a barrier to learning. In this context, it is crucial to analyze how PjBL with AI integration can be effectively implemented in Grade V at UPT SD Negeri 060937 Medan Johor.

The implementation of AI-based PjBL is also aligned with the objectives of the Kurikulum Merdeka, which emphasizes strengthening the Profil Pelajar Pancasila. Through AI-supported projects, students can develop creativity, critical thinking, and collaboration in a more engaging and contextual manner. For example, AI can be utilized to create realistic project simulations, such as environmental projects that use technology to analyze weather or pollution data(Ameen et al., 2021; J. Chen & Florence, 2021; J. S. Chen et al., 2021; Königstorfer & Thalmann, 2020). This not only provides meaningful learning experiences but also equips students with technological skills from an early age. However, the integration of AI in PjBL raises ethical and pedagogical challenges. For instance, how can AI be integrated without replacing the teacher's role as the primary facilitator in learning? How can dependency on technology be minimized to maintain students' creativity? Addressing these questions is essential to ensure that the implementation of AI in PjBL is not merely a trend but genuinely enhances the quality of education.

This research aims to explore the implementation of project-based learning integrated with AI in Grade V at UPT SD Negeri 060937 Medan Johor. Using a qualitative approach, the study will investigate how teachers design and execute AI-supported PjBL, as well as how students respond to this approach. Additionally, the study will identify factors that facilitate or hinder the implementation of AI-based PjBL in elementary schools. The study is particularly relevant in addressing the global need for increased digital and technological literacy. According to a 2023 UNESCO report, integrating technologies like AI in education can improve learning efficiency and effectiveness if applied strategically. In Indonesia, data from the Ministry of Education and Culture indicate that technological literacy among elementary school students needs significant improvement to meet global challenges. Therefore, this research is expected to contribute both practical and theoretical insights to support the transformation of technology- based education at the elementary level(Ali, 2025; Mhlanga, 2020; Rahma, 2023; Yu et al., 2025).

The local context of Medan Johor offers unique challenges and opportunities. The region's socio-economic diversity reflects the broader characteristics of Indonesian society. As such, the findings of this study can benefit not only UPT SD Negeri 060937 but also other schools with similar characteristics.

The implementation of AI in project-based learning could serve as a model for other schools seeking to adopt technology to improve learning quality. Through this research, strategies for the effective implementation of AI-based PjBL are expected to emerge, including pedagogical approaches suited to the characteristics of elementary school students. The study also aims to provide recommendations for education stakeholders, particularly teachers and school administrators, to enhance their capacity to utilize technology to support learning. Additionally, the research will uncover challenges and propose practical solutions applicable to the context of primary education in Indonesia(Di et al., 2020; Di Vaio et al., 2020; Perifanis, 2023).

In conclusion, analyzing the implementation of project-based learning integrated with AI in Grade V at UPT SD Negeri 060937 Medan Johor is a vital step in addressing the opportunities and challenges of education in the digital era. This study will not only provide insights into how technology can support project-based learning but also how this approach can shape young learners to be adaptive, creative, and equipped with competencies relevant to future demands.

LITERATURE REVIEW
Project-Based Learning (PjBL)
Project-Based Learning (PjBL) is an instructional model emphasizing active student engagement through complex and challenging projects designed to foster deep understanding and practical skills (Barak & Yuan, 2021; Ngo & Chase, 2021; Rahayu et al., 2024). According to PjBL is characterized by student decision-making, problem-solving, collaborative design processes, continuous evaluation, reflection, and tolerance for mistakes and adjustments. Studies have shown that implementing PjBL in elementary schools enhances student motivation and critical thinking skills. For instance, Kuswandi et al. (2024) found that PjBL effectively improves subject matter understanding and the overall quality of education at Indonesian elementary schools.

Artificial Intelligence (AI) in Education
Artificial Intelligence (AI) in education includes applications such as personalized learning, intelligent tutoring systems, and automated assessments. According to UNESCO, AI has the potential to revolutionize learning processes by personalizing instruction and improving educational outcomes. In Indonesia, the integration of AI in education is still in its early stages. Emphasized the importance of understanding AI's influence on curricula and teaching methods, as well as adopting strategies to integrate AI into education systems to prepare learners for Indonesia's Golden Era in 2045 (Bhuiyan et al., 2024; L. Chen et al., 2025; Roos, 2018).

Integrating AI into PjBL
Integrating AI into PjBL offers significant benefits, including personalized learning experiences, real-time feedback, and support for teachers in designing meaningful projects. Demonstrated that AI integration in elementary education empowers students to become independent, creative learners capable of adapting to rapid changes. However, implementing AI in PjBL also poses challenges, such as limited infrastructure, teachers' lack of AI knowledge, and resistance to change(Ahmad et al., 2022; Königstorfer & Thalmann, 2020). Highlighted the importance of teacher training on AI technologies and the adoption of ethical guidelines for integrating AI in elementary education UPT SD Negeri 060937 Medan Johor.

UPT SD Negeri 060937 in Medan Johor has begun exploring the use of AI in PjBL for fifth- grade students. This initiative aligns with the objectives of the Kurikulum Merdeka, which emphasizes strengthening the Profil Pelajar Pancasila through innovative and technology- relevant learning approaches. This integration is expected to enhance students' critical thinking, creativity, and collaboration skills. The case study highlights the practical application of AI in creating meaningful project-based learning experiences tailored to the needs of young learners.

Challenges and Opportunities
Despite its potential, integrating AI into PjBL comes with challenges, such as the need for adequate infrastructure, teacher readiness, and policy support. Addressing these challenges requires comprehensive planning, including professional development for educators, investment in technology, and the development of ethical frameworks to guide AI integration in education. Integrating AI into PjBL presents significant opportunities for improving the quality of elementary education. However, its success depends on infrastructure readiness, teacher competency, and supportive educational policies. Further research is needed to evaluate the effectiveness and challenges of AI integration in PjBL, particularly in the context of elementary education in Indonesia. The insights from such research will contribute to shaping future strategies for technology-enhanced education, ensuring students are well-equipped to face the demands of the 21st century.

RESEARCH METHODOLOGY
This study employs a qualitative research methodology to explore the implementation of project-based learning (PJBL) integrated with Artificial Intelligence (AI) in Grade V at UPT SD Negeri 060937 Medan Johor. A case study approach is used to gain an in-depth understanding of the processes, challenges, and outcomes associated with this innovative educational strategy. Data collection methods include interviews, observations, and document analysis. Semi-structured interviews will be conducted with teachers, school administrators, and students to gather insights into their experiences and perceptions of AI-integrated PjBL. Classroom observations will focus on the implementation process, capturing teacher-student interactions, the use of AI tools, and student engagement during project activities. Relevant documents, such as lesson plans, student project outcomes, and school policies, will be analyzed to supplement the primary data. The data will be analyzed using thematic analysis, identifying recurring patterns and themes related to the integration of AI in PjBL. To ensure credibility, data triangulation will be applied by comparing information from different sources and methods. The findings are expected to provide valuable insights into best practices, challenges, and recommendations for effectively integrating AI into PjBL in elementary schools. This methodology aligns with the study's aim to explore and understand the phenomenon comprehensively.

RESULTS AND DISCUSSION
This section presents the results of research related to the integration of Artificial Intelligence (AI) in Project-Based Learning (PjBL) in grade V of UPT SD Negeri 060937 Medan Johor. The findings were analyzed thematically and linked to relevant literature to understand the implications of AI integration in the context of basic education.

1. Implementation of AI in PjBL
The integration of AI in project-based learning shows a significant transformation in the teaching and learning process. Teachers use AI applications to support personalized learning, so that students can receive feedback according to the progress of their respective projects. These findings are in line with the UNESCO report which emphasizes that AI can facilitate personalized instruction to meet the diverse needs of students (UNESCO, 2023). Examples of real-world implementation in schools include: Use of AI for real-time guidance: Students use AI-based tools such as educational chatbots to help generate environmental project ideas or analyze weather and pollution data. Adaptive learning platforms: AI adjusts the difficulty level of tasks based on individual student performance. Efficiency in project design: Teachers find AI helpful in designing and monitoring student projects, allowing them to focus more on facilitating teamwork and critical thinking. which shows that AI helps students become more independent, creative learners who are able to adapt to rapid change (Ali, 2025; Rahma, 2023; Yu et al., 2025)

2. Student Engagement and Learning Outcomes
Classroom observations show that student engagement increases during AI-based projects. They show greater enthusiasm when solving real-world problems with the help of technology.

This is evident in: Increased collaboration among students through AI-guided group assignments. Greater interest in exploring innovative and creative solutions. Learning outcomes also improve, as demonstrated by: Critical thinking skills: Students are aided by AI simulations that present real-world challenges. Data-driven approach: Student projects are more creative and evidence-based, such as utilizing analytical data from AI platforms. That PjBL can improve subject matter comprehension and overall education quality (Di Vaio et al., 2020; Mhlanga, 2020; Perifanis, 2023)

3. Teacher Adaptation and Challenges

Although teachers recognize the benefits of AI in supporting learning, they face several challenges, namely: Lack of technical knowledge: Teachers feel they need more time to understand how AI works and its integration into learning. Need for ongoing training: The lack of professional development programs makes it difficult for teachers to optimally develop their technological competencies. Pedagogical concerns: Teachers feel that over-reliance on technology can reduce hands-on and exploratory learning activities. Whichh emphasize the need for comprehensive teacher training to support the effective use of AI in primary education (Di et al., 2020; Kitsios & Kamariotou, 2021)

4. Infrastructure and Policy Support

Infrastructure limitations are a major obstacle to AI integration. Some of the challenges faced include: Unstable internet access in some classrooms. Limited number of devices, requiring students to take turns using the technology. However, support from schools and local governments plays a major role in overcoming these obstacles. Efforts such as applying for external funding and collaborating with local technology providers are strategic steps to address these shortcomings. These findings are reinforced by the World Bank (2024), which states that investment in digital infrastructure is a key requirement in supporting technology-based education in developing countries (World Bank, 2024).

5. Ethical Considerations

The integration of technology in basic education requires attention to ethical aspects. Some of the issues identified include: Student data privacy is a major concern, given that many AI applications collect personal data. Age-inappropriate content: Teachers emphasize the importance of choosing AI platforms that are appropriate for the cognitive development stage of students. Balance between technology and direct interaction: Teachers suggest that the use of AI should not replace the role of teachers in the teaching and learning process. Emphasizes that teachers still have a central role as facilitators that cannot be replaced by technology (Antonizzi & Smuts, 2020; Brandl & Hornuf, 2020; Romero-Rodríguez et al., 2023)

Discussion

1. The Role of AI in Enhancing Project-Based Learning (PjBL)

The findings from this study reinforce existing literature on the enormous potential of Artificial Intelligence (AI) in transforming the learning process, especially when integrated into project-based learning (PjBL) models. AI enables the personalization of instruction that was previously difficult to achieve through conventional methods. A report from UNESCO (2023) explicitly states that AI has the ability to provide learning that is tailored to the needs and learning styles of each student, as well as providing adaptive support and real-time feedback during the learning process (UNESCO, 2023). In the context of this study, students were proven to be able to complete complex project tasks with the help of AI tools that provided guidance during the process. For example, when working on an environmental project, students used AI applications to analyze air quality data and make predictions about the local impact of climate change. This shows that AI is not only a tool, but also a learning partner that enhances students' understanding of the material and its relevance to the real world.

In addition to helping students, AI has also been proven to provide significant benefits for teachers. The use of AI platforms makes it easier for teachers to design, monitor, and evaluate student projects. Many teachers report that with AI, they can focus more on facilitating discussion and collaboration rather than on

administrative or technical matters. This shows that AI also has the potential to revolutionize the role of teachers into active learning facilitators, rather than mere conveyors of information. However, the effectiveness of AI integration is largely determined by teachers' readiness and adaptability in using this new technology. Professional development is a key factor in ensuring that teachers have the necessary skills to effectively implement AI in the classroom (Ng et al., 2023; Tsopra et al., 2023)

Teachers who have undergone training on AI tend to be more confident in exploring the various functions of this technology, such as using adaptive learning platforms, educational chatbots, and virtual simulation tools. On the other hand, teachers who do not have access to training face difficulties in understanding the technical operations and pedagogical suitability of this technology. Therefore, the integration of AI into PjBL must be accompanied by strategies for developing teacher capacity, including regular training, technical guidance, and the provision of appropriate pedagogical materials.

2. Student Engagement and Development of 21st-Century Skills

One of the most notable impacts of using AI in PjBL is a significant increase in student engagement. In this study, students showed high enthusiasm during the implementation of technology-based projects. They appeared to be more active in discussing, collaborating with groupmates, and finding solutions to the problems given. AI encourages students to be more independent and reflective in their learning process, where they can learn from mistakes, improve strategies, and develop more innovative solutions. Which shows that the integration of AI in education creates a dynamic learning environment, facilitates collaboration, and increases students' sense of ownership of their learning process (Chatterjee et al., 2023; Cheng & Qu, 2020). In addition, students also develop various essential 21st-century skills, such as:

- Critical thinking: With AI-based simulations, students are trained to evaluate data, question assumptions, and make decisions based on analysis.
- Creativity: Students are asked to generate innovative ideas for their projects, such as creating simple technology prototypes using recycled materials.
- Digital collaboration: AI enables more structured teamwork, especially through platforms that facilitate communication and task sharing among team members.

Activities such as AI-based environmental projects, where students use technology to predict the effects of air pollution or design water conservation solutions, prove that learning becomes more contextual and relevant to real life. This also supports the vision of the Merdeka Curriculum, which emphasizes strengthening the Pancasila Student Profile through contextual, collaborative, and project-based learning rooted in local and global values.

3. Challenges in AI Integration into PjBL

Al though AI offers many benefits, its implementation process is not without various challenges, both technical and pedagogical. Shows that most teachers at the elementary level do not yet have the technical and pedagogical readiness to effectively integrate AI into learning (Park & Kim, 2023; Santiago & Guo, 2018) Some of the main challenges found in this study include:

- Limited teacher training: Many teachers have not received specific training on AI. This causes them to be unsure of how to use the technology in a meaningful way that is appropriate for the developmental level of elementary school students.
- Limited time: Teachers also find it difficult to allocate time to design complex AI-based projects, especially if they have to learn new systems independently.
- Uneven access: Not all students have access to digital devices or stable internet. This gap leads to unequal learning experiences and can widen the digital divide between students from different socioeconomic backgrounds.
- School infrastructure readiness: Some schools still lack adequate facilities, such as computer labs, strong internet networks, or age-appropriate AI-based educational platforms.

- These challenges show that integrating AI into PjBL requires a holistic support ecosystem. This support includes not only technology, but also educational policies, funding, and partnerships with external parties, such as technology providers or universities.

Investment in digital infrastructure and teacher capacity building policies is essential to bridge the existing digital divide. Without strategic intervention, the potential of AI in education will only be enjoyed by a small number of students who have adequate access to technology.

The World Bank (2024) also emphasizes that in the context of developing countries, technologies such as AI will only have a positive impact if their integration is accompanied by structural reforms in education and targeted funding (World Bank, 2024).

4. Ethical and Pedagogical Implications
4.1 Ethical Issues in the Use of AI

The integration of Artificial Intelligence (AI) in basic education raises various ethical implications that are important to consider. One of the main issues is student data privacy. Many AI platforms require the creation of accounts and the collection of sensitive personal data, which, if not managed properly, can jeopardize student safety. UNESCO (2023) emphasizes that data protection is a vital component in the implementation of AI, especially for students at the elementary level (UNESCO, 2023).

4.2 Algorithmic Bias and Access to Technology

In addition, bias in AI algorithms is a separate issue. AI trained from global datasets may not understand the local context of Indonesian students, which can result in discrimination or unfair learning outcomes. Inequality of access to technology is also an ethical issue that must be addressed so as not to widen the educational gap between regions or individuals.

4.3 Technology Dependence and Loss of Human Touch

Over-reliance on AI has the potential to displace direct learning experiences. Students become less involved in physical activities, field exploration, and social interactions that are important for their holistic development. Teachers in this study emphasized the importance of balancing the use of technology and direct learning.

4.4 AI as a Teacher Support Tool

Pedagogically, AI should be a tool to assist teachers, not replace them. This is in line with the idea of Daryanto and Rahardjo (2012), who stated that in PjBL, teachers act as facilitators who guide, not merely convey information (Daryanto & Rahardjo, 2012). Effective AI integration must combine the advantages of technology with human sensitivity in educating students.

5. Implications for Policy and Practice
5.1 The Importance of Strategic Planning

For AI to be effectively integrated into basic education, careful planning and supportive policies are needed. This study provides several key recommendations for policymakers and education practitioners.

5.2 Teacher Professional Development

Teacher training is the cornerstone of successful AI integration. Teachers need to be provided with ongoing training that covers technical understanding, AI-based pedagogical approaches, and ethical use. This is in line with the findings of Suharyo et al. (2024), which emphasize the importance of training as a key factor in teacher readiness (Suharyo et al., 2024).

5.3 Investment in Digital Infrastructure

Schools need supporting infrastructure such as stable internet networks, adequate digital devices, and digital learning spaces. Without this investment, AI integration will only benefit a small portion of students.

5.4 Ethical and Regulatory Guidelines

National ethical guidelines are needed regarding the use of AI, including student data protection, age-appropriate access restrictions, and evaluation of AI-based educational platforms. The World Bank (2024) emphasizes the need for strong regulations to ensure student safety in the digital environment (World Bank, 2024).

5.5 Collaboration with Technology Providers

Schools need to collaborate with technology companies and universities to develop AI platforms that are appropriate for the local curriculum, use the Indonesian language, and take into account the cultural context of students. This collaboration can also open up space for innovation based on local needs.

6. Contributions to Educational Research

6.1 Contextual Contributions to Educational Research

This study makes a tangible contribution to academic research on the integration of AI in primary education in developing countries, particularly Indonesia. Many previous studies have focused on developed countries, so this study fills a gap in the literature with a local approach and a more complex reality.

6.2 Best Practices from the Field

Through a case study approach, this research presents best practices in the application of AI in elementary schools. These findings can serve as practical guidance for teachers, principals, and policymakers in designing contextual implementation strategies.

6.3 Basis for Further Research

This research opens up opportunities for further academic exploration, including: Longitudinal studies of student learning outcomes in AI-based projects Analysis of the effectiveness of AI in shaping student character and creativity Comparative studies between schools that use AI and those that do not Encouraging Technology-Based Educational Innovation By highlighting the realities and challenges encountered in the field, this study provides an important basis for formulating digital education policies that are inclusive, ethical, and oriented towards strengthening 21st-century competencies. Purnama et al. (2024) state that AI, if implemented wisely, can encourage students to become creative and adaptive lifelong learners (Purnama et al., 2024).
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Conclusion

The integration of Artificial Intelligence into Project-Based Learning at UPT SD Negeri 060937 Medan Johor has demonstrated significant potential to enhance student engagement, critical thinking, and collaborative skills. However, its success depends on addressing key challenges, including teacher readiness, infrastructure limitations, and ethical concerns. By adopting a holistic approach that combines professional development, robust infrastructure, and supportive policies, schools can harness AI's potential to transform education effectively. Future research should explore long-term outcomes of AI-integrated learning and investigate scalable solutions for addressing barriers to implementation. Through continued exploration and collaboration, AI has the potential to become a powerful tool in fostering meaningful, equitable, and innovative learning experiences in elementary education.

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