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The Effect of Project-Based Learning (PjBL) Models and Their Variations on Student Learning Outcomes and Motivation

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Abstract
This state-of-the-art review comprehensively analyzes the impact of Project-Based Learning (PjBL) models and their variations on student learning outcomes and motivation, with a specific focus on physics education. By examining 40 research articles published between 2017 and 2023, the study synthesizes findings from diverse educational contexts. The results consistently demonstrate that PjBL and its adaptations—such as multimedia-assisted PjBL (e.g., comics, PowerPoint), STEM-integrated PjBL, and technology-enhanced approaches utilizing Augmented Reality (AR) and gamification (e.g., Quizizz)—significantly enhance student learning outcomes, boost motivation, and foster critical and creative thinking skills. These innovative implementations make abstract concepts more tangible and create more engaging, student-centered learning experiences. However, the review also identifies critical limitations in existing literature, including restricted research scope, small sample sizes, and issues with instrument validity. This synthesis provides a valuable mapping of the current research landscape and underscores the need for future studies to design more adaptive, contextual, and rigorously validated PjBL implementations. The findings serve as a crucial reference for educators, researchers, and policymakers aiming to leverage PjBL for improving 21st-century physics education.

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INTRODUCTION

The 21st-century educational landscape demands a significant shift from traditional, teacher-centred instruction towards student-centred approaches that foster critical thinking, creativity, collaboration, and communication (4Cs) (Saavedra & Opfer, 2012). These competencies are essential for students to navigate and thrive in an era of rapid scientific and technological advancement. However, a persistent reliance on conventional lecture methods that emphasise rote memorisation continues to dominate many classrooms. This pedagogical model often leads to passive learning, student disengagement, and a failure to develop the higher-order thinking skills necessary to address modern challenges (Lestari et al., 2020; Astuti, 2019). This gap between the required skills and prevalent teaching practices underscores the urgent need for innovative instructional models that create more contextually relevant and engaging learning experiences.

Among the various student-centred approaches, Project-Based Learning (PjBL) has emerged as an up-and-coming model. Rooted in constructivist theory, PjBL engages students in investigating and responding to authentic, complex questions and challenges over an extended period (Rohman et al., 2024). This model goes beyond mere knowledge transmission, enabling students to actively construct their understanding by applying concepts to real-world problems. Mustapha et al. (2021) highlight that PJBL effectively provides contextual learning experiences, thereby bridging the gap between theoretical knowledge and practical application. International studies further support the efficacy of PJBL; for instance, a meta-analysis by Chen & Yang (2019) concluded that PJBL significantly enhances student academic achievement, particularly in science education, by fostering deeper cognitive engagement.

While the general benefits of PJBL are well documented, its application in specific disciplinary contexts, such as physics, warrants closer examination. Physics education is often perceived as difficult due to its abstract concepts and heavy reliance on mathematical formalism, which can demotivate students (Amalia et al., 2023; Rohman et al., 2024). The unique challenge in physics is to make these abstract principles tangible and relevant. PJBL, with its emphasis on hands-on, investigative projects, offers a potent solution. For example, Nurul et al. (2021) demonstrated that a PJBL-based virtual laboratory (i-Lab) was more effective than traditional labs in improving Indonesian students' understanding of physics concepts. This suggests that PJBL is particularly suited to the inquiry-based nature of science and physics learning.

In response to evolving educational needs, PJBL has been implemented in various innovative forms, integrating technology and interdisciplinary approaches (Rohman et al., 2019). Variations such as multimedia-assisted PJBL (e.g., comics, PowerPoint), STEM-integrated PJBL, and technology-enhanced PJBL using tools like Augmented Reality (AR) and gamified platforms (e.g., Quizizz) have been explored to amplify its impact (Anisa & Darmawan, 2022; Hidayani & Nanda, 2021; Mawarni & San, 2020). These integrations aim to boost student motivation, visualise abstract ideas, and develop critical and creative thinking skills. International research corroborates this trend; a study by Krajcik & Shin (2014) emphasised that technology-supported project-based environments are powerful for promoting scientific understanding and investigation skills, aligning with findings from the Indonesian context.

Despite the promising results and growing body of literature, a critical research gap persists. Existing studies, including those in Indonesia, often suffer from methodological limitations such as restricted scope, small sample sizes, and limited instrument validity (Amalia et al., 2023; Rahmawati, 2019). Furthermore, while individual studies report on specific PJBL variations, there is a lack of comprehensive, state-of-the-art reviews that synthesise the collective evidence on how PJBL and its diverse adaptations specifically impact learning outcomes and motivation in the context of physics education. This absence makes it difficult to draw overarching conclusions and identify the most effective strategies for a structured implementation of PJBL in physics classrooms.

Therefore, this study aims to fill this gap by conducting a systematic literature review of the state of the art. The primary objective is to comprehensively analyse and synthesise the findings of research published between 2017 and 2023 on the effect of PJBL models and their variations on student learning outcomes and motivation, with a specific focus on physics education. This review seeks to map the current research landscape, evaluate the effectiveness of different PJBL implementations, and critically discuss the limitations of existing studies to provide a clear direction for future research.

By addressing these points, this review is expected to serve as a valuable reference for teachers, researchers, and policymakers. It will provide a synthesised evidence base for designing more adaptive, contextual, and practical PJBL implementations that can enhance the quality of physics education and equip students with the essential skills for the 21st century.

METHOD

This study employed a literature review approach by analyzing 40 scientific articles related to Classroom Action Research (CAR) and its various models. The articles were obtained from nationally accredited journals indexed in SINTA as well as reputable international journals published between 2017 and 2023. The selection criteria included articles discussing CAR models (such as the spiral model, Elliot, Hopkins, and collaborative approaches) or the implementation of innovative instructional strategies (e.g., Problem-Based Learning, Project-Based Learning, inquiry, and cooperative learning) within the CAR cycle.

The data were analyzed using content analysis to identify the definitions of CAR, models applied, issues addressed, research cycle steps, and key findings reported.

The procedure for article searching and selection followed the flowchart illustrated in Figure 1.

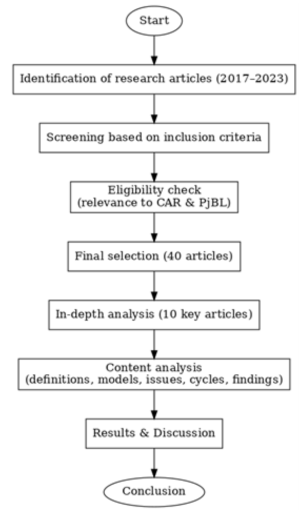

Figure 1. Research method flowchart

RESULTS AND DISCUSSION

From the 40 research articles identified through the selection process, 20 articles were considered relevant and appropriate for the review. However, for deeper analysis, 10 key articles were chosen to represent the diversity of Project Based Learning (PjBL) applications in various educational contexts. The selection was based on methodological variations, research subjects, media used, and the skills targeted for development. Thus, the results and discussion presented here are expected to provide a comprehensive overview of PjBL effectiveness and its development trends over the past five years.

Overall, this review affirms that Classroom Action Research (CAR) has significantly contributed to improving instructional quality and teacher professionalism. Various CAR models—spiral, Elliot, Hopkins, and collaborative—when integrated with innovative

Instructional strategies such as ProblemBased Learning, PjBL, inquiry, and cooperative learning, have been proven effective in enhancing student achievement and teacher competence. Nevertheless, existing limitations must be addressed in future studies to further advance CAR as a reflective strategy for responding to the challenges of 21st-century education.

Table 1. List of Reviewed Research Articles (State of the Art)

No	Author & Year	Method	Subject	Main Findings
1	Santoso & Amalia (2020)	Exp.	HS Students	STAD-PjBL ↑ scores & participatio n
2	Putra & Kurniasi h (2019)	Mix	JHS Students	ComicsPjBL ↑ motivation
3	Yuniarti & Hidayat (2021)	CAR	HS Students	TPS-PjBL ↑ activeness
4	Ramadh ani & Prasetyo (2020)	Exp.	HS Students	Snowball ↑ interaction
5	Anisa & Darma wan (2022)	Exp.	HS Students	AR-PjBL ↑ understand ing
6	Santika & Farhan (2021)	CAR	JHS Students	NHT-PjBL ↑ teamwork
7	Hidayan i & Nanda (2021)	Exp.	HS Students	STEM-PjBL ↑ HOTS
8	Rofiqoh et al. (2020)	Exp.	JHS Students	PPT-PjBL ↑ mastery
9	Nisah et al. (2021)	Quant.	Elem. Students	Sci-PjBL ↑ outcomes
10	Mawarn i & San (2020)	Exp.	HS Students	STEM-PjBL ↑ creativity & HOTS

The quasi-experimental study by Santoso and Amalia (2020) showed that PjBL combined with STAD increased high school students' performance and participation compared to conventional instruction. Each group member played an active role, making individual responsibility a key factor in group success. These findings align with Johnson & Johnson's theory of positive interdependence and reinforce Lestari et al. (2020), who demonstrated that collaboration in PjBL improves learning effectiveness despite requiring longer time allocations.

The mixed-method study conducted by Putra and Kurniasih (2019) developed comic-based PjBL for junior high school physics and proved effective in boosting students' motivation. The use of visual media simplified abstract concepts and enhanced students' reading interest. This finding is consistent with Paivio's dual coding theory and supports Nurul et al. (2021), who argued that innovative PjBLbased media create more meaningful learning experiences.

Through CAR, Yuniarti and Hidayat (2021) confirmed that implementing ThinkPair-Share (TPS) within PjBL significantly improved students' activeness in discussions. The strategy allowed students to think independently, share with peers, and discuss in larger groups, increasing their confidence to express opinions. This aligns with Vygotsky's zone of proximal development and complements Santoso and Amalia's (2020) findings that social interaction enhances learning outcomes.

The quasi-experimental study by Ramadhani and Prasetyo (2020) examined the Snowball Throwing strategy in PjBL and reported that it enhanced classroom participation, created more dynamic interaction, and facilitated even information distribution. These results support constructivist learning theory, which emphasizes active learning through experience, and align with Yuniarti and Hidayat's (2021) findings that cooperative strategies in PjBL reinforce student engagement.

The experimental study of Anisa and Darmawan (2022) integrated Augmented Reality (AR) into biology PjBL, showing that AR facilitated understanding of abstract concepts such as cell structures while increasing motivation. The interactive visualizations supported Mayer's multimedia learning theory and aligned with Putra and Kurniasih's (2019) emphasis on innovative visual media for enhancing learning.

CAR implemented by Santika and Farhan (2021) tested the Numbered Heads Together (NHT) strategy within PjBL, demonstrating its effectiveness in promoting teamwork and equal participation, reducing domination by certain students. This supports Slavin's cooperative learning theory and shows that

NHT-PjBL integration strengthens social and collaborative skills.

The quasi-experimental study by Hidayani and Nanda (2021) found that using Quizizz in PjBL increased high school students' motivation through gamification elements that made learning more enjoyable. Although technical issues such as internet connectivity were noted, the results supported Anisa and Darmawan (2022), reinforcing the role of digital technology in enhancing student engagement and confirming the value of ICT integration in PjBL.

Rofiqoh et al. (2020) demonstrated through an experimental study that PowerPoint multimedia in PjBL improved junior high school students' conceptual understanding and learning outcomes. The significant post-test improvement in experimental groups supported Paivio's dual coding theory that integrated verbal and visual information enhances knowledge retention.

The quantitative study by (Rohman et al., 2024) applied PjBL in elementary science lessons, showing improvements in scores and concept comprehension. This indicated that PjBL is relevant even at early education levels, consistent with Bruner's theory of learning through direct exploration and Mawarni and San's (2020) findings that PjBL develops higher-order thinking skills (HOTS).

Finally, the quasi-experimental research by Mawarni and San (2020) showed that STEM-based PjBL in static fluid topics significantly improved students' creativity and HOTS. These results highlighted the advantages of combining PjBL with STEM to link theory and interdisciplinary practice, though careful project planning is essential for optimal implementation.

CONCLUSION

This review concludes that Classroom Action Research (CAR) and Project-Based Learning (PjBL) are proven to significantly improve the quality of learning in physics education. The integration of CAR cycles with innovative strategies such as cooperative learning, technology-assisted media, and STEM approaches has been shown to enhance students' activeness, motivation, conceptual understanding, and higher-order thinking skills (HOTS).

The findings also highlight that the success of PjBL depends on careful project planning, teacher competence in managing collaborative learning, and the use of appropriate learning media. Although challenges remain—such as time allocation, classroom management, and technological constraints—the overall results confirm the relevance of CAR and PjBL as effective approaches to foster meaningful learning experiences in the 21st century.

Future research is recommended to expand the implementation of CAR and PjBL across different education levels, with broader variations of instructional media and digital platforms. This will not only enrich the theoretical contribution of PjBL but also strengthen its practical application in supporting innovative and sustainable physics education.

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