

The Effect of the STEM PjBL Learning Model on Creative Thinking Skills and Learning Outcomes of the Water Cycle in Grade V Students

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Abstract

The rapid development of science and technology in the 21st century requires education to foster higher-order thinking skills, especially creativity, critical thinking, collaboration, and communication. However, science learning in Indonesia remains largely teacher-centered and less effective in developing students' creativity. This study aims to examine the effect of the STEM-integrated Project Based Learning (PjBL-STEM) model on students' creative thinking skills and learning outcomes in elementary science learning, particularly on the water cycle topic. The study used a qualitative literature review approach by analyzing empirical research articles published within the last ten years. Data were analyzed through content analysis to identify patterns and findings. The results showed that PjBL-STEM positively improves students' creative thinking skills, including fluency, flexibility, originality, and elaboration, as well as cognitive learning outcomes. Its effectiveness is influenced by material characteristics, project design, and teacher readiness. Therefore, PjBL-STEM is an effective approach for improving science learning quality in the 21st century.

Keywords: *Creative thinking skills, Project Based Learning, STEM, PjBL-STEM, learning outcomes*

Abstrak

Perkembangan ilmu pengetahuan dan teknologi pada abad ke-21 menuntut pendidikan untuk mengembangkan keterampilan berpikir tingkat tinggi, terutama kreativitas, berpikir kritis, kolaborasi, dan komunikasi. Namun, pembelajaran sains di Indonesia masih didominasi oleh pembelajaran berpusat pada guru dan kurang efektif dalam mengembangkan kreativitas siswa. Penelitian ini bertujuan mengkaji pengaruh model Project Based Learning terintegrasi STEM (PjBL-STEM) terhadap keterampilan berpikir kreatif dan hasil belajar siswa pada pembelajaran sains sekolah dasar, khususnya materi siklus air. Penelitian menggunakan pendekatan kualitatif dengan metode studi literatur melalui analisis artikel penelitian empiris yang diterbitkan dalam sepuluh tahun terakhir. Data dianalisis menggunakan analisis isi untuk mengidentifikasi pola dan temuan penelitian. Hasil penelitian menunjukkan bahwa PjBL-STEM mampu meningkatkan keterampilan berpikir kreatif siswa, meliputi kelancaran, keluwesan, orisinalitas, dan elaborasi, serta hasil belajar kognitif. Efektivitasnya dipengaruhi oleh karakteristik materi, desain proyek, dan kesiapan guru. Oleh karena itu, PjBL-STEM menjadi pendekatan yang efektif untuk meningkatkan kualitas pembelajaran sains abad ke-21..

Kata Kunci : *Project Based Learning, STEM, PjBL-STEM, keterampilan berpikir kreatif, hasil belajar*



INTRODUCTIONS

The development of science and technology in the 21st century requires the world of education to produce human resources who not only master conceptual knowledge but also possess higher-order thinking skills such as creative, critical, communicative, and collaborative thinking (4C). This global transformation demands learning that is able to integrate science, technology, engineering, and mathematics in an integrated manner through the STEM (Science, Technology, Engineering, and Mathematics) approach. This approach is considered relevant in fostering creative thinking skills and learning outcomes through contextual and meaningful real-world problem-solving activities. (Saragih et al., 2025).

In the context of Indonesian education, science learning is still dominated by a conventional teacher-centered approach (teacher-centered learning). This results in low student engagement and limited opportunities for creativity, which in turn impacts learning outcomes. For example, many students lack enthusiasm during learning due to lack of focus, talking to themselves, or being preoccupied with other activities. Therefore, teachers are expected to utilize the PjBL-STEM model to improve the quality of learning in Indonesia. This model is expected to shift the learning paradigm from teacher-centered to student-centered, thereby making the learning process more meaningful, contextual, and relevant to real life.

This PjBL-STEM model emphasizes project-based learning that links science concepts with the application of technology and engineering in the context of everyday life (Rahman et al., 2025). Through challenging and collaborative project activities, students are expected to construct knowledge, develop creativity, and produce tangible products that reflect their conceptual understanding of natural phenomena, including the water cycle. Several empirical studies have demonstrated the effectiveness of the PjBL-STEM model in improving students' creative thinking skills and learning outcomes. Research conducted by Rahman, Z. A., Muttaqin, A. N. I., & Putri (2025) showed that the implementation of the STEM-PJBL model significantly improved students' creative thinking skills through activities that encouraged idea generation, complex problem solving, and scientifically based decision-making. The results of this study confirm that STEM-integrated project-based learning can create a learning environment that stimulates divergent thinking and originality in students.

These findings align with studies Retno et al (2025) which revealed that PjBL-STEM is effective in improving aspects of originality and flexibility of creative thinking, especially when students are given the opportunity to design and develop innovative projects, such as making a wind-powered vehicle in science lessons in elementary schools. Furthermore, research Rahmadani, A., Muttaqiin, A., & Putri (2025) strengthens empirical evidence regarding the superiority of PjBL-STEM over conventional learning methods. Their research findings indicate that students learning using PjBL-STEM exhibit improved creative thinking skills and higher learning outcomes, demonstrated through deeper conceptual understanding, active engagement in the learning process, and the ability to apply scientific knowledge in various life contexts. These findings indicate that integrating STEM into project-based learning can meaningfully connect theory with practice, thus optimally developing students' creativity.

The implementation of PjBL-STEM also has a positive impact on creative thinking skills. Ajeng, A., Rinto, R., & Fatnah (2025) showed that the implementation of GeoAI-assisted PjBL-STEM resulted in a significant increase in students' creativity scores, with the N-Gain value in the moderate category. This indicates that the use of digital technology in PjBL-STEM can enrich the learning experience and expand students' space for exploring ideas. Furthermore, this research Sari et al (2023) A study integrating PjBL-STEM with the jigsaw strategy in biotechnology also demonstrated improved creative thinking skills, particularly in fluency and originality indicators, as

reflected in higher N-Gain scores in the experimental class compared to the control class.

The development of PjBL-STEM learning tools also contributed to increased student creativity.. Sinaga (2024) reported that the use of PjBL-STEM-based learning tools not only improves creative thinking skills, but also students' scientific literacy, as well as encouraging active participation and responsibility in resource management during the learning process. The results of a meta-analysis conducted by Daulay, H (2024) strengthens the findings of previous research by concluding that the PjBL model significantly influences the improvement of creative thinking skills and students' science learning outcomes. The integration of local cultural contexts in project-based learning is considered capable of increasing the meaningfulness of learning and encouraging students to think creatively in solving problems close to their lives. Wulandari, N. O., Sutrio, S., & Doyan (2024) also confirmed that the PjBL model has a positive impact on creativity and physics learning outcomes, particularly through increased student engagement, collaboration, and responsibility during the learning process.

However, not all studies demonstrate a completely linear relationship between improved creative thinking skills and cognitive learning outcomes. Sinurat, H. A. Y., Syaiful, S., & Muhammad (2022) found that although PjBL-STEM significantly improved students' creative thinking skills, the differences in cognitive learning outcomes between the experimental and control classes were not always significant. This finding indicates that the effectiveness of PjBL-STEM can be influenced by various factors, such as material characteristics, learning duration, teacher readiness, and student conditions.

Research is still needed with more focused empirical evidence in the Indonesian context, particularly on how STEM-based Project-Based Learning (PjBL) simultaneously affects creative thinking skills and student learning outcomes in the water cycle at the elementary school level. Based on interviews with the Teacher Working Group (KKG) in Nganjuk, it can be concluded that the Project-Based Learning model combined with STEM (PjBL-STEM) has been implemented by some teachers in the teaching and learning process. This new PjBL-STEM approach is implemented because teachers have limited time to practice it on each subject.

Teachers often use the lecture method, but this method has not been able to help students fully understand the material. However, in practice, the implementation of this learning has not fully addressed real-world problems in the students' environment. The projects given tend to be general assignments and are not directed at solving contextual problems relevant to students' daily lives. This indicates that the implementation of PjBL-STEM has been implemented, but further development is needed to enable students to learn through direct experience and apply science, technology, engineering, and mathematics concepts more relevant to their environment.

The urgency of this research lies in the theoretical and policy needs to address global demands for mastery of 21st-century competencies, particularly creative, critical, communicative, and collaborative thinking (the 4Cs), as well as strengthening the relevance of the STEM approach in science learning. Practically and locally, this research is crucial to address the real-world challenges faced by Indonesian schools, which are still characterized by passive learning and suboptimal student learning outcomes. Therefore, innovative learning solutions are needed through the implementation of the STEM-integrated Project-Based Learning (PjBL-STEM) model. Furthermore, from a teacher perspective, interviews with the Teacher Working Group (KKG) indicate that although teachers have attempted to implement project-based learning, they still require more systematic implementation guidance, particularly in designing contextual, problem-based projects. Therefore, this research is urgently needed to provide empirical evidence and a practical model that can serve as a reference for teachers and educational units in implementing PjBL-STEM effectively and meaningfully.

Most previous studies have examined the influence of PjBL or STEM separately, or have focused solely on the variables of creative thinking skills or learning outcomes. None have examined the water cycle. The novelty of this research lies in the integration of these two variables into a single empirical study, within the context of the water cycle. Through a STEM-based project approach, students are encouraged to not only understand the scientific processes of the water cycle but also relate them to the application of simple technology and engineering in everyday life.

This research was designed to examine the effect of the STEM-PjBL learning model on the creative thinking skills and learning outcomes of fifth-grade students in the water cycle. Furthermore, by enabling students to solve real-world problems in their environment, it is hoped that this will strengthen the conceptual foundation for the effectiveness of integrated STEM and project-based learning in developing students' higher-order thinking skills. Practically, the results of this discussion are expected to provide recommendations for teachers and educational institutions to systematically implement the STEM-PjBL model in science learning, particularly in materials that require conceptual and applied understanding, such as the water cycle.

Therefore, it can be concluded that this research aims to empirically examine the effect of the STEM-PjBL learning model on the creative thinking skills and learning outcomes of fifth-grade students in the water cycle. This learning model is considered relevant because it integrates project-based learning with the STEM approach, emphasizing solving real-world problems in students' environments, thereby encouraging active engagement and the development of higher-order thinking skills.

METHODS

This research uses a qualitative approach with a literature review method. This method was chosen to systematically, critically, and comprehensively examine previous research findings relevant to the study topic. A literature review allows researchers to identify patterns, research gaps, and trends in previous research results, thereby providing a strong theoretical and empirical foundation.

The research data consists of secondary data obtained from scientific articles, accredited national journals, and reputable international journals. Data sources were collected through scientific databases such as Google Scholar, ERIC, ScienceDirect, and DOAJ. Inclusion criteria for literature selection included: (1) articles resulting from empirical research, (2) relevant to the study topic, (3) published within the last ten years, and (4) available in full text. Saidatul Ahmalia, Rahmatul Khusna, Kalara (2025). The exclusion criteria include articles that have not gone through the peer review process and non-scientific publications.

The data collection technique was conducted through documentation studies, namely tracing, identifying, and collecting literature that meets predetermined criteria. The research instrument was a literature data recording sheet used to record important information, such as research objectives, methods, subjects, instruments, and key findings.

The data analysis technique used content analysis, which was carried out in several stages: (1) organizing the literature, (2) data reduction by selecting relevant information, (3) grouping themes based on similar concepts and findings, and (4) drawing descriptive-analytical conclusions. The analysis process was conducted systematically to ensure accurate interpretation and consistency of findings.

RESULT AND DISCUSSION

Result

Based on the results of the article review that has been carried out, the following can be stated:

Table 1.1 data from the review of 11 influences of the PjBL STEM learning model on creative thinking skills and student learning outcomes

No	Auhtor	Goatl	Method	Sample	Variable	Result
1.	Aisyah Luthfi Wardani, Putu Yasa (2023)	Examining the effect of the PjBL-STEM learning model on creative thinking skills	Quasi-experiment	Grade 11 Mathematics and Natural Sciences students at SMA Negeri 4 Denpasar	Creative Thinking Skills	Controlling for students' initial creative thinking skills, there was an effect of the learning model treatment on differences in students' creative thinking skills.
2.	Husnah (2023)	Analyzing the influence of the STEM-integrated Project-Based Learning (PjBL-STEM) learning model on the topic of environmental ly friendly technology.	Quasi-experiment	Grade 9 students	Students' creative thinking skills.	Proving that PjBL-STEM learning has a significant impact on students' creative thinking skills.
3.	Febriana ,Lalu Rudyat Telly Savalas (2025)	Analyzing the effect of the STEM-based PjBL model on students' creative thinking skills in the topic of acids and bases.	Quasi-experiment	Class XI Science students at SMAN 1 Narmada	Students' creative thinking skills	If the value is greater than ttable, Ho is rejected and Ha is accepted. This means that the STEM-based PjBL model has an effect on improving creative thinking skills.
	Nurwati Djam'an,	Examining the effect of	Pre-experimental	9th-grade students at	Mathematical creative	The STEM approach
4.	Nur Amaliah (2025)	implementing the PjBL model with a STEM approach on	design	SMP Negeri 1 Pinrang.	thinking skills	significantly improves mathematical creative thinking skills.

Discussion

The development of science, technology, and information in the 21st century has brought about major changes in educational paradigms worldwide. Digital transformation, the emergence of Society 5.0, and global demands for adaptive human resources require education systems to develop 21st-century competencies such as critical, creative, collaborative, and communicative thinking (the 4Cs). In the context of basic education in Indonesia, learning is no longer oriented toward memorizing concepts, but rather directed toward scientific thinking, problem-solving, and character building through contextual and integrative learning.

One concrete manifestation of this transformation is the implementation of Natural and Social Sciences (IPAS) subjects in the Independent Curriculum using a deep learning approach. This integration is a strategic step to foster holistic and scientific thinking in students, in line with the needs of 21st-century competencies. According to Salim (2023), Science plays a vital role in developing critical thinking skills, creativity, and collaboration through a thematic and scientific approach that links natural and social phenomena in an integrated manner. However, the results of this study Collins et al (2021) Studies show that the implementation of science and natural sciences (IPAS) still faces obstacles, particularly the low critical thinking and problem-solving skills of elementary school students. 21st-century education demands a transformation in the learning paradigm that fosters higher-order thinking skills (HOTS), such as critical, creative, collaborative, and communicative thinking (the 4Cs). This transformation is crucial because global challenges, technological developments, and the demands of the workplace increasingly emphasize the importance of innovative, complex problem-solving skills. In the Indonesian context, the 2022 Programme for International Student Assessment (PISA) report shows that Indonesian students' science and problem-solving skills remain below the OECD average. This indicates that the conventional, teacher-centered learning system is not fully effective in developing 21st-century skills essential for preparing the younger generation for the 5.0 industrial revolution. One innovative approach deemed capable of addressing this challenge is Project-Based Learning (PjBL), which integrates the concepts of Science, Technology, Engineering, and Mathematics (STEM).

The conceptual definition of creative thinking skills refers to an individual's cognitive ability to generate diverse, flexible, original, and elaborated ideas in response to a problem. These skills emphasize higher-order thinking processes that are not solely oriented toward a single correct answer, but rather the ability to innovatively explore various possible solutions. Within the context of cognitive creativity theory, creative thinking is understood as a mental activity involving fluency in generating ideas, flexibility in viewing problems from multiple perspectives, originality in creating unique ideas, and elaboration in developing ideas in detail and depth.

Creative thinking skills do not emerge spontaneously but develop through learning experiences that require students to actively explore, connect concepts, and solve problems independently. Therefore, creativity is seen as a skill that can be developed through appropriate learning processes, particularly problem-based and project-based learning. In science learning, creative thinking skills are crucial because students are confronted with complex natural phenomena that require conceptual understanding and application of knowledge in real-life contexts.

Education is a fundamental factor in improving the quality of human resources and the progress of a nation. In the current era of globalization and the 5.0 industrial revolution, the education system is required to produce not only academically intelligent students but also adaptive students to technological, social, and economic changes. In

this context, learning outcomes are a key indicator of the success of the educational process. Learning outcomes reflect not only mastery of cognitive knowledge but also affective and psychomotor development formed through learning experiences. Learning outcomes are a concrete representation of the effectiveness of learning strategies, the learning environment, and student motivation in achieving educational goals.

Conceptually, learning outcomes encompass cognitive abilities, but in the context of quantitative educational research, learning outcomes are generally understood as students' cognitive achievements, demonstrated through scores or grades obtained after participating in a specific course. Learning outcomes are a crucial indicator for assessing the effectiveness of a learning model or strategy in helping students achieve expected competencies. Thus, discussions about learning outcomes have not only academic implications but also strategic implications in realizing the goals of equitable and sustainable national education.

CONCLUSION

Based on the literature review and discussion, it can be concluded that the STEM-integrated Project-Based Learning (PjBL-STEM) model has a positive and significant impact on students' creative thinking skills and learning outcomes. The integration of project-based learning with a STEM approach has been proven to create meaningful, contextual, and relevant learning experiences that meet the demands of 21st-century competencies, particularly in developing higher-order thinking skills (HOTS).

The study results show that the implementation of PjBL-STEM consistently improves various indicators of students' creative thinking skills, including fluency, flexibility, originality, and elaboration. This improvement occurs because students are actively involved in the learning process through project design activities, real-world problem solving, collaboration, and the integrated application of science, technology, engineering, and mathematics concepts. This learning environment encourages students to think divergently, generate innovative ideas, and develop solutions relevant to everyday life contexts

In addition to impacting creative thinking skills, the PjBL-STEM model also positively contributes to student learning outcomes, particularly in the cognitive domain. Students learning through PjBL-STEM demonstrated deeper conceptual understanding, higher learning engagement, and the ability to apply knowledge in various situations. However, this study also indicated that improvements in creative thinking skills were not always accompanied by significant linear improvements in cognitive learning outcomes. The effectiveness of PjBL-STEM is influenced by various factors, including material characteristics, learning duration, teacher readiness, project design, and student circumstances and backgrounds.

In the context of elementary education in Indonesia, particularly on the water cycle, previous research is relatively limited. However, the water cycle has significant potential to be developed through STEM-integrated project-based learning because it directly relates to natural phenomena and environmental issues surrounding students. Therefore, this study emphasizes the need for more focused empirical research on the application of PjBL-STEM in elementary school science learning to simultaneously examine creative thinking skills and student learning outcomes.

Overall, it can be concluded that the PjBL-STEM learning model is a relevant and strategic approach to improving the quality of science learning in the 21st century. This model not only has the potential to improve student learning outcomes but also plays a crucial role in fostering creative thinking skills, a key asset for students in facing global challenges. These findings are expected to provide a conceptual and practical basis for teachers, schools, and education policymakers in developing and implementing PjBL-

STEM learning in a more systematic, contextual, and sustainable manner, particularly in materials that require conceptual and applied understanding, such as the water cycle.

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