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The Potential Effectiveness of the Project Based Learning (PjBL) Learning Model in Improving Ecoliteracy Reviewed from Creative Thinking

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Abstract
The urgency of improving ecoliteracy and creative thinking skills is increasingly urgent in the midst of global environmental challenges. Project-Based Learning (PjBL) emerged as a potential approach to develop both skills simultaneously. This study aims to analyze the effectiveness of PBL in improving ecoliteracy from the perspective of creative thinking skills. The Systematic Literature Review (SLR) method with the PRISMA protocol was used to review articles published in Elsevier (ScienceDirect) with a random index from Q1 to Q4 14 articles were analyzedThrough a student-centered and project-based approach, PjBL was able to create a learning environment that encourages innovation, collaboration, and creative problem-solving. PjBL's success in developing 21st century skills is seen consistently across various educational contexts and cultural backgrounds. PjBL's ability to improve students' ecoliteracy also demonstrates its potential as a tool to educate future generations who are environmentally conscious. Through projects relevant to contemporary ecological issues, PjBL not only enhances students' knowledge of the environment, but also encourages them to take concrete action in preserving the environment. The implications of this study emphasize the importance of integrating PBL in the environmental education curriculum to prepare a more environmentally conscious and creative generation in facing future ecological challenges
Keywords: *Project Based Learning, Creative Thinking Skills, Systematic Literature Review*

Abstrak
Urgensi peningkatan keterampilan ekoliterasi dan berpikir kreatif semakin mendesak di tengah tantangan lingkungan global. Project-Based Learning (PjBL) muncul sebagai pendekatan potensial untuk mengembangkan kedua keterampilan tersebut secara bersamaan. Penelitian ini bertujuan untuk menganalisis efektivitas PBL dalam meningkatkan ekoliterasi dari perspektif keterampilan berpikir kreatif. Metode Systematic Literature Review (SLR) dengan protokol PRISMA digunakan untuk meninjau artikel yang diterbitkan di Elsevier (ScienceDirect) dengan indeks acak dari Q1 hingga Q4. Sebanyak 14 artikel dianalisis. Melalui pendekatan yang berpusat pada siswa dan berbasis proyek, PjBL mampu menciptakan lingkungan belajar yang mendorong inovasi, kolaborasi, dan pemecahan masalah yang kreatif. Keberhasilan PjBL dalam mengembangkan keterampilan abad ke-21 terlihat secara konsisten di berbagai konteks pendidikan dan latar belakang budaya Kemampuan PjBL untuk meningkatkan ekoliterasi siswa juga menunjukkan potensinya sebagai alat untuk mendidik generasi masa depan yang sadar lingkungan. Melalui proyek-proyek yang relevan dengan isu-isu ekologi kontemporer, PjBL tidak hanya meningkatkan pengetahuan siswa tentang lingkungan, tetapi juga mendorong mereka untuk mengambil tindakan konkret dalam melestarikan lingkungan. Implikasi dari penelitian ini menekankan pentingnya mengintegrasikan PBL dalam kurikulum pendidikan lingkungan untuk mempersiapkan generasi yang lebih sadar lingkungan dan kreatif dalam menghadapi tantangan ekologi di masa depan.
Kata Kunci: Pembelajaran Berbasis Proyek, Keterampilan Berpikir Kreatif, Tinjauan Literatur Sistematis

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INTRODUCTION

The ability to think creatively is one of the important skills that need to be developed in students to face the challenges of the 21st century. However, the reality is that the creative thinking ability of students in Indonesia is still relatively low. This can be seen from the results of the 2018 PISA study which shows that the science literacy score of Indonesian students is only 396, far below the international average of 489 (OECD, 2019). This low score indicates the weakness of students' high-level thinking skills, including creative thinking. Several studies also confirm the low creative thinking ability of students at various levels of education (Ginting & Suratno, 2023; Wahyu et al., 2020). The causative factors include teacher-centered learning, lack of hands-on activities, and lack of development of students' creative ideas.

Several studies have identified key factors that can enhance students' creative thinking abilities. Research by (Sternberg et al., 2021) found that providing students with opportunities for open-ended problem solving, encouraging risk-taking, and creating a supportive classroom environment are crucial elements for developing creativity. Additionally,(Zhou, 2021) demonstrated that incorporating interdisciplinary learning experiences and hands-on activities significantly improved students' divergent thinking abilities. The use of technology and multimedia resources has also been shown to stimulate creative expression, with studies by Kim and (Park et al., 2020) revealing that digital tools can facilitate innovative thinking when integrated thoughtfully into the curriculum.

Environmental factors within the classroom setting also play a vital role in fostering creativity. Research by (Anderson & Graham, 2021) highlighted that collaborative learning environments, regular feedback, and the freedom to explore multiple solutions contribute to enhanced creative thinking. Their study showed that students who were given autonomy in their learning process and encouraged to connect ideas across different subjects demonstrated higher levels of originality and fluency in creative tasks. Furthermore, teacher modeling of creative behavior and the use of questioning techniques that promote deeper thinking have been identified as essential practices for developing students' creative potential (Wang, 2012)

To overcome these problems, innovative learning models are needed that can facilitate the development of student creativity. One of the potential models is Project Based Learning (PjBL). PjBL is a student-centered learning model by using projects/activities as a learning medium to achieve attitude, knowledge and skill competencies (Musa et al., 2011). Through PjBL, students are actively involved in designing, solving problems, making decisions, and conducting investigative activities. These processes can stimulate the development of creative thinking skills.

Project Based Learning (PjBL) is a student-centered learning approach that engages learners in complex, real-world tasks leading to the development of products or solutions. According to Musa et al. (2011), PjBL facilitates meaningful learning experiences by emphasizing hands-on activities, collaborative problem-solving, and the development of workplace skills. This learning model encourages students to actively participate in designing, investigating, and presenting solutions to authentic problems. Meanwhile, ecoliteracy, as conceptualized by Goleman (2012), encompasses not just environmental knowledge but also the development of emotional, social, and ecological intelligence that enables individuals to understand ecological principles and live sustainably in harmony with nature.

Creative thinking, as explored in various studies, represents a complex cognitive skill essential for innovation and problem-solving. Research by (Barak & Yuan, 2021) characterizes creative thinking as the ability to generate original ideas, make unique connections, and develop innovative solutions to challenges. In the context of environmental education, (N. Putri, 2018) demonstrate how creative thinking skills can be applied to environmental problem-solving, particularly in waste utilization and

ecological conservation efforts. The integration of these three elements - PjBL, ecoliteracy, and creative thinking - creates a powerful framework for developing environmentally conscious and innovative learners capable of addressing contemporary ecological challenges.

Several studies have shown a positive relationship between PjBL and the development of creativity. Study conducted by (Fatmawati et al., 2020) found that the implementation of PjBL can improve students' creative thinking skills in biology learning. Other research by (Sari et al., 2017) showed that PjBL was effective in improving students' creative and critical thinking skills in physics learning. Further (Mihardi, 2013) reported that the PjBL model is superior in improving students' creative thinking skills compared to conventional learning models. The study shows that students who study with PjBL have higher creativity scores in terms of fluency, flexibility, and originality.

Several studies have shown the effectiveness of PjBL in increasing student creativity. (Sari et al., 2017) found that the application of PjBL can improve the collaboration and communication skills of junior high school students. Research (Márquez Ibarra et al., 2020) also revealed that PjBL is able to increase student engagement in learning science, technology, engineering, and mathematics. Furthermore, Han et al. (2015) reported that PjBL has a positive impact on the achievement of students with high, medium, and low abilities in STEM learning.

Although several studies have proven that the effectiveness of PjBL, research that specifically examines the potential of PjBL in improving ecoliteracy in terms of creative thinking skills is still limited. In fact, ecoliteracy or ecological intelligence is an important aspect that needs to be developed in students in the current era of environmental crisis (Goleman, 2012) This is an urgency that needs to be researched faster. Because ecoliteracy includes an understanding of ecological principles and the ability to live in harmony with nature. The development of ecoliteracy requires creativity to find innovative solutions to environmental problems.

Based on this urgency, this study aims to analyze the potential effectiveness of the PjBL learning model in improving ecoliteracy from the perspective of students' creative thinking skills. The results of this study are expected to be significant that new knowledge about the effectiveness of PjBL in developing 21st century skills, especially creativity and ecoliteracy.

This study aims to investigate several key aspects of Project Based Learning implementation in educational settings. Specifically, it examines the impact of PjBL application on students' creative thinking abilities, exploring how this pedagogical approach influences various dimensions of creativity such as originality, fluency, and flexibility in problem-solving. Furthermore, the research investigates the relationship between PjBL implementation and the development of student ecoliteracy, focusing on how project-based approaches enhance environmental awareness, understanding of ecological principles, and sustainable practices. Additionally, this study analyzes the various challenges encountered during PjBL implementation and explores potential solutions for effectively improving students' creative thinking skills. Through these research focuses, the study seeks to provide a comprehensive understanding of PjBL's potential in fostering both creative thinking and ecological literacy while offering practical insights for educators implementing this approach.

METHOD

Research Design

This study adopts the Systematic Literature Review (SLR) approach to investigate the potential effectiveness of the Project Based Learning (PjBL) learning model in improving ecoliteracy, with a special focus on the aspect of creative thinking. The SLR protocol follows the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-

Analyses) guidelines to ensure a systematic and structured review process(Page et al., 2021).

Eligibility Criteria

Articles included in this review must meet the following criteria:

1. Indexed in Scopus (Q1-Q4)
2. Discussing the implementation of PjBL in the context of developing ecoliteracy
3. Present empirical data related to the impact of PjBL on ecoliteration and/or creative thinking
4. Written in English
5. Published between 2010-2024

An article is excluded if:

1. Is a review article or non-primary research
2. In the form of conference proceedings
3. Not fully accessible
4. Outside the scope of environmental education or creativity development

Search Strategy

Keyword search ("project-based learning" OR "experiential learning" OR "hands-on learning") AND (ecoliteracy OR "ecological literacy" OR "environmental literacy" OR "sustainability education") AND ("creative thinking" OR "innovative thinking" OR "imagination" OR "original thinking"), Study Selection The study selection process involves two stages:

1. Initial screening by title and abstract
2. Evaluation of the full text of articles that passed the initial screening

Reference management

This research was conducted using Mendeley software.

Data Extraction and Analysis Data is extracted from selected articles using standardized extraction forms. The information collected includes:

1. Study characteristics (author, year, country)
2. Research design
3. Sample characteristics
4. PjBL interventions implemented
5. Measurement of ecoliteracy and creative thinking
6. Key findings and reported effects

Data analysis

This study uses a thematic narrative synthesis approach. This process involves:

1. In-depth reading of each article
2. Encoding relevant information according to the research question
3. Grouping code into broader themes
4. Preparation of narratives that integrate findings from various studies

This synthesis will answer research questions about the effectiveness of PjBL in improving ecoliteracy, the role of creative thinking, and factors that affect the successful implementation of PjBL in this context.

PRISMA Flow Chart The article selection process is illustrated using a PRISMA flow chart, as shown in Figure 1.

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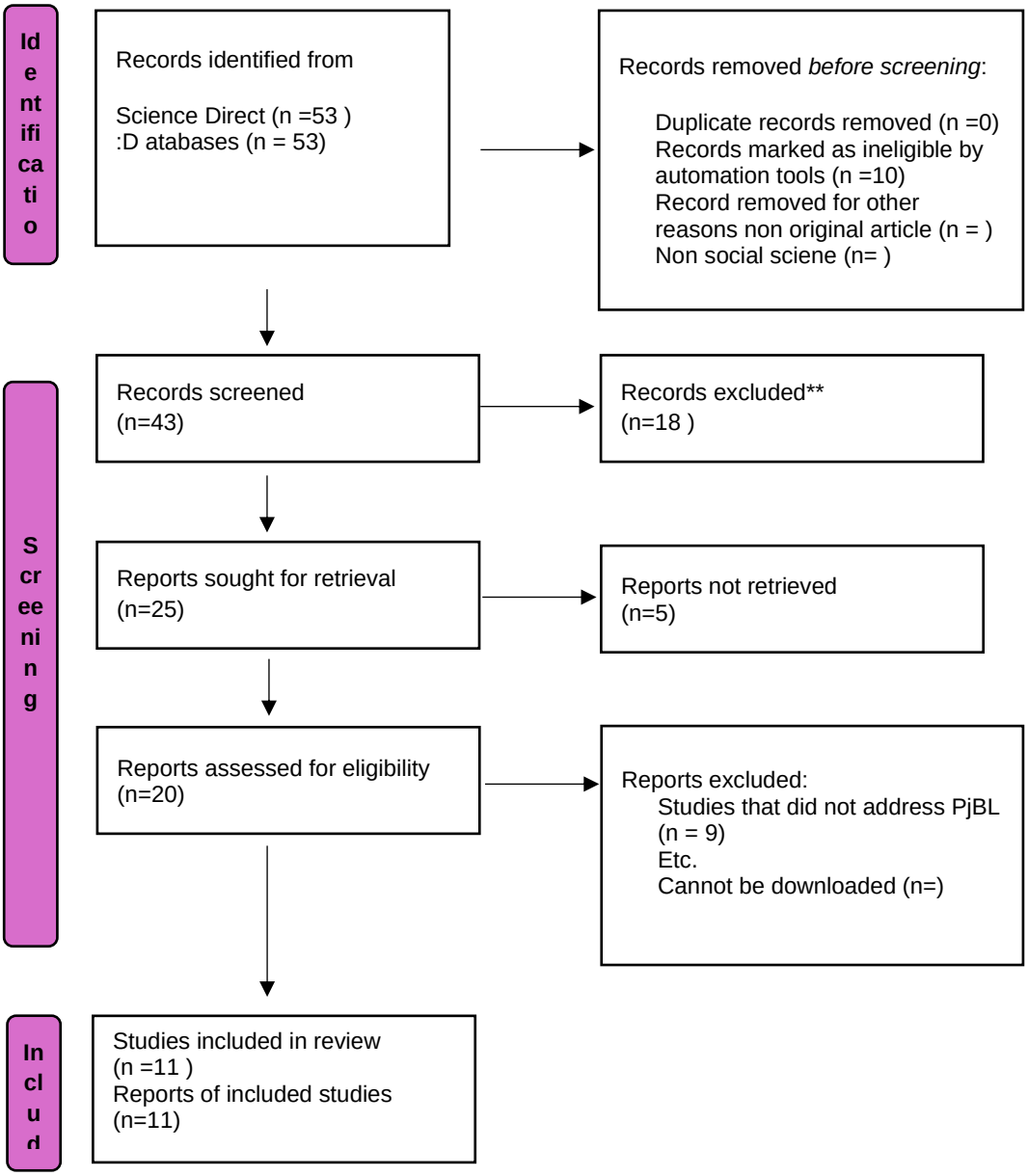

Figure 1. PRISMA PjBL Flow Chart

Criteria for Inclusion Articles

Frequently Used Methods

The research methodology used in these articles is quite diverse. Some studies used qualitative approaches, such as case studies with mixed methods designs involving pre-post questionnaires and focus group interviews ((Márquez Ibarra et al., 2020). Quantitative approaches are also applied, including the design of quasi-experiments with pretest-posttest (Yustina et al., 2020). Some studies adopt classroom action research methods, which involve cycles of planning, action, observation, and reflection (S. S. Putri et al., 2019; Trisianawati, 2018). Data collection is generally carried out through questionnaires, observations, interviews, and documentation**.**

Sample Size and Context

The sample size in these studies varied, ranging from 29 to 224 participants. (Zhou, 2021) involved 224 participants in the study, while Faridah Musa et al. used a sample of 29 students. The context of the research covers various levels of education,

from elementary school to college. Some studies were conducted at leading universities, as reported by (Barak & Yuan, 2021), while others are implemented in educational institutions in various countries, including Malaysia (Musa et al., 2011)Indonesia (S. S. Putri et al., 2019), and China. Research participants generally consist of undergraduate, graduate, or prospective teachers from various social and cultural backgrounds.

Based on the collected articles, it shows a synthesis that the suitability with the SLR goals to evaluate the potential effectiveness of Project Based Learning (PjBL) in improving ecoliteracy and creative thinking. This study explores the impact of PjBL on various aspects of learning, including creativity (S. S. Putri et al., 2019), innovative thinking skills (study at South China Normal University), and ecoliteracy (S. S. Putri et al., 2019). Diverse methodologies and broad contexts provide a comprehensive understanding of the application of PjBL in a variety of educational settings. The findings of these studies generally show positive results regarding the effectiveness of PjBL in enhancing creativity and related skills, which supports the relevance of these articles for further processing in SLRs.

RESULT

The findings of various studies on the implementation of Project-Based Learning (PjBL) reveal its significant impact on creative thinking and ecoliteracy, while also highlighting the challenges and proposed solutions for its effective application. The summary of these results is presented in the table below for clarity and efficiency

Table 1. Summary of findings

Focus Area	Key Findings	Supporting Studies
Influence of PjBL on Creative Thinking	- PjBL enhances innovative thinking, questioning skills, and idea connections. - Promotes effective communication and collaboration. - Improves problem-solving, brainstorming, and 21st-century skills. - Encourages active learning and creativity in project outcomes.	Barak & Yuan (2021), Zhou (2021), Musa et al. (2011), S. S. Putri et al. (2019), Yustina et al. (2020), Rahardjanto et al. (2019), Trisianawati (2018)
Effect of PjBL on Ecoliteracy	- PjBL substantially improves ecoliteracy through collaborative problem-solving. - Encourages critical thinking about ecological issues. - Facilitates engagement with real-world environmental challenges.	S. S. Putri et al. (2019), Rahardjanto et al. (2019)
Challenges in Implementing PjBL	- Limited resources, time constraints, and lack of support. - Difficulties in student collaboration and communication. - Insufficient teacher knowledge and overreliance of students on instructors.	Musa et al. (2012), Yustina et al. (2020), Siew & Ambo (2018), Trisianawati (2018), Berestova et al. (2021)

Focus Area	Key Findings	Supporting Studies
Solutions for PjBL Implementation	- Comprehensive teacher training on PjBL methodologies. - Improved access to technology for project management. - Cooperative learning to foster collaboration. - Interdisciplinary approaches to expand creativity. - Continuous evaluation and feedback.	Musa et al. (2012), Yustina et al. (2020), Siew & Ambo (2018), S. S. Putri et al. (

The influence of PjBL on students' creative thinking ability

Project-Based Learning (PjBL) has become the focus of contemporary educational research as a method that has the potential to improve students' creative thinking skills. Based on this study, it shows that the findings from 11 research articles are relevant to understand the impact of PjBL on student creativity. Among others, namely; Research from (Barak & Yuan, 2021) identify the positive influence of PjBL on students' innovative thinking. Their research showed an improvement in the ability to observe and ask questions of Chinese students, while local students showed an improvement in the skills of connecting ideas. In addition, it is supported by research from (Zhou, 2021)) emphasized that PjBL promotes creative thinking through effective communication between students. His study revealed the significant impact of PjBL on creative thinking, which is different from its effect on critical thinking. Research from (Musa et al., 2011) found that PjBL improves critical thinking and problem-solving skills. They observed an increase in brainstorming and idea negotiation activities among students, which contributed to the development of 21st-century skills.

Research by (S. S. Putri et al., 2019)shows that PjBL improves students' creative thinking skills. They noted an increase in students' liveliness and expression during the learning process, which was reflected in the production of creative projects. Research from (Yustina et al., 2020) reports that PjBL facilitates collaboration and higher-order thinking skills. They found that this method encourages creative problem-solving and the development of original solutions.

Research conducted at South China Normal University revealed that PjBL enhances students' innovative thinking through value assessment and promotes creativity with a focus on real product outcomes. This approach has proven to be effective in integrating creativity into AI education. For example, by (Rahardjanto et al., 2019)affirms that PjBL significantly improves students' creative thinking skills. They also found that Hybrid-PjBL showed better results compared to conventional methods of enhancing creative thinking. Research from (Trisianawati, 2018)confirmed through statistical tests that PjBL significantly improved students' creative thinking skills, outperforming guided discovery learning methods in this aspect.

The synthesis of these findings shows that Project-Based Learning has a consistent positive impact on the development of students' creative thinking skills. PjBL has been shown to encourage active participation in learning, improve problem-solving skills, and facilitate the production of innovative ideas. This method also strengthens collaboration, communication, and higher-order thinking skills. The consistency of these findings across different educational and cross-cultural contexts confirms the effectiveness of PjBL as a powerful pedagogical approach to developing students' creative thinking in the context of 21st century education.

The effect of the application of PjBL on student cocoliteracy

Based on articles that have been identified from previous research. This shows a finding that is relevant to answer RQ2, namely research from (S. S. Putri et al., 2019) conducted significant research on the influence of PjBL on student ecoliteracy. They found that the implementation of PjBL substantially improved students' ecoliteracy abilities. This study revealed that students became more active in the environmental learning process, showing increased engagement and interest in ecological issues. Furthermore, this study reveals that PjBL facilitates increased coliteracy through collaborative problem-solving. This process not only improves students' understanding of ecological concepts, but also encourages the development of cooperative skills that are essential in addressing complex environmental challenges. Furthermore, another component found that PjBL encourages critical thinking about ecology, through projects that focus on environmental issues, students learn to analyze, evaluate in the context of daily life.

Meanwhile, other research conducted by (Rahardjanto et al., 2019)did not specifically discuss the influence of PjBL on ecoliteration. However, their research focuses on student learning outcomes, creative thinking, and motivation, which can be considered an important component in the development of holistic ecoliteracy.

Thus, the synthesis that can be taken from this RQ shows that Project-Based Learning has great potential in increasing student ecoliteracy. PjBL not only enhances conceptual understanding of ecology, but also encourages the development of practical skills, critical thinking, and a positive attitude towards the environment. This method creates a learning environment that supports active exploration of environmental issues, allowing students to relate theoretical knowledge to practical applications in real-world contexts.

Challenges and solutions for the implementation of PjBL to improve skills away from creative thinking

Based on articles that have been identified from previous research. This shows that the findings are relevant to answer RQ3, namely that there are challenges that need to be faced in the implementation of PjBl, namely. For example: Research from (Musa et al., 2012) identified a lack of resources and support as key obstacles to the implementation of PjBL, including limited learning materials and time available for project implementation. In addition, research from (Yustina et al., 2020)reported that students often experience difficulties in collaborating and communicating effectively during the PjBL process, which can hinder creativity and collaborative problem-solving.

Research from (Siew & Ambo, 2018) revealed that many teachers still lack knowledge on how to foster scientific creativity through PjBL, pointing to the need for more intensive teacher training. Plus research by (Trisianawati, 2018)found that students tend to rely too much on lecturers, which hinders independence in learning. Research cited by (Berestova et al., 2021) It shows that the lack of product guidance can limit the creativity of students in the control group.

The researcher offers solutions and strategies that are proposed based on the findings, namely research from (Musa et al., 2012). suggest the provision of training for educators on PjBL methodologies to improve teachers' ability to facilitate effective project-based learning. (Yustina et al., 2020)emphasized the importance of access to technology for the effective implementation of PjBL, which can facilitate project management and encourage creativity.

(Siew & Ambo, 2018) propose cooperative learning approaches to improve teamwork and student engagement. (S. S. Putri et al., 2019)emphasizing the importance of positive feedback and suggestions during the learning process, with continuous evaluation and reflection to improve learning outcomes. Research from (Siew & Ambo, 2018) It also

suggests an interdisciplinary approach that allows for problem-solving through design and manufacturing, which can expand the scope of students' creativity.

The synthesis of these findings shows that the successful implementation of PjBL to improve creative thinking skills requires a holistic approach that involves all stakeholders in the educational process. Technology integration, comprehensive teacher training, and a more collaborative and interdisciplinary approach to learning emerged as key strategies.

DISCUSSION

This study aims to analyze the potential effectiveness of the PjBL learning model in improving ecoliteration from the perspective of students' creative thinking skills. The results of the study show that Project-Based Learning (PjBL) has a significant positive impact on the development of students' creative thinking skills. Various studies, such as those conducted by (Barak & Yuan, 2021; Musa et al., 2012; Zhou, 2021) revealed that PjBL stimulates various aspects of creativity, promotes innovative thinking, and encourages effective communication between students. seperti (Musa et al., 2012) bahwa PjBL mengembangkan keterampilan berpikir tingkat tinggi, seperti brainstorming and negotiation, which is relevant to 2nd century competencies1. In addition, (Rahardjanto et al., 2019) showed that Hybrid-PjBL provides better results than conventional methods, while (Yustina et al., 2020) emphasized the importance of collaboration and problem-solving in supporting student creativity. These findings are consistent across a variety of educational and cross-cultural contexts, confirming the effectiveness of PjBL as a powerful pedagogical approach to developing students' creative thinking in the context of 21st-century education.

The study also found findings in terms of the influence of PjBL on student ecoliteracy, although the research is more limited, the existing results show promising potential. Research by (S. S. Putri et al., 2019) found that PjBL substantially improves students' ecoliteracy abilities, encourages active involvement in environmental issues, and facilitates collaborative problem-solving in ecological contexts. PjBL not only enhances conceptual understanding of ecology, but also encourages the development of practical skills and positive attitudes towards the environment. Other research, such as (Rahardjanto et al., 2019), although not directly addressing ecoliteracy, shows that PjBL is able to improve student motivation, creativity, and learning outcomes, which is relevant to the development of ecoliteracy holistically.

However, the implementation of PjBL also faces several challenges. (Musa et al., 2012)identify a lack of resources and support as a major obstacle, while (Yustina et al., 2020) reported students' difficulties in collaborating and communicating effectively. Strengthened by research (Siew & Ambo, 2018)revealed a lack of teachers' knowledge on how to foster scientific creativity through PjBL. To address these challenges, several solutions were proposed, including the provision of training for educators, increased access to technology, the implementation of cooperative learning approaches, an emphasis on positive feedback, and the use of interdisciplinary approaches.

Overall, these findings confirm the transformative potential of PjBL in 21st century education, particularly in supporting students' creativity and ecoliteracy. However, its implementation requires a holistic approach that involves all education stakeholders. Future research is suggested to explore the long-term impact of PjBL through longitudinal studies, as well as examine its application in diverse educational contexts. PjBL has proven to be a powerful pedagogical tool to equip students with the necessary skills and mindset in the face of the complexities of the modern world, especially in creativity and ecological awareness. The limitations of this study lie in the variation of the methodology and sample size used in the analyzed studies, which can affect the generalization of the results. In future research, it is recommended to conduct

longitudinal studies to assess the long-term impact of PjBL on students' creative thinking and ecoliteracy skills.

CONCLUSION

This research as a whole has succeeded in identifying that effective learning methods in improving students' creative thinking and ecoliteracy skills. Through a student-centered and project-based approach, PjBL is able to create a learning environment that encourages innovation, collaboration, and creative problem-solving. PjBL's success in developing 21st century skills is seen consistently across various educational contexts and cultural backgrounds.

Although PjBL shows great potential, its implementation is not free from challenges. Limited resources, lack of teacher training, and difficulties in managing group dynamics are some of the obstacles that need to be overcome. However, with the right strategies, such as comprehensive teacher training, technology integration, and an interdisciplinary approach, these challenges can be effectively managed.

PjBL's ability to improve students' ecoliteracy also demonstrates its potential as a tool to educate future generations who are environmentally conscious. Through projects relevant to contemporary ecological issues, PjBL not only enhances students' knowledge of the environment, but also encourages them to take concrete action in preserving the environment. The implications of this study emphasize the importance of integrating PBL in the environmental education curriculum to prepare a more environmentally conscious and creative generation in facing future ecological challenges

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