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Enhancing Engagement and Literacy-Based Creative Thinking through Project-Based Learning

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Abstract: This study aims to examine the effectiveness of the Project-Based Learning (PBL) model in enhancing student engagement and literacy-based creative thinking skills in an Environmental Chemistry course. The novelty of this research lies in integrating a structured literature review project as a core PBL activity to simultaneously strengthen academic literacy and foster creative thinking within environmental chemistry contexts. The study employed a Classroom Action Research (CAR) design with a mixed-method approach conducted in two cycles, each consisting of planning, implementation, observation, and reflection stages. The participants were 33 third-semester students. Data were collected through classroom engagement observations, learning achievement tests, literature review project assessments, and documentation. Quantitative data were analyzed using Likert scales and percentage achievement indicators. The findings revealed a significant improvement in both student engagement and literacy-based creative thinking skills from Cycle I to Cycle II. Therefore, literature-integrated PBL is an effective pedagogical strategy to enhance both the learning process and student outcomes in Environmental Chemistry courses. Further research is recommended to investigate its long-term effectiveness, broader applicability across disciplines, and potential integration with emerging learning technologies.

Keywords: education; literacy; learning; writing skills.

Abstrak: Penelitian ini bertujuan menganalisis efektivitas model Project-Based Learning (PBL) dalam meningkatkan keterlibatan belajar dan keterampilan berpikir kreatif berbasis literasi pada mata kuliah Kimia Lingkungan. Kebaharuan penelitian ini terletak pada integrasi tugas proyek berbasis telaah literatur ilmiah sebagai strategi sistematis untuk memperkuat literasi akademis sekaligus mendorong berpikir kreatif dalam konteks kimia lingkungan. Penelitian menggunakan metode penelitian Tindakan Kelas dengan pendekatan campuran yang dilaksanakan dalam dua siklus, masing- masing meliputi tahap perencanaan, pelaksanaan, observasi, dan refleksi. Subjek penelitian berjumlah 33 mahasiswa semester tiga. Data dikumpulkan melalui observasi keterlibatan belajar, tes hasil belajar, penilaian proyek artikel telaah literatur, dan dokumentasi. Analisis data dilakukan secara kuantitatif menggunakan skala Likert dan persentase capaian indikator. Hasil penelitian menunjukkan peningkatan signifikan padaketerlibatan belajar dan keterampilan berpikir kreatif berbasis literasi dari Siklus I ke Siklus II. Dengan demikian, PBL berbasis proyek literatur efektif meningkatkan kualitas proses dan hasil pembelajaran Kimia Lingkungan.

Kata Kunci: pendidikan; literasi; pembelajaran; keterampilan menulis.

INTRODUCTION

The global and national educational landscape is undergoing transformation driven by technological advancements, social shifts, and evolving economic demands (Pelino, 2025). Inclusive education has emerged as a philosophy advocating for the fulfilment of educational rights in general educational settings for all individuals, regardless of physical, intellectual, or emotional differences. However, implementing inclusive education still faces challenges at both global and national levels, particularly in preparing an educational system capable of developing skills and adapting to global changes. Formal education involving lecturers and students relies on interaction as the core of the learning process. Learning is designed to enable students to achieve predetermined competencies so that educational goals can be optimally realised. In this process, active participation from both lecturers and students as learners is essential. Effective learning activities are expected to stimulate and develop students' potential, foster critical and creative thinking abilities, and enhance problem-solving skills.

Student-centred learning is applied in the Environmental Engineering Programme at Universitas Kebangsaan Republik Indonesia, particularly in the third-semester Environmental Chemistry course. In this course, the topic of organic chemistry requires students to explain the classification of organic compounds in nature and their relevance to environmental engineering. Limited literacy, particularly in organic chemistry, hampers the development of students' creative problem-solving skills in scientific contexts (Shultz & Li, 2016).

Theoretical knowledge is fundamental for understanding complex chemical behaviours and to visualise molecular transformations, predict reactions, and design new compounds. The gap in organic chemistry literacy directly contributes to low creative scientific thinking abilities. Additionally, students still struggle with questioning, analysing, investigating, and evaluating environmental problems at local, regional, and global scales (Alıyeva, 2025). One approach to addressing these issues is implementing a student-centred learning model such as Project-Based Learning (PBL). The PBL model emphasises creative learning through identifying, analysing, and solving real-world problems. By applying PBL, students are expected to improve their engagement and literacy, particularly in understanding organic chemistry concepts. Implementing the PBL learning model in Environmental Chemistry aims to improve students' ability to understand and analyse organic chemistry in a meaningful way.

The PBL model is a student-centred approach effective in teaching and assessment across different subjects and continues to be an engaging model for learning content and skills aligned with the curriculum (Vista, 2025). It helps students develop collaborative skills and individual responsibility by involving students in environment-based projects (Mu et al., 2025). PBL uses projects as tools to achieve attitudinal, knowledge, and psychomotor competencies for solving problems through research, analysis, creation, and presentation of learning products based on real-world experiences. In PBL, lecturers act as facilitators, guiding students through the project-based learning process and helping them develop necessary skills and knowledge. Guidelines are essential for achieving optimal results in PBL. Lecturers serve as coaches, providing feedback, support, and direction to students while they work on projects. Before starting PBL, lecturers should be prepared to discuss possible project directions, consider topics of interest to students, help formulate their questions, and guide them to available resources (Samon et al., 2023). When applying PBL with student-centred learning principles, problem-focused projects, student involvement in research to construct knowledge, and collaborative project completion (Yusri et al., 2024), PBL develops critical thinking skills.

In traditional education, students often memorise facts or formulas without fully understanding their applications. Conversely, PBL requires students to analyse information, evaluate options, and synthesise ideas to solve complex problems. When working on organic chemistry projects, students must research the topic, assess various factors' impacts, and propose actionable solutions. This process encourages them to think critically about the data they encounter, consider multiple perspectives, and validate their conclusions. Such skills are invaluable in today's information-rich world, where students must distinguish credible sources.

Adopting and integrating a 21st-century curriculum with knowledge, critical thinking, innovation skills, media and information literacy, and practical experience within core academic subjects (K et al., 2023), although some students feel shy about seeking help from lecturers or asking questions in class, peer communication allows less capable students to improve their skills through discussions with classmates. To encourage creative thinking, teaching and learning must gradually incorporate creative elements. Students should actively participate in their learning environment and develop skills such as critical thinking, problem-solving, communication, and collaboration if they aim for meaningful learning. Critical thinking helps with various high-level mental processes that improve students' problem-solving abilities. It involves the ability to check, evaluate, summarise, and synthesise material. With projects as student assignments, creative problem-solving skills are developed through technical competence, collaborative problem-solving, and adaptability (Cooper et al., 2025).

As a purposeful and reflective assessment, critical thinking involves a fair examination of evidence, background, methods, standards, and concepts to decide what to believe or do (X. Song et al., 2024). In philosophy, it is a way of thinking about any subject, content, or problem where the thinker improves the quality of thinking by skilfully controlling the inherent structures and applying intellectual standards to those structures (Almulla & Al-rahmi, 2023). The cognitive dimension includes three skills (analysing, concluding, and evaluating) and six standards (clarity, precision, relevance, consistency, depth, and flexibility). The affective dimension covers six dispositions (curiosity, integrity, openness, fairness, confidence, perseverance) (H. Song & Cai, 2024). From a cognitive psychology perspective, creative thinking involves a thoughtful approach to problems, understanding logic and reasoning, and applying knowledge effectively. Using cognitive skills or strategies increases the chances of achieving desired outcomes. This includes purposeful reasoning to solve problems, drawing conclusions, calculating probabilities, and making decisions. Creative thinking develops different types of mental processes: reasoning, making assessments and decisions, and problem-solving. It represents a teaching philosophy that addresses current societal issues through education. This approach considers students' broader social environment across all disciplines to raise awareness and promote social change through learning.

Literacy is now seen as more than just reading and writing skills. Over recent decades, it has expanded to include critical engagement with texts as complex, multimedia constructions (Hanghøj et al., 2022). Literacy practices are social activities involving cultural perspectives on reading and writing. Project-based tasks in the classroom help improve science and information literacy (Juleha et al.,2019). Students engage in integrated learning to develop collaboration and creativity skills, essential for working and living in an increasingly digital world (McGuinness & Fulton, 2019).

Digital literacy addresses how students master the ‘grammar’ of digital information to conduct solid research and accurately and ethically create and present new knowledge through evolving technology platforms and multimedia products (Neuman et al., 2019). Literacy has evolved from general reading and writing abilities to capacities required in specific fields (Dong et al., 2023). Digital literacy affects many aspects of life, requiring more than just technical knowledge. It involves understanding concepts rather than just mastering tools (Wang & He, 2022). Digital literacy includes various competencies such as computer skills, ICT literacy, information literacy, and media literacy. Creating high-quality learning resources based on literacy principles to support active learning is becoming an important trend in education.

The increasing complexity of environmental challenges requires graduates who are not only proficient in Environmental Chemistry concepts but also capable of critical and creative thinking grounded in scientific literacy. However, low levels of student engagement and literacy-based creative thinking skills indicate a gap between expected competencies and existing instructional practices, which often remain teacher-centered and content-focused. This condition highlights the urgent need for innovative pedagogical approaches that actively engage students while fostering higher-order thinking and academic literacy. Although the Project-Based Learning (PBL) model has been widely implemented to enhance engagement, its integration with structured literacy development remains limited. Therefore, this study is necessary to address this gap by embedding a structured literature review project within the PBL framework, enabling a more systematic development of both engagement and literacy-based creative thinking skills.

The uniqueness of this research lies in this explicit integration, which positions academic literacy not merely as a supporting element but as a central component of project-based learning in Environmental Chemistry. Given these challenges, an evaluation of creative thinking skills based on literacy through the implementation of the PBL learning model is necessary. Therefore, the research questions are: (1) Can the application of the PBL model increase student engagement in organic chemistry learning? (2) Can the application of the PBL model improve creative thinking skills based on literacy in Environmental Chemistry learning? In line with these research questions, the study aims to analyse the improvement of student engagement through the implementation of the PBL model in organic chemistry learning and measure the enhancement of students’ creative thinking skills based on literacy by applying the PBL model in Environmental Chemistry.

METHODS

This study’s subjects were third-semester Environmental Engineering students taking the Environmental Chemistry course, totalling 33 students. The research employed a mixed-method approach (quantitative followed by qualitative) (Borza & Inta, 2017). It consisted of two cycles: the first cycle involved one meeting with two credit units (2 × 50 minutes), and the second cycle also included one meeting with two credit units (2 × 50 minutes). PBL utilised four primary learning processes in terms of absorption capacity: exploratory, assimilative, transformative, and exploitative learning (Teixeira et al., 2025). Higher education students were assessed through action research involving planning, acting, observing, and reflecting in the classroom. The cycle method helped review and reflect on results to improve teaching and learning outcomes. Students identified problems, prepared interventions, acted out scenarios, and analysed their performance for future improvements. This approach exposed them to practical critical thinking strategies.

Table 1. Observation Results of Student Engagement

Research Phase	Average Activity Score	Percentage (%)	Engagement Category
Pre-Cycle	2.4	48	Fair
Cycle I	3.6	72	Good
Cycle II	4.4	88	Very active

Note: The percentage is derived from comparing student activity scores with the maximum score based on a Likert scale of 1–5. There was an increase in student creativity exceeding the criterion ≥75% in Cycle II. The initial phase (Pre-Cycle) aimed to gather information about conditions before intervention (Nedeva et al., 2025). This step involved planning PBL implementation to improve learning outcomes for Environmental Chemistry students.

Activities included creating perceptions of PBL technical implementation, observing learning activities, and developing teaching materials and assessment questions to evaluate student learning outcomes; preparing learning tools (RPP, materials, and media); 1) selecting organic chemistry topics in the second week with an assignment for students to write a literature review article on the topic; 2) preparing data collection instruments for learning activities and designing learning outcome tests for evaluation to assess improvements during PBL implementation; 3) establishing baseline information on student activity and learning outcomes as targets for each cycle before applying the project-based learning model; and 4) preparing general procedures for students as materials for PBL implementation. CAR was used to improve students' thinking skills based on literacy, following Kemmis and McTaggart's model with components including planning, acting, observing, and reflecting (Rabgay & Kidman, 2023).

RESULTS AND DISCUSSION

RESULTS

The implementation of the Project-Based Learning (PBL) model has had a significant impact on student engagement throughout the learning process. This section presents findings regarding student activities at various stages of the research, highlighting how student participation developed from the pre-cycle phase through to Cycle II. This analysis focuses on various indicators of active learning, including participation in discussions, asking critical questions, collaboration, and the ability to develop and present ideas related to organic chemistry within an environmental context.

Student Activity in Learning

Observations showed that student activity increased with each cycle after implementing the PBL model. In the pre-cycle phase, student participation was low.

Students asked a few questions, engaged minimally in discussions, and struggled to analyse organic chemistry problems related to environmental issues. By Cycle I, the PBL approach began to show positive effects. Students became more involved in group discussions, gathering literature sources, and drafting project article frameworks. While overall activity reached the 'good' category, some areas, such as asking critical questions and presenting original ideas, remained underdeveloped. In Cycle II, student activity improved significantly after adjustments based on reflections from Cycle I. Students actively explored literature, engaged in argumentative discussions, and confidently presented project results. Activity levels reached the 'very active' category, exceeding the success criterion of ≥75%.

Table 2. Percentage of Student Engagement Indicator Achievement Per Cycle

No	Student Engagement Indicator	Cycle I (%)	Cycle II (%)
1	Participation in group discussions	70	90
2	Ability to ask questions and express opinions	68	85
3	Collaboration in completing the project	75	92
4	Persistence in finding and reading literature	72	88
5	Engagement during project result presentations	74	90
	Average	72	89

Table 2, the progress in student activity across the research cycles, demonstrates that the implementation of the PBL model effectively engages students in Environmental Chemistry learning. Initially, low participation in the pre-cycle phase reflected students' limited involvement in questioning, discussion, and problem analysis. However, the introduction of PBL in cycle I began to foster more active participation, as evidenced by increased involvement in group discussions, literature exploration, and project development, although higher-order skills such as critical questioning and idea generation were not yet optimal. Following reflective improvements in instructional strategies, Cycle II showed a substantial enhancement in student engagement, with learners actively engaging in literature-based inquiry, constructing arguments, and confidently presenting their work. The achievement of activity levels exceeding the ≥75% success criterion indicates that PBL, particularly when iteratively refined, serves as an effective approach to promoting active, inquiry-driven, and participatory learning.

Creative Thinking Skills Based on Literacy

Creative thinking skills were assessed through a literature review assignment and learning outcome tests. In Cycle I, students demonstrated moderate to creative thinking, particularly in fluency and idea elaboration. However, originality and flexibility were limited, as many students copied ideas from sources without deeper analysis.

Table 3. Assessment of Literacy-Based Creative Thinking Skills

Aspect of Creative Thinking	Cycle I	Category	Cycle II	Category
Fluency	70	Creative	88	Highly Creative
Flexiblity	65	Creative	85	Highly Creative
Originality	60	Moderately Creative	82	HighlyCreative
Elaboration	72	Creative	90	Highly Creative
Average	67	Creative	86	Highly Creative

By Cycle II, improvements were more balanced across all indicators. Students integrated multiple literature sources, connected organic chemistry concepts with real-world environmental problems, and proposed alternative solutions in a structured, argumentative manner. On average, their creative thinking skills reached the 'highly creative' category, meeting the research success indicator (≥75%).

The rise in student activity during environmental chemistry learning suggests that the PBL model supports student-centred learning. This aligns with constructivist theory, which states that knowledge is built through meaningful activities and social interaction. Through environment-based problem projects, students actively engaged in inquiry, analysis, and synthesis of information, making learning more relevant and meaningful. Additionally, the improvement in literacy-based creative thinking skills suggests that PBL encourages higher-order cognitive processes, as described by Bloom's revised taxonomy, particularly analysing, evaluating, and creating. Activities such as literature searches, article writing, and project presentations helped students develop integrated information literacy and digital literacy.

Table 4. Student Learning Completion Rates

Research Phase	Number of Students Completed	Completion Percentage	Category
Pre-Cycle	14 out of 33	42%	Not Completed
Cycle I	23 out of 33	70%	Moderately Completed
Cycle II	29 out of 33	88%	Completed

According to Table 4, the improvements made in Cycle II, such as stronger faculty guidance, better alignment among instructors, and refined project assessment indicators, proved effective in enhancing learning quality. This shows that reflection within PTK is key to optimising the implementation of learning models. The inter-cycle variables for student activity increased by 16%, literacy-based creative thinking improved by more than 19%, and mastery of learning outcomes rose by 18%. Therefore, applying PBL not only boosted student engagement but also significantly developed literacy-based creative thinking skills, essential for environmental engineering students tackling complex environmental problems.

DISCUSSION

The increase in student activity observed throughout the research cycle confirms that the implementation of the Project-Based Learning (PBL) model effectively encourages active engagement in Environmental Chemistry learning. The low level of participation in the pre-cycle phase reflects the limitations of conventional teacher-centred teaching, which often restricts students' opportunities to engage in inquiry, discussion, and problem-solving. Improvements in Cycle I, particularly in group discussions, literature exploration, and project planning, indicate that PBL creates a more student-centred learning environment. These findings are consistent with research by Marini et al. (2026), which highlights that PBL enhances student engagement by involving learners in meaningful, context-based tasks. Similarly, a study by Abidin (2026) that a project-oriented learning environment significantly increases student participation and responsibility in the learning process. The more significant improvement observed in Cycle II highlights the importance of reflective refinement in optimising the implementation of PBL. Following the learning adjustments, students demonstrated improved ability in conducting literature-based investigations, constructing arguments, and presenting their ideas with confidence. This aligns with the findings of Wu et al. (2026), who found that a well-structured, iterative PBL process significantly enhances collaborative learning, critical thinking, and student autonomy within a higher education context. Furthermore, significant improvements in indicators such as the ability to ask questions and generate ideas suggest that structured academic tasks, such as literature review projects, can effectively stimulate higher-order thinking skills when integrated into a PBL framework.

Furthermore, the fact that student activity levels exceeded the success criterion of ≥75% further reinforces the effectiveness of PBL as an inquiry-based pedagogical approach. These findings are supported by a meta-analysis conducted by Chen et al. (2026), which demonstrated that collaborative and project-based learning significantly improve student engagement and learning outcomes compared to traditional methods. Furthermore, research published in Scopus-indexed journals, such as the work by Acuña et al. (2025), emphasises that PBL fosters deeper learning, active participation, and sustained motivation when supported by well-designed tasks and continuous feedback. Therefore, the findings of this study confirm that literature-integrated PBL, implemented through iterative cycles, is a powerful strategy for enhancing student engagement, particularly in complex, context-based subjects such as Environmental Chemistry.

The findings indicate a significant improvement in students' literacy-based creative thinking skills following the implementation of the Project-Based Learning (PBL) model. In Cycle I, students demonstrated moderate levels of creativity, particularly in terms of fluency and elaboration; however, limitations were evident in terms of originality and flexibility, as many students relied heavily on reproducing ideas from existing literature without deeper critical analysis. This pattern suggests that students are still at an early stage of developing higher-order thinking skills and have not yet fully engaged in independent knowledge construction. In Cycle II, a more balanced and significant improvement was observed across all indicators, with students demonstrating the ability to synthesise various sources, link organic chemistry concepts to real-world environmental issues, and propose structured, evidence-based solutions. These findings are consistent with research by Kuo (2026), which highlights that well-implemented PBL fosters deeper learning and supports the development of creative and critical thinking through authentic, inquiry-based tasks.

The development of creative thinking skills can be explained theoretically through the constructivist learning perspective, particularly the theories of Alamro (2026), which emphasise that knowledge is actively constructed through interaction, experience, and social collaboration. The integration of literature review activities within the PBL framework provides students with the opportunity to engage in meaningful inquiry, evaluate information, and construct new understanding based on evidence. This process aligns with the higher-order cognitive domains in Benjamin Bloom's revised taxonomy, particularly the stages of analysing, evaluating, and creating. Activities such as literature searches, academic writing, and project presentations not only enhance students' conceptual understanding but also strengthen their information and digital literacy skills, which are essential competencies in contemporary environmental science education (Hachoumi et al., 2025). Furthermore, a significant increase in the course completion rate from 42% in the pre-cycle phase to 88% in Cycle II demonstrates the effectiveness of iterative improvements within the Classroom Action Research (CAR) framework. Improvements in the alignment of teaching, lecturer guidance, and assessment design contributed to the creation of a more supportive learning environment, thereby enabling students to achieve higher levels of engagement and achievement. Emphasise that structured facilitation and continuous reflection are key factors in maximising the impact of PBL in higher education. Overall, these results confirm that PBL integrated with literature not only enhances student engagement but also significantly develops literacy-based creative thinking skills and learning outcomes, making it a highly relevant pedagogical approach for addressing complex real-world environmental issues.

Furthermore, a significant increase in the course completion rate from 42% in the pre-cycle phase to 88% in Cycle II demonstrates the effectiveness of iterative improvements within the Classroom Action Research (CAR) framework. Improvements in the alignment of teaching, lecturer guidance, and assessment design contributed to the creation of a more supportive learning environment, thereby enabling students to achieve higher levels of engagement and achievement. These findings are supported by studies in Scopus-indexed journals, such as those conducted by Zou et al. (2026), that structured facilitation and continuous reflection are key factors in maximising the impact of PBL in higher education. Overall, these results confirm that PBL integrated with literature not only enhances student engagement but also significantly develops literacy-based creative thinking skills and learning outcomes, making it a highly relevant pedagogical approach for addressing complex real-world environmental issues.

CONCLUSION

Based on the research findings and discussion, it can be concluded that implementing the PBL model successfully increased student activity in organic chemistry learning within the Environmental Chemistry course. Student activity improved progressively from Cycle I to Cycle II, reaching the 'very active' category and meeting the research success criteria. The approach also effectively enhanced students' literacy-based creative thinking skills. Students demonstrated better abilities in analysing literature, connecting organic chemistry concepts with environmental issues, and producing more original and contextually relevant ideas and solutions. Thus, PBL can serve as a valuable alternative learning method to improve higher education outcomes, especially in courses requiring the integration of theoretical knowledge, literacy, and real-world problem-solving.

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