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Bibliometric Analysis of PBL and Interactive Multimedia Integration: Enhancing Elementary Students' Environmental Literacy

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Abstract

The enhancement of Environmental Literacy in elementary education is critical, necessitating a shift from conventional methods to active strategies like Problem-Based Learning (PBL), which effectiveness is significantly amplified by integrating Interactive Multimedia to boost student motivation and clarify complex concepts. This study utilized a Multi-Database Bibliometric Analysis to systematically map the intellectual structure and empirical trends in this domain. Data were collected from seven databases (Scopus, WoS, ERIC, PsycINFO, Garuda, Neliti, SINTA) from 2018–2023. An initial 312 articles were screened, resulting in a final verified dataset of 12 studies focused on quantitative/mixed designs with elementary students. The analysis confirmed a strong positive trend, with empirical findings validating the significant impact of the integrated approach on enhancing learning outcomes and critical thinking. The bibliometric mapping revealed three key interconnected thematic clusters: (1) Core Human and Motivation, (2) Technology and Digital Learning, and (3) Methodology and Outcomes (linking PBL and learning outcomes). This study concluded that the fusion of PBL and interactive multimedia has constituted a robust and transformative strategy for enhancing environmental literacy, providing a data-driven confirmation of its efficacy and establishing a clear roadmap for future research, while highlighting the need to address infrastructure and teacher training challenges.

Keywords: *: Bibliometric Analysis; Problem-Based Learning (PBL); Interactive Multimedia; Environmental Literacy; Elementary School.*

INTRODUCTION

Environmental literacy is a paramount competence for Elementary School students, necessitating not only a firm grasp of ecological concepts but also the development of acute environmental awareness and a commitment to responsible behavior. Nationally, data suggests that the current level of environmental literacy in basic education remains critically low, often stemming from conventional and monotonous instructional methods that fail to stimulate deep cognitive engagement and

active participation. To effectively address this pervasive pedagogical gap, a shift towards experience-based, active, and contextual learning strategies is imperative. The Problem-Based Learning (PBL) model emerges as a highly relevant and potent approach, strategically designed to engage students in solving real-world problems, thereby cultivating the critical thinking and problem-solving skills that are essential components of environmental stewardship.

The effectiveness of PBL in the digital age is significantly amplified by the seamless integration of interactive multimedia. Utilizing advanced tools such as animations, simulations, or Genially-based platforms, interactive multimedia has been repeatedly shown to boost student motivation, clarify complex environmental concepts, and enhance active student participation (Oktaviane et al., 2025). This integration aligns with Mayer's (1998) Multimedia Learning Theory, which asserts that the strategic combination of visual and auditory elements optimizes conceptual acquisition. The resulting synergy between PBL, interactive multimedia, and environmental literacy has become a substantial focus of academic investigation. However, existing research primarily consists of specific case studies or empirical media development projects, providing fragmented evidence rather than a consolidated view.

While empirical findings on the integration of these variables are valuable, a comprehensive, quantitative, and structural review of the global literature is currently lacking. This gap necessitates the application of Bibliometric Analysis, a rigorous scientific method used to systematically map, measure, and analyze the intellectual landscape of a specific research domain (Zhou et al., 2025). Therefore, this research employed Bibliometric Analysis with three core objectives: (1) to delineate the thematic evolution and emerging research sub-topics concerning PBL and multimedia integration, (2) to examine global collaboration patterns among institutions and nations, and (3) to identify the most impactful models and publications driving the enhancement of elementary students' environmental literacy. The outcomes of this study are expected to establish a definitive data-driven research roadmap for future scholars, and furnish educational practitioners with evidence-based guidelines for implementing the most effective instructional strategies.

METHODS

This study employed a Multi-Database Bibliometric Analysis design, a specialized quantitative approach intended to statistically map the intellectual structure

and evolutionary trends within scholarly publications concerning the impact of multimedia-assisted Problem-Based Learning (PBL). Data collection was conducted comprehensively across both international and national databases, including Scopus, Web of Science (WoS), ERIC, PsycINFO, Garuda, Neliti, and SINTA, focusing on documents published between 2018 and 2023. A structured search string (combining "Problem Based Learning," "interactive multimedia," "learning motivation," "environmental literacy," and "fifth grade elementary school") was applied, yielding a total of 312 initially identified articles.

To ensure data reliability, a rigorous screening process was implemented. Following the removal of duplicates and title/abstract screening, 45 articles were deemed eligible for full-text review. Subsequent quality appraisal was conducted to confirm methodological adequacy, resulting in a final verified dataset of 12 studies that met all inclusion criteria (focusing on fifth-grade elementary students in Indonesia and utilizing quantitative/mixed designs). These 12 articles served as the final dataset for the bibliometric analysis. The data were processed using dedicated software, such as VOSviewer, to visualize the research structure, including keyword co-occurrence maps ("IPS learning motivation," "environmental literacy"), co-authorship patterns, and citation networks, ultimately providing in-depth insight into the development and key research foci within this domain.

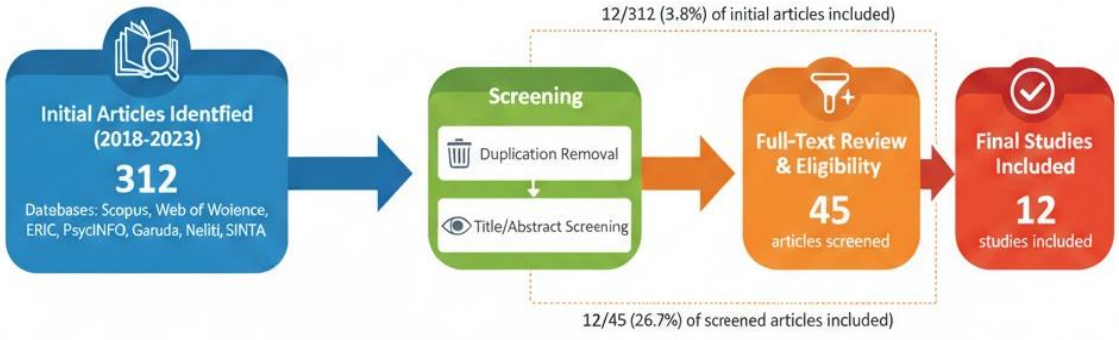

Figure 1. Illustrating literature search and selection process

RESULTS AND DISCUSSION

Results

The thematic analysis of relevant studies concerning the influence of interactive multimedia-assisted Problem-Based Learning (PBL) on students' environmental literacy revealed three main themes emerging from in-depth qualitative and quantitative data.

1. Research Trends and Empirical Findings of Interactive Multimedia + PBL

In line with the rapid advancement of technology, the utilization of interactive multimedia in learning has shown an increasingly positive trend. Recent research indicates that interactive multimedia, such as video, animation, and simulations, not only enriches the learning experience but has also been proven to enhance student motivation and academic achievement (Kirani et al., 2025; Rahayu & Prihatini, 2021; Amalia et al., 2023). Within this context, the Project-Based Learning (PBL) approach is also gaining widespread acceptance, where students are engaged in an active learning process by completing projects oriented toward real-world problems (Ramadani et al., 2024; Roemintoyo dan Budiarto, 2023).

This trend aligns with research findings showing that the implementation of PBL strategies integrated with multimedia can significantly boost problem-solving skills, scientific literacy, and language competence (Doyan et al., 2024; Kamila et al., 2024). PBL plays a crucial role in developing more interactive and collaborative learning environments, facilitating students in finding solutions and establishing connections between theory and practice (Allison et al., 2015). Furthermore, adaptation to digital media, as demonstrated by Waang (2023) and Wakil et al (2023), ensures that students receive more flexible learning that caters to the needs of the current digital generation. As a part of this study, we present Table 1, which summarizing research on interactive multimedia conducted in Indonesia from 2020 to 2025. This table highlights various research titles, years, methods employed, and the main findings obtained, providing a clearer overview of the empirical trends and discoveries in the utilization of interactive multimedia and PBL in education.

Table 1. Summary of Research Review on Interactive Multimedia in Indonesia (2020–2025)

No	Research Title	Year	Methods	Main Findings
1	Winda Yuningsih et al.	2020	Pre-experiment (Pre-test Post-test)	Multimedia for science literacy based on the lightning theme, utilizing animation and video, developed through the ADDIE model.
2	Rohatul Fikriyah Safira (2024)	2024	Systematic Literature Review	Digital interactive multimedia such as Adobe Animate, PowerPoint, Unity; focusing on interactive features and visualization of environmental concepts.
3	Zulaiha Zulaiha et al.	2025	Descriptive Qualitative	Web-based multimedia on climate change and environmental issues, developed through needs analysis

				using the Alessi-Trollip model.
4	Yurika Oktaviane et al.	2025	R&D with ADDIE model	Genially-based interactive multimedia for digital literacy and learning motivation, duration of 4 weeks.
5	Mainofriwita & Hadiyanto (2021)	2021	Quasi-experiment with control and experimental groups	Laptop media literacy, investigating the influence on media recognition ability and cognitive ability.
6	Umi Risatul Firdaus & Sigit Prasetyo (2025)	2025	Systematic Literature Review	Video-based interactive multimedia for early childhood learning; analysis of effectiveness through literature study and observation.
7	Riska Diona et al. (2024)	2024	Research and Development (ADDIE) with small-scale trial	Science literacy multimedia on the lightning theme based on text, images, animation, video; feasibility testing by experts and teachers; pretest-posttest scale.
8	Andi Nur Maharani (2025)	2025	Qualitative Case Study	Interactive video media for early childhood digital literacy; observation of attention and participation.
9	Aulia Eka Putri et al. (2025)	2025	R&D with ADDIE model	Genially-based multimedia for digital literacy and learning motivation; expert validation and field testing; significant N-Gain increase in digital literacy and motivation.
10	Linda, P. Y. N, Heryanto, D et al.	2025	Quantitative research using a quasi-experiment method and The Matching Only Pretest-Posttest Control Group Design.	The data indicate a difference in learning outcomes between the experimental and control groups due to different treatments. Based on this, it can be concluded that the Teams Games Tournament model assisted by interactive multimedia influences the learning outcomes of the knowledge aspect of elementary school students in cluster XII, Bengkulu City.
11	Heryanto, D et al 2025	2025	Quantitative research using a quasi-experiment method, structured in "The Matching only pretest-Posttest control Group Design."	Statistical analysis yielded a t-count value of 5.786 with a significance value of 0.000 ($p < 0.001$), indicating a significant difference between the two groups. The t-count value greater than the t-table and the low significance value reinforces the argument that the innovative learning approach positively influences the historical literacy ability of grade IV students.
12	Yusnia, Y., Heryanto, D	2025	Quantitative research using the Experiment method with a One Group Pretest-Posttest design.	Interactive learning media integrated with Augmented Reality showed moderate effectiveness in its development. In other words, the intervention conducted through this application successfully increased

	learning achievement by \$57.01\%\$, which can be categorized as sufficiently effective on students' cultural understanding ability.

2. Supporting Factors and Causes of Failure

Key supporting factors include the readiness of school technological infrastructure, teacher competence in managing digital media, and parental support. Conversely, constraints or causes of failure are often linked to the lack of training in digital media use, hardware limitations in schools, and students' insufficient understanding of the digital media itself (Zulaiha et al., 2025). The following table summarizes the supporting and constraining factors.

Table 1. The Supporting and Constraining Factors

Supporting Factors	Constraining Factors
Adequate technological infrastructure	Lack of teacher training on media used
Parental support	Hardware limitations
Teacher competence in digital media	Students' lack of understanding (of digital media)

3. Bibliometric Mapping of Interactive Multimedia Integrated with PBL and Environmental Literacy

Bibliometric mapping regarding interactive multimedia integrated with Problem-Based Learning (PBL) concerning environmental literacy is an essential study in understanding how technology and modern learning methods can enhance environmental awareness and knowledge among students. In this context, research indicates that implementing PBL coordinated with the principles of sustainable education and environmental literacy can lead to more effective and profound learning.

This network visualization, based on keyword co-occurrence data, sharply maps the thematic structure within Environmental Literacy research. The central keyword, Environmental Literacy, has the largest node size and acts as the gravitational core, confirming its position as the primary topic. The map reveals three main interconnected thematic clusters: (1) The Core Human and Motivation Cluster (Green Lines), which is most strongly and directly linked to Environmental Literacy, including "human", "motivation", and "learning", highlighting the research focus on fundamental psychological and pedagogical aspects. (2) The Technology and Digital Learning Cluster (Red Lines), encompassing themes like "e-learning", "multimedia systems", and "interactive computer systems", indicates that a significant portion of the research is

delivered or analyzed in the context of information technology and online learning systems. (3) The Methodology and Outcomes Cluster (Light Blue Lines), which includes "problem-based learning" and "learning outcomes", demonstrates researchers' attention to how specific teaching methods affect the results of Environmental Literacy. Although this image does not directly present co-authorship data or temporal freshness trends (usually represented by publication year colors), it effectively visualizes the strong interconnections between Environmental Literacy, the development of motivation and learning, and the application of digital systems and problem-based learning methods within the academic environment.

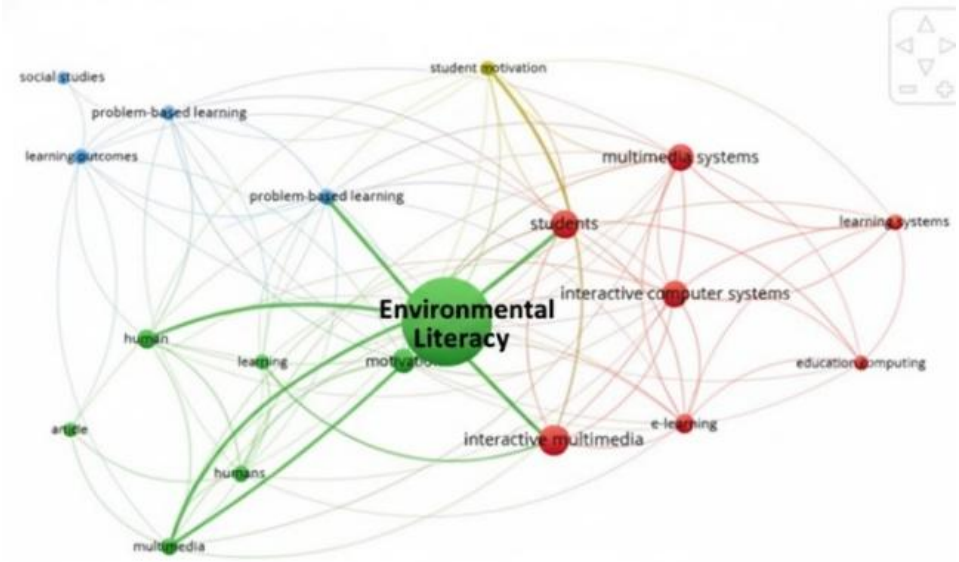

Figure 1. Bibliometric Visualization Results

The implementation of PBL in sustainable education has a positive impact on students' development of environmental literacy. Zulfah et al. (2024) propose that PBL integrated with Education for Sustainable Development (ESD) helps students improve their understanding of environmental, social, and economic issues, including the importance of balance between human needs and the environment. By using an interdisciplinary approach, students not only learn theory but also engage directly in real-world cases relevant to their local context, which supports the enhancement of environmental literacy (Zulfah et al., 2024; Sukri, 2023).

Interactive multimedia serves as an important tool in delivering learning materials related to the environment. The use of technology in learning, such as Augmented Reality (AR) applications and interactive videos, has proven to increase

student engagement in the learning process. For example, research by Islami (2025) indicates that the use of well-designed interactive videos can foster student interest and participation, as well as improve knowledge retention about environmental material. Similarly, Suryani et al. (2020) find that interactive multimedia is capable for providing a richer context for students to understand environmental issues, while also developing their character.

The collaboration between various learning approaches, such as PBL and the use of interactive media, encourages students to be more active learners and adaptable to technology. In a study by Puspita et al. (cited in Suryani et al., 2020), it concludes that using interactive media not only assists science learning but also develops environmental awareness among students. Active student involvement in problem-based projects, guided by teachers, can improve learning outcomes and their understanding of current environmental issues (Fuadati & Yusro, 2023).

Furthermore, bibliometric mapping of existing research can provide insight into trends in PBL and environmental literacy studies. Shafarin et al. (2025) state that the understanding of environmental literacy is often influenced by the teaching methods used. Studies indicate an increase in student interest and comprehension when learning is integrated with interactive technology and contextual approaches relevant to their daily lives (Shafarin et al., 2025; Sukri, 2023). By utilizing the right tools and methods, educators can design more meaningful and relevant learning experiences for students, thereby supporting better development of environmental literacy in society.

Discussion

The integration of Problem-Based Learning (PBL) and interactive multimedia has gained prominence as an effective pedagogy to enhance environmental literacy among elementary students. Environmental literacy, which encompasses knowledge, skills, and attitudes necessary for responsible environmental behavior, is increasingly recognized as critical in educational curricula. Research has demonstrated that employing PBL alongside interactive multimedia fosters engagement and motivation in students and effectively nurtures their understanding of environmental issues, preparing them as conscientious future citizens (Widowati et al., 2021)(Herlanti, 2022; (Pratiwi et al., 2024). This paper conducts a bibliometric analysis to shed light on the existing research landscape, focusing on how integrating PBL and multimedia enhances environmental literacy for elementary students.

PBL fundamentally shifts the role of students from passive recipients to active participants in their learning environment. According to Widowati et al., students exhibit heightened engagement and motivation when engaged in PBL, noting that it significantly increases their interest in environmental education (Widowati et al., 2021). In another study, the implementation of Local Environmental Problem-Based Learning creates a noticeable improvement in students' sensitivity and awareness towards environmental issues, suggesting that integrating real-world problems into the learning process deepens students' connections with their environment (Herlanti, 2022). The correlation between PBL and learner engagement has been substantiated across various studies, highlighting its efficacy in improving not only environmental knowledge but also critical thinking and problem-solving abilities essential for environmental stewardship (Wajdi et al., 2022; Suryawan et al., 2025)(Rahman et al., 2024; Rachman et al., 2021).

The findings of several studies indicate that exposure to PBL encourages students to explore various approaches to real-world environmental challenges (Wajdi et al., 2022; (Pratiwi et al., 2024). This actively engages learners in research and collaborative projects that yield a deeper understanding of environmental contexts and sustainable practices. Furthermore, roles often designated to teachers expand beyond mere knowledge transmitters to facilitators, thereby enriching the learning experience (Herlanti, 2022; Quezada et al., 2024). As such, studies confirm that PBL serves as a robust educational model through which students achieve higher levels of environmental literacy.

Interactive multimedia presents a notable enhancement to the PBL framework. Research indicates that integrating technology and interactive elements into learning can significantly boost students' engagement and comprehension of complex environmental concepts (Wajdi et al., 2022; Suryawan et al., 2025). For instance, the use of video-assisted instruction in a classroom setting has shown to bolster students' learning capabilities and motivation, demonstrating the potential of multimedia to facilitate a dynamic and interactive learning environment that resonates with today's digital natives (Putri et al., 2025; Rediyono, 2025).

Moreover, studies have examined the effectiveness of using multimedia tools within the PBL context, finding that these resources can bridge gaps in learners' understanding of abstract concepts in environmental science (Hodaifah et al., 2025) (Saubari & Sudatha, 2023). The interactive elements engage multiple senses, thus aiding

retention and providing a more profound connection to the subject matter. Additionally, facilitating group dynamics through shared multimedia experiences leads to enhanced collaborative learning, fostering a social constructivist environment conducive to personal investment in environmental topics (Fikry & Rahmatina, 2023; Poniyanti et al., 2024).

A significant aspect of enhancing environmental literacy through PBL and interactive multimedia lies in developing critical thinking skills among students. Research has illustrated the capacity of these educational strategies to effectively train students in analytical and evaluative reasoning, vital for addressing environmental issues (Wajdi et al., 2022; (Pratiwi et al., 2024). The dynamic environment encouraged by PBL allows learners to engage in discussions and apply their knowledge to solve real-world problems, supporting critical inquiry. This approach equips students with the competence to assess various sources of information, consider multiple scientific viewpoints, and devise sound solutions to environmental challenges (Rahman et al., 2024; Hodaifah et al., 2025).

Pratiwi et al. find that multimedia has augmented students' critical thinking prowess significantly, demonstrating that such pedagogical methods aid in conceptual understanding and prepare students to act responsively concerning environmental issues (Pratiwi et al., 2024). Furthermore, critical thinking fosters an analytic approach, encouraging students to question assumptions and seek evidence-based solutions, which are necessary traits for nurturing environmentally aware citizens (Wajdi et al., 2022; Rachman et al., 2021). The cumulative effect of these educational practices collectively boosts students' holistic understanding of environmental topics and their consequences.

The fusion of PBL with local wisdom and cultural elements, when implemented through multimedia, proves crucial in contextualizing environmental education for local students (Sukri, 2023; Suryawati et al., 2020). By integrating local environmental issues into the learning process, educators can create relevance for students, facilitating a greater sense of ownership and accountability towards their immediate environment. Research indicates that utilizing culturally pertinent examples in PBL scenarios enhances engagement and promotes a deeper understanding of local biodiversity and sustainability practices (Sukri, 2023; Suryawati et al., 2020).

The inclusion of local wisdom assists in showcasing the interconnectedness of

human activities and environmental outcomes, thereby fostering critical environmental literacy (Kusmanto, 2025; Suryawati et al., 2020). This pedagogical strategy encourages students to appreciate their cultural heritage while simultaneously grappling with modern environmental challenges. Collaborative multimedia projects grounded in local contexts can extend the reach of PBL, transcending traditional classroom boundaries and reinforcing students' connection to their community and environment.

CONCLUSION

The In conclusion, the integration of PBL and interactive multimedia represents a transformative approach to enhancing environmental literacy among elementary school students. Research illustrates the positive impacts, including increased engagement, critical thinking, and a holistic understanding of environmental issues. Nevertheless, future research is necessary to continue exploring the nuances of this pedagogical strategy, particularly in diverse educational contexts and concerning environmental challenges as they evolve. As such, it is vital for educators to receive appropriate training in multimedia tools and PBL methodologies, ensuring a coherent approach toward fostering environmental literacy in an increasingly complex world. Continued empirical studies will further solidify the foundational principles established herein, and enhance academic discourse surrounding environmental education in elementary settings.

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