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Systematic Literature Review (SLR): Integrated Problem-Based Learning (PBL) Model for Ecotourism to Enhance Scientific Literacy and Environmental Awareness

Khaerus Syahidi[1,2], A. Wahab Jufri[2], Aris Doyan[3], Kosim[4], Joni Rokhmat[2], AA Sukarso[5]

[1] Program Studi Pendidikan Fisika, Universitas Hamzanwadi, Selong, Indonesia.
[2] Program Doktor Pendidikan IPA, Pascasarjana, Universitas Mataram, Indonesia.
[3] Magister Pendidikan IPA, Pascasarjana, Universitas Mataram, Indonesia
[4] Prodi Pendidikan Fisika, FKIP, Universitas Mataram, Indonesia
[5] Prodi Pendidikan Biologi, FKIP, Universitas Mataram, Indonesia

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Corresponding author:
Khaerus Syahidi
khaerussyahidi@hamzanwadi.ac.id

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Abstract: The problem-based learning (PBL) model is a form of learning that emphasizes the learning process and developing problem-solving skills. The low level of environmental awareness is increasingly worrying. Ecological awareness, in this case ecotourism, is decreasing along with technological developments. For this reason, scientific literacy and environmental awareness are needed, especially in character formation. This article research conducted a systematic literature review using PRISMA approach, namely carrying out a synthesis of studies from articles on the theme of the ecotourism-integrated problem-based learning (PBL) model to increase scientific literacy and environmental awareness. The articles used in this paper are from Google Scholar, scopus and science direct with the application of proportional sampling techniques, 15 of the 72 articles that meet the inclusion criteria, the year of publication between 2020 until 2024, the languages used are Indonesian and English, the research subject is Problem-Based Learning (PBL). The research results show that PBL has positive potential in increasing scientific literacy and environmental awareness. Both the use of the PBL model directly and with integration show an increase in scientific literacy and concern for the environment.

Keywords: Environmental awareness; PRISMA; problem-based learning (PBL); Scientific literacy; Systematic literature review.

Introduction

The environmental problem is no longer just an Indonesian problem but has become a global problem. The Sustainable Development Goals (SDGs) were created to answer the world's demands in addressing five major issues, namely planet earth, prosperity, peace, interconnected partnerships, and humans (Kementerian Perencanaan Pembangunan Nasional/BAPPENAS, 2017), (Lambini et al., 2021).

Ecotourism represents a responsible approach to tourism that prioritizes the preservation of natural areas, delivers economic advantages, and upholds the cultural integrity of local communities. While this journey is adventurous, it offers tourists an enjoyable experience. Ecotourism consistently upholds the quality, integrity, and sustainability of both nature and culture by ensuring community support. The involvement of local communities is crucial in efforts to preserve the integrity of the environment. This involvement spans from the planning phase through the implementation of development and oversight in the utilization of resources (Fandeli, 2000).

Scientific literacy is characterized as the capacity to utilize scientific knowledge to formulate questions, acquire new insights, elucidate scientific phenomena, and derive conclusions grounded in scientific evidence. This capability is essential for comprehending and

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making informed decisions regarding the natural world and the alterations imposed upon it by human activities. In essence, scientific literacy encompasses the ability to grasp scientific concepts and their practical applications (Hakim, 2023). Scientific literacy is essential for effectively applying knowledge to address problems encountered in everyday life, whether in personal, social, or global contexts (Mujtahid et al., 2021).

To comprehend the integration of ecotourism in enhancing scientific literacy and environmental awareness, it is essential to implement Problem-Based Learning (PBL). Problem-Based Learning (PBL) is an educational model wherein students encounter a real-world problem that they have experienced. (Wood, 2003) ontends that the problem-based learning model constitutes a teaching and learning process that introduces contextual challenges, thereby stimulating students to engage in learning. These problems are presented prior to the learning process to encourage students to investigate, articulate, and devise solutions to the issues at hand.

The PBL learning model is characterized by its emphasis on students as active learners and on addressing authentic or relevant problems, which are resolved through the application of their existing knowledge and information from various sources (Dahlia, 2022). The objective of this article is to elucidate the implementation of the integrated problem-based learning (PBL) model in ecotourism, aimed at enhancing scientific literacy and environmental awareness through. The study has the following problem statement:

1. What is the trend of research of integrated problem-based learning (PBL) model for ecotourism to enhance scientific literacy and environmental awareness from 2020 to 2024?
2. How do science learning strategies facilitate integrated problem-based learning (PBL) model for ecotourism to enhance scientific literacy and environmental awareness?
3. What are the aspect and instruments used to measure integrated problem-based learning (PBL) model for ecotourism to enhance scientific literacy and environmental awareness?
4. How is research on integrated problem-based learning (PBL) model for ecotourism to enhance scientific literacy and environmental awareness?
5. What is the integrated problem-based learning (PBL) model for ecotourism to enhance scientific literacy and environmental awareness?

Method

The research methodology employed in composing this article is a systematic literature review using PRISMA, where in researchers analyze various studies pertinent to the topic at hand. The criteria for the studies examined in this article include published articles or journals sourced from Google Scholar, scopus and science direct, utilizing keywords aligned with the research theme from the past four years (2020-2024). The languages utilized are English and Indonesian, and the focus of the study is on public comprehension of ecotourism aimed at enhancing scientific literacy and environmental awareness through Problem-Based Learning (PBL)

Data Collection and Eligibility Criteria

The data collection process was carried out manually by extracting data based on content analysis such as article type, journal name, year of publication, topic, title, research methodology, relationship between variables, indicators and research results in the form of the integrated problem-based learning (PBL) model for ecotourism to enhance scientific literacy and environmental awareness.

The inclusion criteria (IC) that guide the preparation of this systematic literature review are explained as follows:

1. IC1: all original and peer-reviewed literature is written in Bahasa and English.
2. IC2: research aims to determine the integrated problem-based learning (PBL) model for ecotourism to enhance scientific literacy and environmental awareness.
3. IC3: research uses quantitative, qualitative or both metods, namely mixed metods (qualitative and quantitative).

Data items

Data items extracted from each article are summarized into the following categories: year of publication, researcher, research method, research variables, and research results on the integrated problem-based learning (PBL) model for ecotourism to enhance scientific literacy and environmental awareness. The steps for the systematic literature review process are presented in full in Figure 1.

The initial sample was 213 scientific articles based on previously determined keywords. Next, articles were selected based on title, abstract, and keywords, so 97 relevant empirical studies were found. Among the 72 empirical studies, 15 were identified as appropriate to the selection criteria after thoroughly reviewing their entire content based on criteria 2 and 3. The total number of articles used in this systematic literature review is 15 empirical research articles used to discuss integrated problem-based learning (PBL) model for ecotourism to enhance scientific literacy and environmental awareness.

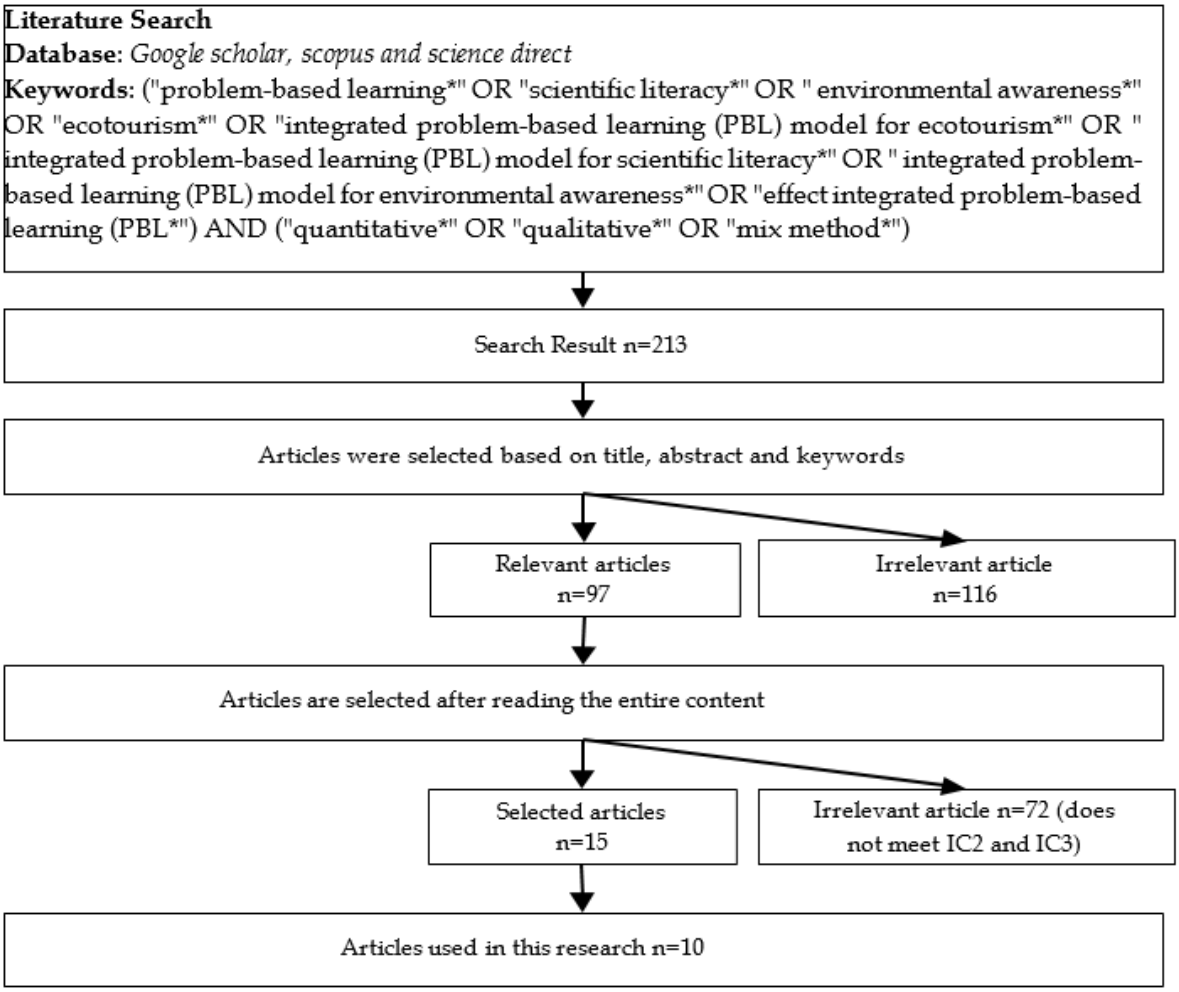

Figure 1. Reporting Items for Systematic Reviews (Adoption of PRISMA) Source: Researcher Process (2024)

Results and Discussion

Tabel 1. List and synthesis of articles

Author	Title	Method	Variable	Result
Fathiah Alatas, Laili Fauziah (2020)	Problem-based learning (PBL) model aimed at enhancing scientific literacy skills regarding the concept of global warming.	Quasi-exsperiement research with non-equivalent control group design	The problem-based learning (PBL) model enhances students' scientific literacy skills.	The study's results indicated that students' scientific literacy skills improved through the problem-based learning (PBL) model concerning the concept of global warming.
Yeyendra, Mellisa, Ibnu Hajar, Sandra Puspitasari, Rosi Santika (2024)	Ethnoecology Integrated Online Problem-Based Learning (e-PBL) Model for Enhancing Environmental Literacy among Biology Education Students	Quasi Experimental Design with Non-Equivalent Control Group Design.	Integrated Ethnoecology Problem-Based Learning (e-PBL) Online Learning Model for Enhancing Students' Environmental Literacy	The study's results indicated that the independent sample t-test yielded a Sig. (2-tailed) value of less than 0.05 when comparing the experimental and control groups. In conclusion, the ethnoecology-integrated e-PBL learning model positively influences the environmental literacy skills of biology education students.
Aswan, Ramlawati, Rahmia (2024)	Implementation of the Problem-Based Learning (PBL) Model with the Teaching at the Right Level (TaRL) Approach to Enhance Students' Science Literacy Skills in	Design kemmis and mc taggart	Problem-Based Learning (PBL) Model with the Teaching at the Right Level (TaRL) Approach to enhance students' scientific literacy	The results indicated an enhancement in scientific literacy indicators, including problem identification, explanation of scientific phenomena, and hypothesis generation from cycle 1 to cycle 3. The average N-Gain also demonstrated an increase from the first to the third cycle.

Author	Title	Method	Variable	Result
	Environmental Pollution Topics		skills regarding environmental pollution.	
Neng Leli Nailul Zulfah, Shinta Purnamasari, Dudung Abdurrahman (2024)	Implementation of problem-based learning (PBL) integrated with education for sustainable development (ESD) to enhance students' environmental literacy regarding energy.	One-group pretest-posttest with pra-eksperimental design	Problem-based learning (PBL) integrated with education for sustainable development (ESD) enhances students' environmental literacy.	The results indicate that the environmental literacy N-gain is 0.61, suggesting that PBL learning, when integrated with ESD, positively influences the enhancement of students' environmental literacy. With the integration of ESD and environmental literacy through project-based learning, students can gain a deeper understanding of sustainability issues and Cultivate a mindset of environmental stewardship
Retno Palupi (2020)	Effectiveness of the Problem-Based Learning Model in Enhancing High School Students' Science Literacy Regarding Colloid Material	Pre-eksperimen with One-Group Pretest-Posttest Design	Problem-Based Learning Model to Enhance High School Students' Science Literacy Skills	The results indicate that the significance value of students' scientific literacy abilities yields a tcount greater than ttable, demonstrating a significant difference between the pretest and posttest scores. The N-gain test revealed an increase of 0.46, categorizing it as moderate. Additionally, students expressed positive feedback regarding the implementation of the Problem Based Learning (PBL) model in relation to colloid material.
Irsyaad Hafizd (2023)	Development of LKPD Utilizing Project-Based Learning Materials on the Mangrove Ecosystem to Enhance Environmental Awareness Among Students of SMP Negeri 261 Jakarta	ADDIE Models	Problem-Based Learning Model	The outcomes of the development of Student Worksheets (LKPD) grounded in Project Based Learning are deemed feasible based on the validation results from experts in language, graphics, learning models, mangroves, and environmental science. The validation results from language, graphics, and learning model experts yielded a percentage of 97.33%, while the validation from mangrove experts resulted in a value of 82%, and the validation from environmental experts achieved a value of 93.33%, all categorized as very valid. The implementation results indicated an increase of 1.26%, classified as an insignificant increase.
Lutfiyanti Fitriah, Ita (2022)	Development of BioPhy Magazine Containing Local Wisdom to Improve Problem Solving Ability and Promote Environmental Awareness Campaign	Quantitative descriptive research method (Model Tessmer)	Promote Environmental Awareness Campaign	The analysis results indicate that the BioPhy magazine is valid, effective in enhancing problem-solving skills, and successful in motivating students to engage in environmental awareness campaigns.
Roswita M. Aboe, Naniek Jusnita (2022)	The Implementation of Project-Based Learning in Designing Ecotourism Learning Media	A mixed method of quantitative and qualitative descriptive analysis.	Project-Based Learning in Designing Ecotourism Learning Media students' perceptions	The results indicated that 24 respondents achieved scores within the very good category, reflecting a high level of understanding among students regarding the learning process of a project. The alignment of English content with ecotourism courses corresponds well with project-based learning, facilitating a conducive teaching and learning environment that yields high scores. Conversely, the

Author	Title	Method	Variable	Result
				lowest scores among respondents were recorded in project-based learning aimed at enhancing their skills, motivation, and mastery of the material, which ultimately supports their learning. In terms of implementation, respondents attained an overall score of 83.00 in the presentation assessment.
Aditya Fahlevi, Zuhdan Kun Prasetyo, Suyanta, Sabar Nurohman, Sri Rejeki Dwi Astuti (2023)	Profile of Students' Environmental Literacy and the Needs of Science Teaching Materials Integrated with the Local Potential of Rawa Bento Based on Problem Based Learning	Quantitative descriptive research method	Determine the profile of environmental literacy among junior high school students and the need for integrated science teaching materials based on problem-based learning (PBL)	The study's findings indicated that: 1) a significant proportion of students exhibit low environmental literacy scores, with 38.9% classified as having low levels, 54.4% falling into the moderate category, and merely 6.7% achieving high levels; 2) students demonstrate the least proficiency in analyzing the impacts of environmental issues; 3) there is a pressing need for the integrated development of project-based learning (PBL) electronic teaching materials in Rawa Bento to enhance students' environmental literacy.
Faizah Maulida, Ida Farida, Neneng Windayani (2023)	How to Improve Students' Environmental Literacy on Plastic Waste Issues: Problem-Based Flipped Classroom	A pre-experimental approach with a one-group pretest-posttest design.	Environmental Literacy on Plastic Waste Issues: Problem-Based for Student	The results indicated that students possess a favorable attitude toward environmental issues. Notably, the application of the problem-based flipped classroom model focused on the subject of plastic waste significantly enhances students' literacy and deepens their comprehensive understanding of critical issues such as this.
Natale, C. C., Mello, P. S., Trivelato, S. L. F., Marzin-Janvier, P., & Manzoni-de-Almeida, D. (2021)	Evidence of Scientific Literacy Through Hybrid and Online Biology Inquiry-Based Learning Activities	Numerical experimental data (qualitative method)	Scientific Literacy Through Hybrid and Online Biology Inquiry-Based Learning Activities	Results show the emergence of epistemic practices in the written discourse of the students participating in online and hybrid modalities.
Kong, S. C., Cheung, M. Y. W., & Tsang, O. (2024)	Developing an artificial intelligence literacy framework: Evaluation of a literacy course for senior secondary students using a project-based learning approach	Course participants, Course administration and design, Instruments (quantitative and qualitative method)	Artificial intelligence literacy framework, literacy course for senior secondary students using a project-based learning	Both the quantitative and qualitative results indicated that the students' competence in using AI to solve problems had increased, as had their confidence and readiness to do so.
Kim, S. L., & Kim, D. (2021)	English learners' science-literacy practice through explicit writing instruction in invention-based learning	Iinterviews, observations, and field notes (quantitative and qualitative method)	Science-literacy practice through explicit writing instruction in invention-based learning	As a result, although L2 learners experienced struggles during the writing process, students' language skills and conceptual learning developed. In addition, students perceived writing as an essential skill for learning science
Almulla, M. A. (2020)	The effectiveness of the project-based learning (PBL) approach as a way to engage students in learning	Structural equation modeling (SEM), a quantitative research method	The project-based learning (PBL) approach as a way to engage students in learning	The results show that the PBL technique improves student engagement by enabling knowledge and information sharing and discussion. Thus, the PBL approach is highly recommended for educational use by students and should be encouraged in universities.

Author	Title	Method	Variable	Result
Saad, A., & Zainudin, S. (2022)	A review of Project-Based Learning (PBL) and Computational Thinking (CT) in teaching and learning	Structural equation modeling (SEM), a quantitative research method	Project-Based Learning (PBL) and Computational Thinking (CT) in teaching and learning	Several important implications could help educators develop an effective PBL-CT course design and provide some guidelines for future research. An effective PBL-CT integration enhances teaching and learning besides improving students' computational thinking skills. Thinking skills are critical 21st-century skills needed for students' success.

The study analyzes the profile of studies on problem-based learning (PBL) model, the trend of research of problem-based learning (PBL) model for ecotourism to enhance scientific literacy and environmental awareness from 2020 to 2024, how do science learning strategies facilitate problem-based learning (PBL) model for ecotourism to enhance scientific literacy and environmental awareness, what are the aspect and instruments used to measure problem-based learning (PBL), how is research on problem-based learning (PBL) model for ecotourism to enhance scientific literacy and environmental awareness, what is the correlations problem-based learning between problem-based learning (PBL) model for ecotourism to enhance scientific literacy and environmental awareness.

The profile of research on problem-based learning (PBL) model for ecotourism to enhance scientific literacy and environmental awareness based on the number of publications from 2020 to 2024. Difference type of research on the theme of integrated problem-based learning (PBL) model for ecotourism to enhance scientific literacy and environmental awareness is some article combine with another method in their reseach and the others only using one variable like a critical and creative thinking. Various types of research are concluted to study problem-based learning (PBL) model. The difference in these types of research are categorized into empirical research article.

From the analyzed articles, from the research (Alatas & Fauziah, 2020) Students' scientific literacy skills improve through the problem-based learning (PBL) model concerning the concept of global warming. Research (Yeyendra Yeyendra, 2024) found the findings indicate that the ethnoecological integrated e-PBL learning model positively influences the environmental literacy skills of biology education students.

The implementation of the Problem-Based Learning (PBL) Model alongside the Teaching at the Right Level (TaRL) Approach demonstrates an enhancement in scientific literacy indicators, including problem identification, explanation of scientific phenomena, and hypothesis formulation from cycle 1 to cycle 3. The average N-Gain also reflects an improvement from the first to the third cycle (Rahmia, 2023; Syahidi et al., 2020).

Research from (Neng Leli Nailul Zulfah, 2024)(Jauhariyah et al., 2021) indicate that the environmental literacy N-gain is 0.61, suggesting that PBL learning, when integrated with ESD, positively influences the enhancement of students' environmental literacy. With the integration of ESD and environmental literacy through project-based learning, students can gain a deeper understanding of sustainability issues and cultivate a mindset of environmental.

These results are also in line with findings by (Palupi, 2020) indicate that the significance value of students' scientific literacy abilities yields a tcount greater than ttable, demonstrating a significant difference between the pretest and posttest scores. The N-gain test revealed an increase of 0.46, categorizing it as moderate. Additionally, students expressed positive feedback regarding the implementation of the Problem Based Learning (PBL) model in relation to colloid material.

The research by (Irsyaa Hafidz, 2023) The outcomes of the development of Student Worksheets (LKPD) grounded in Project Based Learning are deemed feasible based on the validation results from experts in language, graphics, learning models, mangroves, and environmental science. The validation results from language, graphics, and learning model experts yielded a percentage of 97.33%, while the validation from mangrove experts resulted in a value of 82%, and the validation from environmental experts achieved a value of 93.33%, all categorized as very valid. The implementation results indicated an increase of 1.26%, classified as an insignificant increase.

(Fitriah & Ita, 2022) research result indicate that the BioPhy magazine is valid, effective in enhancing problem-solving skills, and successful in motivating students to engage in environmental awareness campaigns.

Research from (Aboe, R. M., Jusnita, N., & Berbasis Proyek, 2022) indicated that 24 respondents achieved scores within the very good category, reflecting a high level of understanding among students regarding the learning process of a project. The alignment of English content with ecotourism courses corresponds well with project-based learning, facilitating a conducive teaching and learning environment that yields high scores. Conversely, the lowest scores among respondents were recorded in project-based learning aimed at enhancing

their skills, motivation, and mastery of the material, which ultimately supports their learning. In terms of implementation, respondents attained an overall score of 83.00 in the presentation assessment.

The study's from (Fahlevi et al., 2023) findings indicated that: 1) a significant proportion of students exhibit low environmental literacy scores, with 38.9% classified as having low levels, 54.4% falling into the moderate category, and merely 6.7% achieving high levels; 2) students demonstrate the least proficiency in analyzing the impacts of environmental issues; 3) there is a pressing need for the integrated development of project-based learning (PBL) electronic teaching materials in Rawa Bento to enhance students' environmental literacy.

The result from (Maulida et al., 2023) research indicated that students possess a favorable attitude toward environmental issues. Notably, the application of the problem-based flipped classroom model focused on the subject of plastic waste significantly enhances students' literacy and deepens their comprehensive understanding of critical issues such as this.

Resarch from (Natale et al., 2021) show the emergence of epistemic practices in the written discourse of the studentsn participating in online and hybrid modalities. That mean is possible to promote student engagement in scientific practices related to biology through online and hybrid instruction.

This study evaluated an AI literacy course designed to endow senior secondary students with the knowledge and skills to solve real-life problems using (Yeyendra Yeyendra, 2024)AI (Yeyendra Yeyendra, 2024). The course adopted a PBL pedagogical approach in which students, guided by instructors, developed AI applications to solve self-defined problems. Both the quantitative and qualitative results indicated that the students' competence in using AI to solve problems had increased, as had their confidence and readiness to do so (Siu-Cheung Kong, Man-Yin William Cheung, 2024).

The study result by (Kim & Kim, 2021) although L2 learners experienced struggles during the writing process, students' language skills and conceptual learning developed. In addition, students perceived writing as an essential skill for learning science.

The results show in research by (Almulla, 2020) the PBL technique improves student engagement by enabling knowledge and information sharing and discussion. Thus, the PBL approach is highly recommended for educational use by students and should be encouraged in universities.

The result from (Aslina Saad, 2022) several important implications could help educators develop an effective PBL-CT course design and provide some guidelines for future research. An effective PBL-CT integration enhances teaching and learning besides improving students' computational thinking skills. Thinking skills are critical 21st-century skills needed for students' success.

Several studies have proven that the application of an integrated problem-based learning (PBL) model in ecotourism can increase scientific literacy and environmental awareness.

Conclusion

A comprehensive review of the systematic literature review using PRISMA indicates that a variety of research methodologies are employed to address issues within the field. The findings from the article review suggest that environmental pollution serves as the most relevant subject matter for application. This is attributed to the prevalence of environmental challenges that can be utilized within educational models. The PBL model discussed in the reviewed articles encompasses both the traditional PBL approach and a hybrid model that integrates blended learning. The implementation of the PBL model in science education has been shown to enhance students' scientific literacy, whether through the pure PBL model or the integrated approach. Nonetheless, there exists research indicating that while the PBL model combined with blended learning can also foster improvements in scientific literacy, the N-Gain Score assessment, which evaluates the differences between pretest and posttest results, did not demonstrate a significant enhancement in students' scientific literacy skills due to their unfamiliarity with blended learning. The benefits of employing the problem-based learning (PBL) model include the cultivation of critical and creative thinking, the enhancement of independent problem-solving abilities, and a notable increase in learning motivation. The benefits of employing the problem-based learning (PBL) model include the cultivation of critical and creative thinking, the enhancement of independent problem-solving abilities, and a notable increase in learning motivation

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Conflict of Interest

The content of this article does not create a conflict of interest.

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