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Reconstructing the Philosophy of Science in the Project-Based Eco-Citizenship Learning Model for Elementary Education: A Systematic Literature Review

[1] Chairan Zibar L.Parisu, [2]Insih Wilujeng, [3]Woro Sri Hastuti, [4]Arna Juwairiyah

[1,2,3,4] Universitas Negeri Yogyakarta, Indonesia

[1]chairanzibarl.parisu@gmail.com, [2] insih@uny.ac.id [3] woro_srihastuti@uny.ac.id, [4]arnajuwairiyah89@gmail.com.

ABSTRACT : This study aims to examine the reconstruction of the philosophy of science in the Project-Based Eco-Citizenship learning model in elementary education through a Systematic Literature Review (SLR) approach. This study examines 30 selected articles from the Google Scholar, Scopus, and SINTA databases published in 2015–2025. The analysis was conducted using the PRISMA stages and thematic analysis examined from the perspective of the philosophy of science, namely ontological, epistemological, and axiological dimensions. The results of the study indicate that ontologically, students are positioned as active subjects who learn through direct interaction with the environment as the real reality of learning. Epistemologically, knowledge is built through experience, collaboration, and reflection in contextual project activities so that learning becomes more meaningful and applicable. Meanwhile, axiologically, this model plays a role in instilling the values of environmental concern, social responsibility, and sustainability that shape the character of eco-citizens in students. The integration of these three dimensions shows that Project-Based Eco-Citizenship is not only oriented towards cognitive achievement, but also character development and ecological awareness. Thus, this model is relevant to the demands of the Independent Curriculum and the strengthening of 21st-century skills in forming a generation that is critical, collaborative, creative, and cares about the environment.

Key words: Project-Based Learning, Eco-Citizenship, Philosophy of Science, Environmental Education

INTRODUCTION

Twenty-first-century education requires a transformation of learning paradigms that are no longer solely oriented toward knowledge transmission but rather toward the development of holistic competencies, including character formation, ecological literacy, and higher-order thinking skills. This transformation is closely linked to global dynamics that demand the preparedness of younger generations to address increasingly complex social and environmental challenges. In this context, project-based learning has emerged as a relevant educational approach because it effectively integrates knowledge acquisition with authentic learning experiences. Previous studies have demonstrated that project-based learning can

enhance ecological awareness and actively engage students in environmental issues (Mahsun et al., 2025; Putra et al., 2024). Therefore, primary schools play a strategic role in fostering environmental awareness from an early age.

Global environmental challenges, such as climate change, pollution, and ecosystem degradation, underscore the urgency of integrating environmental education into formal education systems. Learning activities that focus solely on theoretical knowledge are insufficient to cultivate environmentally responsible behavior. Research conducted by Indra and Eliza (2024) found that the implementation of Project-Based Learning (PjBL) significantly improved students' environmental care character. Similarly, project-based learning that focuses on local environmental issues has proven effective in enhancing students' ecological awareness (Kim & Lee, 2025). These findings indicate that contextual learning approaches are essential for developing meaningful environmental understanding.

One innovative approach to environmental education is the integration of Project-Based Learning with the concept of eco-citizenship. This model provides students with opportunities to learn through direct experiences by addressing authentic environmental problems. Gal (2024) reported that project-oriented approaches, such as hackathon learning, significantly increase students' active participation in environmental issues. Furthermore, project-based learning has been shown to improve students' critical thinking and collaborative skills (Wahyuni & Suharini, 2025). Thus, PjBL serves not only as a strategy for enhancing cognitive outcomes but also as a means of fostering students' social and ecological awareness.

The implementation of Project-Based Eco-Citizenship has yielded various positive outcomes. Anggraini and Herwin (2025) demonstrated that a project-based STEAM approach effectively enhanced students' environmental awareness through the integration of multiple disciplines. Likewise, the Ethno-STEM approach contributed to contextualizing learning by connecting educational activities with local cultural values (Pada et al., 2024). In addition, the use of creative media such as ecoprint within project-based learning significantly increased student engagement and environmental awareness (Dewi et al., 2024). These findings highlight the importance of pedagogical innovation in strengthening the effectiveness of environmental education.

Project-based approaches can also be enhanced through the integration of technology and interactive learning media. Laili et al. (2025) found that interactive media based on PjBL improved students' understanding of Integrated Science and Social Studies (IPAS). Furthermore, project-based learning that utilizes local resources, such as eco-enzyme projects, has proven effective in improving students' skills and

environmental awareness (Al-Bahij et al., 2024). These findings suggest that project-based learning offers considerable flexibility for adaptation to diverse educational needs and learning contexts.

Despite extensive evidence supporting the effectiveness of PjBL in environmental education, its implementation continues to face several challenges, particularly regarding the strengthening of its conceptual and philosophical foundations. Many educational practices remain focused on technical implementation without being supported by a robust theoretical framework. Philosophical foundations are essential because they provide direction, purpose, and meaning to the learning process. Without a clear conceptual basis, learning activities risk becoming procedural rather than meaningful experiences for students.

Moreover, bibliometric studies indicate that research on PjBL has continued to increase; however, it remains largely dominated by practical and implementation-oriented studies rather than in-depth philosophical investigations (Fawaida et al., 2025). This trend reveals a significant research gap, particularly concerning the reconstruction of the philosophy of science within project-based learning. Therefore, an approach that integrates ontological, epistemological, and axiological dimensions is required to provide a more comprehensive foundation for learning.

Based on these considerations, reconstructing the philosophy of science within the Project-Based Eco-Citizenship learning model is essential to strengthen both its theoretical and practical foundations in primary education. Accordingly, this study employs a Systematic Literature Review (SLR) approach to comprehensively examine existing research in this area. The findings are expected to contribute to the development of innovative learning models that not only improve learning outcomes but also cultivate environmentally responsible students who are capable of contributing to sustainable development.

METHOD

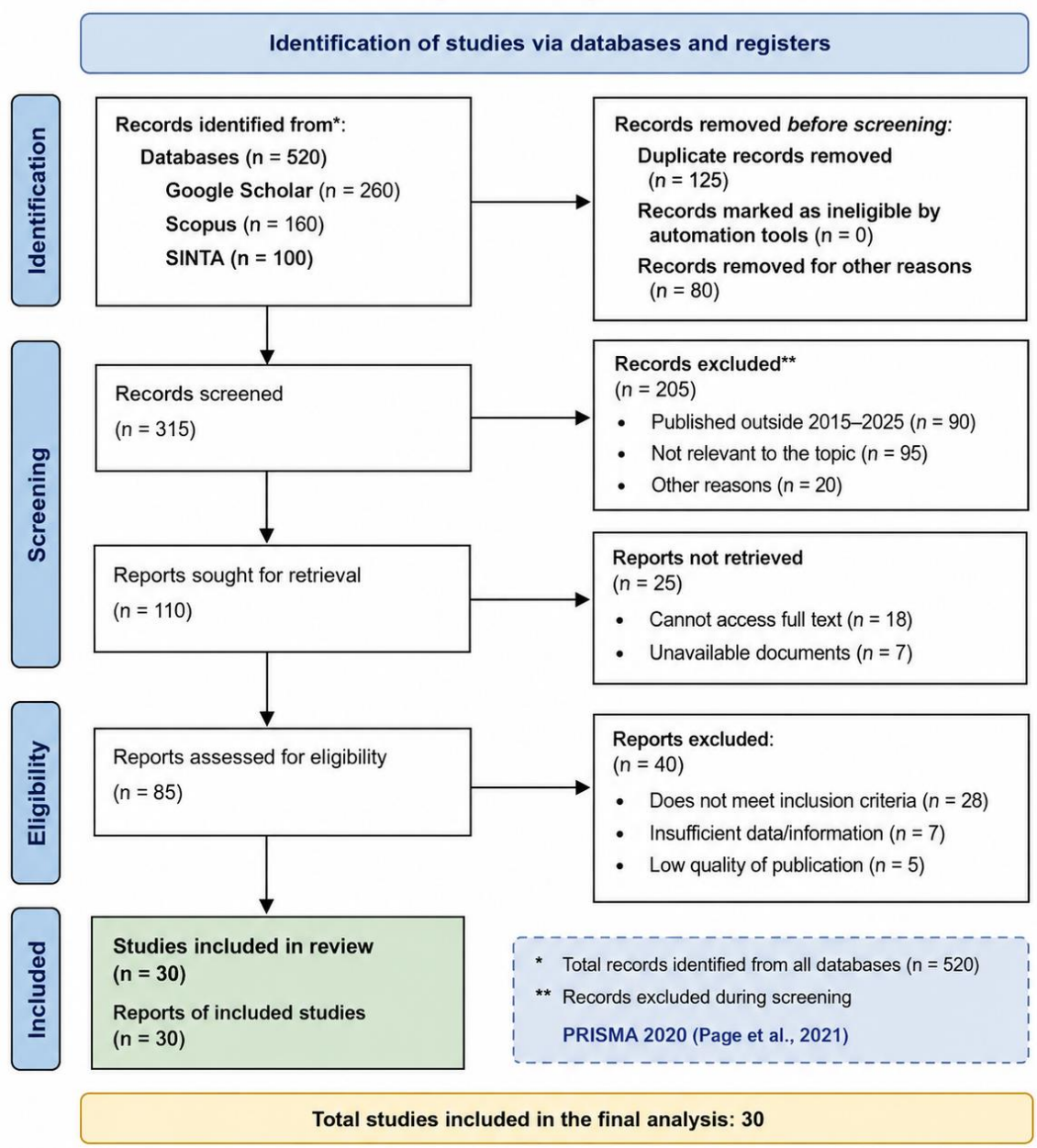
This study employed a Systematic Literature Review (SLR) approach to examine the reconstruction of the philosophy of science within the Project-Based Eco-Citizenship learning model in elementary schools. This approach was selected because it enables researchers to generate a systematic, transparent, and structured synthesis of existing research findings (Snyder, 2019; Xiao & Watson, 2019). Through a comprehensive literature review, researchers can gain a deeper understanding of the phenomena under investigation, identify conceptual frameworks that strengthen understanding, and explore the relationship between project-based learning and the

philosophy of science in the context of environmental education and character development.

This study adopted the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework, which consists of four stages: identification, screening, eligibility assessment, and inclusion (Page et al., 2021). These stages were implemented systematically to ensure that the literature selection process was objective and comprehensive. During the identification stage, articles were collected from multiple academic databases. The screening stage involved selecting articles based on predefined criteria. Subsequently, the eligibility stage was conducted to assess the suitability and quality of the selected studies. This approach facilitates the identification and synthesis of relevant findings while enhancing the credibility of the research outcomes (Page et al., 2021).

The databases used in this study included reputable sources, namely Google Scholar, Scopus, and SINTA. The literature search was conducted using combinations of keywords such as “Project-Based Learning,” “Eco-Citizenship,” “Environmental Education,” “Elementary School,” and “Philosophy of Science.” To ensure broader coverage and greater relevance, additional keyword combinations were employed, including “Project-Based Learning and Environmental Education” and “Eco-Citizenship and Elementary School.” The publication period was limited to 2015–2025 to ensure the relevance and recency of the reviewed literature. Articles were selected based on several criteria, including publication quality, publication year, and relevance to the research objectives.

The article selection process involved several stages. Initially, 520 articles were identified through searches across the selected databases. During the screening stage, 205 articles were excluded due to duplication, publication outside the specified period, or lack of relevance to the research topic. Subsequently, the remaining articles underwent further review. At the eligibility stage, studies that were inaccessible, lacked full-text availability, or failed to meet the inclusion criteria were excluded. Based on the PRISMA selection process, approximately 45 articles advanced to the eligibility stage, and 30 articles were ultimately included in the final analysis.



Gambar 1. Diagram PRISMA

Data analysis was conducted using thematic analysis techniques through coding, categorization, and synthesis to identify key patterns in the literature. Furthermore, the results of the analysis were interpreted using a philosophical perspective, encompassing aspects of ontology (the nature of learning), epistemology (how to acquire knowledge), and axiology (the values and goals of education). To ensure the validity and legitimacy of the data, this study employed source triangulation, selected articles from reputable journals, and implemented an audit trail that transparently documented the entire selection process. With this approach, the

research results are expected to have a high level of credibility and be scientifically accountable.

RESULT AND DISCUSSION

1. Ontological Dimension

The ontological dimension emphasizes the nature of learning and the position of learners within the context of environmental education. In the Project-Based Eco-Citizenship model, students are viewed as individuals with ecological and social potential that develops through direct interaction with the environment. The environment functions not only as a learning object but also as a living space that forms an integral part of knowledge construction and character development

Table 1. Studies and Research Findings on the Ontological Dimension

No.	Authors and Year	Research Focus	Main Findings
1	Pamungkas et al. (2026)	Implementation of Project-Based Environmental Education	The model effectively improves students' sustainability competencies through active participation in project-based learning and field activities.
2	Hakim et al. (2026)	E-module-based Project-Based Learning	Project-based e-modules significantly enhance students' environmental awareness and problem-solving skills.
3	Azrai et al. (2024)	The impact of PjBL on students' environmental behavior	PjBL contributes positively to the development of pro-environmental behavior and environmental responsibility.
4	Angraeni et al. (2024)	Ecopreneurship-based PjBL for environmental literacy development	The integration of ecopreneurship concepts enhances environmental literacy and students' ability to address environmental issues creatively.
5	Aprilia et al. (2025)	Implementation of PjBL in science education	PjBL improves environmental literacy, scientific understanding, and environmental care attitudes.

The ontological dimension of the Project-Based Eco-Citizenship model positions learners as active participants who interact directly with the environment as a learning reality. Pamungkas et al. (2026) argue that project-based environmental education transforms students' understanding of reality from abstract concepts into concrete experiences through contextual engagement. The environment is no longer viewed solely as a learning object. It becomes part of students' everyday lives and experiences. Learning gains greater meaning because students participate directly in activities related to environmental issues. This finding indicates that the nature of learning is holistic and closely connected to learners' lived experiences.

Hakim et al. (2026) report that project-based learning supported by e-modules provides an interactive and contextual learning experience. Students actively construct knowledge through exploration and problem-solving activities related to environmental issues rather than passively receiving information. The approach enables learners to develop a deeper understanding of the relationship between humans and the environment. From an ontological perspective, knowledge emerges through direct interaction with environmental realities and authentic experiences. Learning extends beyond cognitive achievement and contributes to the development of long-term ecological awareness.

Azrai et al. (2024) demonstrate that students' participation in environmental projects significantly influences the development of pro-environmental behavior. Project-based activities allow learners to apply environmental concepts through practical actions that affect their surroundings. Learning reality encompasses cognitive, affective, and psychomotor dimensions in an integrated manner. Knowledge is understood as a dynamic process that evolves through direct experience. Students internalize ecological values and incorporate them into their personal identities.

Angraeni et al. (2024) explain that ecopreneurship-based Project-Based Learning improves environmental literacy through activities connected to students' daily lives. Learning focuses on conceptual understanding as well as the development of critical and creative thinking skills for addressing environmental challenges. The environment serves as the primary learning resource, allowing students to experience environmental phenomena directly. This perspective reinforces the view that learning should be grounded in authentic and contextual realities. Such experiences create deeper and more sustainable learning outcomes.

Aprilia et al. (2025) found that Project-Based Learning in science education significantly improves environmental literacy and environmental care attitudes. Project activities provide opportunities for students to connect theoretical concepts with practical experiences. The environment becomes an essential component of the learning process, helping students understand the relationship between scientific concepts and everyday life. An ontological perspective views learning as an interaction between individuals and their social and natural environments. Students acquire knowledge while developing ecological awareness and social responsibility.

2. Epistemological Dimension

The epistemological dimension concerns how knowledge is constructed, acquired, and validated throughout the learning process. Within the Project-Based Eco-Citizenship model, knowledge is viewed as the result of active construction developed through experience, interaction, and reflection on environmental realities.

Table 2. Studies and Research Findings on the Epistemological Dimension

No.	Authors and Year	Research Focus	Main Findings
1	Ayerbe López & Perales (2024)	Implementation of Project-Based Learning (PjBL) in environmental education	Students' knowledge develops through direct involvement in authentic environmental projects.
2	Pertiwi et al. (2024)	Implementation of the STEM-PjBL approach to improve environmental literacy	The integration of STEM and PjBL significantly improves students' environmental literacy.
3	Mubariqoh & Fauzi (2025)	Implementation of PjBL in elementary education	PjBL enhances students' environmental awareness and understanding of local environmental issues.
4	Segara et al. (2024)	Development of eco-literacy through PjBL	PjBL effectively improves environmental literacy and critical thinking skills.
5	Purwati (2023)	Poster-assisted PjBL	The use of poster media supports learning activities and improves environmental literacy.

The epistemological dimension of project-based learning emphasizes that knowledge is actively constructed through direct experience and interaction with the environment. Ayerbe López and Perales (2024) found that the implementation of Project-Based Learning in environmental education enhances students' awareness and understanding through participation in authentic projects. Students do not merely receive information. They construct knowledge through exploration, observation, and reflection on environmental issues. This finding aligns with the constructivist perspective, which recognizes experience as a primary source of knowledge development. Project-based learning strengthens contextual and meaningful knowledge construction.

Pertiwi et al. (2024) reported that the integration of STEM within Project-Based Learning significantly improves environmental literacy. Learning activities combine science, technology, engineering, and mathematics concepts within authentic project contexts. Students develop conceptual understanding while applying knowledge to everyday situations. Knowledge emerges from the integration of practical experiences and conceptual understanding. An epistemological perspective highlights the development of critical thinking, analytical reasoning, and problem-solving skills that contribute to deeper and more relevant learning outcomes.

Mubariqoh and Fauzi (2025) demonstrated that Project-Based Learning at the elementary school level enhances students' understanding of environmental issues and strengthens environmental awareness. Learning activities involve students directly in solving real-world problems, including waste management and environmental campaigns. Knowledge develops through direct experience that engages both cognitive and practical activities. This perspective views knowledge as the product of interaction between individuals and their environment.

Segara et al. (2024) explained that project-based learning within the context of eco-literacy improves critical thinking skills and environmental awareness. Learning activities focus on solving authentic problems and encouraging creativity in generating innovative solutions. Students construct knowledge through exploration, discussion, and practical application. Knowledge remains dynamic and continuously develops through contextual learning experiences. Project-based learning positions students as active participants in the development of applicable and sustainable knowledge.

Purwati (2023) found that poster-assisted Project-Based Learning improves learning engagement and environmental literacy. Students process information, participate in discussions, and present project outcomes. Knowledge develops through active learning experiences rather than through reading or listening alone. An epistemological perspective recognizes knowledge as the result of interaction, reflection, and experiential construction. Project-based learning serves as an effective approach for developing meaningful and sustainable knowledge.

3. Axiological Dimension

The axiological dimension concerns the values, ethics, and purposes of knowledge developed through the learning process. Within the Project-Based Eco-Citizenship model, learning extends beyond the transfer of knowledge to include the development of character, attitudes, and environmental awareness. Values such as environmental stewardship, social responsibility, and sustainability serve as fundamental principles in shaping students' behavior toward sustainable living.

Table 3. Studies and Research Findings on the Axiological Dimension

No.	Authors and Year	Research Focus	Main Findings
1	Xi & Wang (2022)	Implementation of Project-Based Learning (PjBL) in environmental education	PjBL effectively promotes environmental values and develops pro-environmental attitudes through authentic learning experiences.
2	Nurazizah et al. (2024)	SDGs-based PjBL	The integration of Sustainable Development Goals (SDGs) into PjBL enhances students' sustainability awareness and environmental responsibility.
3	Fitriani et al. (2023)	PjBL in environmental education	PjBL strengthens environmental awareness and students' social responsibility in addressing environmental issues.
4	Nova (2023)	PjBL for character education	PjBL contributes to the development of environmentally responsible character through project-based activities.
5	Sari et al.	Sustainability-oriented	Sustainability-based PjBL improves

(2024)	PjBL	sustainability attitudes and environmental awareness among students.

The axiological dimension of project-based learning emphasizes that education functions not only as a process of knowledge transmission but also as a means of cultivating values and character. Xi and Wang (2022) found that Project-Based Learning significantly enhances students' pro-environmental attitudes. Participation in authentic projects encourages learners to recognize the importance of environmental conservation and adopt environmentally responsible behaviors in their daily lives. Environmental stewardship develops through contextual and meaningful learning experiences. Project-based learning supports the internalization of ecological values through direct engagement with environmental issues.

Nurazizah et al. (2024) reported that the integration of Sustainable Development Goals (SDGs) within Project-Based Learning increases students' awareness of sustainability. Learning activities help students understand the relationship between human actions and environmental consequences. An axiological perspective highlights the role of education in shaping long-term thinking oriented toward sustainability. Students develop not only conceptual understanding but also a sense of responsibility for environmental preservation.

Fitriani et al. (2023) demonstrated that project-based learning enhances environmental awareness and social responsibility. Project activities involving collaboration and problem-solving encourage students to participate actively in protecting their environment and communities. Learning outcomes include the development of social values that support responsible citizenship. Educational experiences contribute to the formation of environmentally conscious and socially responsible individuals.

Nova (2023) found that Project-Based Learning effectively develops environmentally responsible character. Direct involvement in environmental projects encourages students to build awareness and positive attitudes toward environmental conservation. Values are experienced through authentic activities rather than delivered solely through instruction. Project-based learning integrates cognitive and affective dimensions in the process of character development.

Sari et al. (2024) reported that sustainability-oriented Project-Based Learning strengthens students' sustainability attitudes. Students gain an understanding of sustainability concepts and apply them in practical actions. Learning experiences provide meaningful opportunities to develop sustainability

values. An axiological perspective recognizes education as a process of preparing future generations with environmental awareness and responsibility toward sustainable development.

4. Integration of the Project-Based Eco-Citizenship Model

The integration of the Project-Based Eco-Citizenship model combines project-based learning with the concept of ecological citizenship oriented toward environmental sustainability. The model integrates cognitive, affective, and psychomotor domains in a balanced manner through contextual and meaningful project-based learning activities. The approach aligns with the implementation of the Merdeka Curriculum and supports the development of twenty-first-century competencies, including critical thinking, collaboration, communication, and creativity.

Table 4. Studies and Research Findings on the Integration of the Project-Based Eco-Citizenship Model

No.	Authors and Year	Research Focus	Main Findings
1	Krajcik & Shin (2021)	Implementation of Project-Based Learning (PjBL)	PjBL integrates students' knowledge, skills, and attitudes through authentic project-centered learning activities.
2	Chawla & Cushing (2020)	Environmental Education	Experiential environmental education increases student engagement and environmental awareness.
3	Wiek et al. (2021)	Sustainability Education	Sustainability education effectively develops sustainability competencies, including systems thinking, anticipatory thinking, strategic thinking, and collaboration.
4	Zubaidah (2022)	Development of Twenty-First-Century Skills	Active learning strengthens the 4C competencies: critical thinking, creativity, collaboration, and communication.
5	Fitria et al. (2023)	PjBL in the Implementation of the Merdeka Curriculum	PjBL supports contextual and meaningful learning while strengthening character development and the Pancasila Student Profile.

The integration of Project-Based Learning (PjBL) and the eco-citizenship concept creates a holistic and comprehensive learning model. The model combines cognitive, affective, and psychomotor dimensions through contextual project activities. Krajcik and Shin (2021) found that project-based learning integrates students' knowledge, skills, and attitudes simultaneously. Students develop conceptual understanding and apply their learning in authentic situations. Learning becomes more meaningful because it is grounded in direct experience.

Chawla and Cushing (2020) reported that experiential environmental education increases student engagement and environmental awareness. Students learn through direct interaction with their surrounding environment. Knowledge acquired through authentic experiences becomes more contextual and applicable. This approach supports the development of ecological awareness while strengthening students' understanding of environmental issues.

Wiek et al. (2021) demonstrated that sustainability education develops competencies required for addressing complex environmental challenges. These competencies include systems thinking, problem-solving, strategic decision-making, and collaboration. The findings highlight the relevance of the Project-Based Eco-Citizenship model for sustainability education and the development of future-oriented competencies.

Zubaidah (2022) emphasized that twenty-first-century learning focuses on the development of the 4C competencies: critical thinking, creativity, collaboration, and communication. Project-based activities provide opportunities for students to practice these skills in authentic learning contexts. The integration of PjBL and eco-citizenship supports the development of competencies needed in contemporary education.

Fitria et al. (2023) found that Project-Based Learning within the Merdeka Curriculum promotes contextual and meaningful learning while strengthening students' character development. Students engage in projects connected to real-life situations and community issues. Learning experiences contribute to the development of the Pancasila Student Profile and encourage active participation in environmental sustainability efforts.

The Project-Based Eco-Citizenship model offers a strategic framework for developing environmentally responsible, socially conscious, and future-ready learners. The integration of project-based learning and ecological citizenship supports knowledge acquisition, character development, sustainability awareness, and twenty-first-century competencies within a single educational framework.

CONCLUSION

This Systematic Literature Review demonstrates that the reconstruction of the philosophy of science within the Project-Based Eco-Citizenship learning model provides a comprehensive theoretical foundation for environmental education in elementary schools. The findings reveal that the model integrates three fundamental dimensions of the philosophy of science: ontology, epistemology, and axiology. From an ontological perspective, students are positioned as active learners who construct understanding through direct interaction with environmental realities, transforming learning into a meaningful and authentic experience. From an epistemological perspective, knowledge is developed through exploration, collaboration, inquiry, reflection, and problem-solving activities embedded in project-based learning. Knowledge acquisition is not limited to the transmission of information but emerges through contextual experiences that connect theoretical concepts with real-world environmental issues. This perspective supports the development of critical thinking, environmental literacy, creativity, and problem-solving competencies that are essential for contemporary education.

The axiological dimension highlights the role of Project-Based Eco-Citizenship in fostering environmental stewardship, social responsibility, sustainability awareness, and ethical values among students. Learning experiences encourage learners to internalize ecological values and translate them into responsible actions within their communities. The integration of ontological, epistemological, and axiological dimensions indicates that Project-Based Eco-Citizenship extends beyond cognitive achievement and supports balanced development across cognitive, affective, and psychomotor domains. The model aligns closely with the objectives of the Merdeka Curriculum and contributes to the development of twenty-first-century competencies, including critical thinking, communication, collaboration, and creativity. The findings suggest that Project-Based Eco-Citizenship represents a relevant and sustainable educational approach for preparing environmentally conscious and socially responsible citizens. Future studies may focus on empirical validation of the model in diverse educational settings and investigate its long-term impact on students' ecological behavior, sustainability competencies, and civic engagement in addressing environmental challenges.

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