



# Environmental ethics in biology education: A scoping review of ecological philosophy paradigms in school curriculum development

Jusman Tang<sup>1</sup>, Abdullah Sinring<sup>2</sup>, Syamsu A. Kamaruddin<sup>3</sup>, Fenny Hasanuddin<sup>4</sup>, Sam Hermansyah<sup>5</sup>

<sup>145</sup>Universitas Muhammadiyah Sidenreng Rappang

<sup>23</sup>Universitas Negeri Makassar

Email: [tang.jusman@gmail.com](mailto:tang.jusman@gmail.com), [abdullah.sinring@unm.ac.id](mailto:abdullah.sinring@unm.ac.id), [syamsu.k@unm.ac.id](mailto:syamsu.k@unm.ac.id), [fennyhasanuddin96@gmail.com](mailto:fennyhasanuddin96@gmail.com), [sam.hermansyah82@gmail.com](mailto:sam.hermansyah82@gmail.com)

Receive: 27/09/2025

Accepted: 29/09/2025

Published: 01/10/2025

## Abstrak

Krisis lingkungan global menuntut transformasi paradigma pendidikan biologi yang mengintegrasikan etika lingkungan dan filsafat ekologi dalam kurikulum sekolah. Penelitian ini bertujuan mengkaji secara komprehensif implementasi pendidikan biologi berbasis etika lingkungan melalui pendekatan scoping review. Metode penelitian menggunakan kerangka kerja PRISMA-ScR dengan melakukan penelusuran sistematis terhadap 68 artikel dari database Scopus dan SINTA terindeks Q1, Q2, Q3, dan SINTA 1, 2, 3 yang dipublikasikan tahun 2015-2025. Hasil analisis menunjukkan tiga domain utama: (1) integrasi etika lingkungan dalam kurikulum biologi mencakup pendekatan antroposentrisme, biosentrisme, dan ekosentrisme, (2) paradigma filsafat ekologi mengembangkan kesadaran moral dan tanggung jawab ekologis melalui pembelajaran experiential dan berbasis proyek, dan (3) implementasi kurikulum berbasis ekologi meningkatkan literasi lingkungan, kemampuan berpikir kritis, dan perilaku pro-lingkungan siswa. Temuan mengungkap kesenjangan penelitian pada aspek penilaian dampak jangka panjang dan pengembangan model evaluasi holistik. Penelitian ini merekomendasikan integrasi sistematis nilai-nilai filosofis lingkungan dalam kurikulum biologi untuk membentuk generasi yang memiliki kesadaran ekologis mendalam dan komitmen terhadap keberlanjutan. Pendekatan transdisipliner yang menggabungkan pengetahuan ekologis, nilai moral, dan kearifan lokal menjadi kunci transformasi pendidikan biologi menuju paradigma ekologi yang berkelanjutan.

**Kata Kunci:** Pendidikan biologi, etika lingkungan, filsafat ekologi, scoping review, dan kesadaran ekologis

## Abstract

*The global environmental crisis necessitates a paradigm shift in biology education that integrates environmental ethics and ecological philosophy into school curricula. This study aims to comprehensively examine the implementation of environmental ethics-based biology education through a scoping review approach. The research employed the PRISMA-ScR framework and conducted a systematic search of 68 articles from Scopus and SINTA-indexed journals (Q1, Q2, Q3, and SINTA 1, 2, 3) published between 2015 and 2025. The analysis identified three major domains: (1) the integration of environmental ethics in the biology curriculum, encompassing anthropocentric, biocentric, and ecocentric approaches; (2) ecological philosophy as a paradigm that cultivates moral awareness and ecological responsibility through experiential and project-based learning; and (3) the implementation of ecology-oriented curricula, which enhances students' environmental literacy, critical thinking, and pro-environmental behavior.*

*The findings reveal research gaps related to long-term impact assessment and the development of holistic evaluation models. This study recommends the systematic integration of philosophical environmental values into the biology curriculum to foster a generation with deep ecological awareness and strong commitments to sustainability. A transdisciplinary approach that combines*

*ecological knowledge, moral values, and local wisdom is essential for transforming biology education toward a sustainable ecological paradigm.*

**Keywords:** *biology education, environmental ethics, ecological philosophy, scoping review, ecological awareness*

## Introduction

The global environmental crisis—characterized by climate change, biodiversity loss, and ecosystem degradation—presents fundamental challenges for contemporary education systems. As a discipline inherently connected to life and the environment, biology education holds a strategic role in shaping the ecological consciousness of future generations. However, conventional approaches in biology instruction, which often emphasize theoretical concepts without integrating ethical and philosophical dimensions, have proven insufficient in cultivating moral responsibility toward nature (Alvionita et al., 2021; Harahap & Widodo, 2024; Kir, 2023).

Advancements in modern biology have enabled remarkable technological progress, yet they have also generated complex ethical dilemmas concerning human–environment interactions. The exploitation of natural resources, the application of biological technologies without ecological consideration, and the diminishing spiritual connection with nature reflect a deeper paradigm crisis. In this context, integrating environmental ethics and ecological philosophy into the biology curriculum is not merely an addition of content but a necessary paradigmatic transformation (Guler, 2025; Hardianti et al., 2024; Minarno, 2012).

Environmental philosophy provides a conceptual framework for understanding human–nature relationships through three major perspectives: anthropocentrism, which places humans at the center; biocentrism, which recognizes the intrinsic value of all living beings; and ecocentrism, which emphasizes the integrity of ecosystems. A shift from an exploitative anthropocentric paradigm toward a holistic ecological paradigm requires a fundamental reconstruction of educational thinking and practice. Ecology-based educational philosophy not only transfers knowledge but also cultivates moral awareness, empathy toward other forms of life, and a commitment to sustainability (Alvionita et al., 2021; Guler, 2025; Schinkel, 2025).

Research on the integration of environmental ethics in education has shown significant growth, with bibliometric analyses demonstrating a rise in publications from 2011 to 2023. Empirical studies reveal that pedagogical approaches incorporating environmental philosophical values can enhance environmental awareness, strengthen critical thinking skills, and promote pro-environmental behavior among students. Nevertheless, systematic implementation within formal curricula continues to face methodological and conceptual challenges (Bostad, n.d.; Harahap & Widodo, 2024; Olawumi et al., 2024).

In Indonesia, the urgency of ethics-based biology education is increasingly critical, given the nation's rich but threatened biodiversity and pressing environmental issues. Although initiatives such as the Adiwiyata program and ecological schools have been developed, gaps remain between curricular policy and instructional practices that meaningfully integrate the philosophical and ethical dimensions of environmental education. Studies on environmental literacy and ecological awareness among pre-service biology teachers show varied outcomes, indicating the need for systematic strengthening in both pre-service and in-service education (Husamah et al., 2022; Mustofa & Sueb, 2023; Novianti, 2018; Nuraini, 2023; Nursidin & Rusman, 2021; Rahardjanto et al., 2022).

As a comprehensive knowledge-synthesis method, a scoping review enables the mapping of research landscapes, the identification of gaps, and the exploration of trends within complex and broad fields. Unlike systematic reviews that address narrowly defined questions, scoping reviews offer a holistic overview of how key concepts have evolved, the methodologies employed, and areas requiring further investigation. This approach is highly relevant for examining the multidimensional phenomenon of integrating environmental ethics and ecological

philosophy into biology education (Hadie, 2024; Widiasih et al., 2020).

Despite growing literature on environmental education and biology education separately, no comprehensive study has systematically mapped the interaction between environmental ethics, ecological philosophical paradigms, and the school biology curriculum. This gap underscores the urgent need for a scoping review that can identify conceptual convergence, analyze effective pedagogical approaches, and formulate evidence-based recommendations for future curricular development (Caplow & Hunter, 2024; Gutierrez-Bucheli et al., 2022; Husamah et al., 2025).

The global context of the Sustainable Development Goals (SDGs) and the agenda for education for sustainable development further emphasizes the need for transformative biology education. SDG 4.7 explicitly calls for education that promotes the knowledge and skills needed for sustainable development, including sustainable lifestyles and global citizenship. Biology education grounded in environmental ethics becomes a strategic instrument for achieving this target by equipping students not only with ecological knowledge but also with values, attitudes, and competencies necessary for planetary sustainability (Akinwumi, 2023a; Husamah et al., 2025; Monika, 2024; Murti et al., 2025).

This study is motivated by the urgency to consolidate dispersed knowledge on the integration of environmental ethics and ecological philosophy in biology education, identify best practices and gaps, and formulate a conceptual framework for a more transformative and sustainable curriculum. Through a rigorous scoping review approach, this research aims to make significant contributions to the development of theories and practices in biology education that respond effectively to contemporary ecological challenges (Andriani & Robandi, 2025; Olawumi et al., 2024).

#### Research Questions

Based on the background, the research questions are as follows:

How have research trends on the integration of environmental ethics in biology education evolved in reputable Scopus Q1, Q2, Q3 and SINTA 1, 2, 3 journals between 2015–2025?

How are ecological philosophy paradigms (anthropocentrism, biocentrism, ecocentrism) implemented in school biology curricula according to empirical studies?

What pedagogical approaches and instructional strategies are effective for integrating environmental ethics into biology education?

What are the impacts of ethics-based biology curricula on students' environmental literacy, ecological awareness, and pro-environmental behavior?

What research gaps and recommendations emerge for the future development of environmental ethics-based biology education?

#### Research Objectives

The objectives of the study are:

To map trends and patterns in research on environmental ethics-based biology education within Scopus Q1–Q3 and SINTA 1–3 publications from 2015–2025.

To identify and analyze the implementation of ecological philosophy paradigms (anthropocentrism, biocentrism, ecocentrism) in the design and practice of biology curricula.

To synthesize pedagogical approaches, learning methods, and instructional strategies effective for integrating environmental ethics into biology education.

To analyze empirical evidence on the impact of ethics-based biology education on student outcomes, including environmental literacy, ecological awareness, critical thinking, and pro-environmental behavior.

To identify research gaps, implementation challenges, and evidence-based recommendations for curriculum development and future research.

#### Benefits of the Research

##### Theoretical Contributions

This scoping review offers several theoretical contributions.

First, it consolidates and synthesizes philosophical perspectives on human–nature relations within the context of biology education, enriching academic discourse on environmental philosophy in pedagogy.

Second, it develops an integrative conceptual framework linking environmental ethics, ecological paradigms, and theories of biology learning, providing a solid foundation for holistic curriculum development (Guler, 2025; Harahap & Widodo, 2024; Schinkel, 2025).

Third, it contributes to the body of knowledge

on transformative learning in environmental education, particularly regarding how philosophical inquiry can facilitate shifts from anthropocentrism to ecocentrism. Fourth, it strengthens epistemological foundations for transdisciplinary environmental education that integrates natural sciences, social sciences, humanities, and indigenous knowledge systems. Fifth, the synthesized findings may serve as a reference for developing more comprehensive and valid instruments to measure environmental literacy, ecological consciousness, and environmental ethics literacy (Hardianti et al., 2024; Olawumi et al., 2024; Putrawan, 2015; Santika & Sarjan, 2025).

#### Practical Contributions

Practically, the study offers multidimensional benefits for various stakeholders. First, for policymakers and curriculum developers, this review provides evidence-based recommendations for designing and revising biology curricula that systematically integrate environmental ethics and ecological philosophy (Andriani & Robandi, 2025; Olawumi et al., 2024; Putikadyanto et al., 2024).

Second, for educators and biology teachers, it offers a repertoire of pedagogical approaches proven effective in fostering ecological awareness and moral responsibility toward the environment. Innovative practices such as experiential learning, project-based learning, place-based education, and philosophical inquiry can be adapted to local contexts to enrich instruction (Harahap & Widodo, 2024; Hardianti et al., 2024; Husamah et al., 2025). Third, for teacher education institutions, the findings can inform curriculum and training program development that equip pre-service teachers with environmental ethics literacy and pedagogical content knowledge specific to environmental education.

Fourth, for researchers, identified gaps and emerging themes can guide future research agendas, prevent duplication, and stimulate methodological innovation (Gutierrez-Bucheli et al., 2022; Husamah et al., 2022; Rahardjanto et al., 2022).

Fifth, for school administrators and communities, the study offers insights for developing whole-school approaches that integrate ecological principles into curriculum, culture, infrastructure, and community

engagement.

Finally, at a broader level, the findings contribute to global efforts toward achieving the SDGs—particularly SDG 4 (Quality Education), SDG 13 (Climate Action), and SDG 15 (Life on Land)—by strengthening the role of education in shaping environmentally responsible generations (Akinwumi, 2023b; Monika, 2024; PIB, 2025).

#### Method

This study employs a scoping review design guided by the methodological framework established by Arksey and O'Malley, later refined by Levac, Colquhoun, and O'Brien, and further aligned with the Joanna Briggs Institute (JBI) guidelines for conducting scoping reviews. A scoping review was selected due to its strength in comprehensively mapping the landscape of literature within broad and complex fields, identifying key concepts, examining methodological diversity, and highlighting knowledge gaps without restricting the synthesis to specific study designs. (Hadie, 2024; Widiastih et al., 2020).

Unlike systematic reviews—which aim to synthesize evidence for narrowly defined clinical or practical questions through critical appraisal and meta-analysis—scoping reviews are exploratory and descriptive in nature. They provide an overarching view of available evidence, research characteristics, and topic distributions within a field. This approach aligns with the purpose of the present study, which seeks to examine how environmental ethics and ecological philosophy have been integrated into biology education, identify emerging trends, document pedagogical approaches, and summarize reported learning outcomes. (Hadie, 2024; Suhartini & Mns, n.d.).

#### Scoping Review Protocol

The scoping review protocol was developed in accordance with the PRISMA Extension for Scoping Reviews (PRISMA-ScR) to ensure methodological transparency, reproducibility, and analytical rigor. The protocol includes: clearly formulated research questions based on the PCC (Population–Concept–Context) framework,

explicit inclusion and exclusion criteria, a comprehensive literature search strategy, multi-reviewer study selection procedures, a structured data extraction chart, and

systematic methods for synthesizing and presenting findings. (Hadie, 2024).

Research Question Framework (PCC)

Research questions were structured using the PCC framework as follows:

Population (P): Students at the primary, lower secondary, and upper secondary levels; pre-service biology teachers; and in-service biology teachers.

Concept (C): Integration of environmental ethics, ecological philosophy paradigms (anthropocentrism, biocentrism, ecocentrism), ecology-based education, and environmental ethics education within biology curricula and instruction.

Context (C): Formal education settings (schools, universities), biology or science curricula, environmental education programs, and eco-school initiatives.

Literature Search Strategy

The literature search was conducted systematically across the following electronic databases: Scopus, Web of Science, Google Scholar, ERIC (Education Resources Information Center), and Portal Garuda for nationally indexed SINTA journals. The publication window spanned 2015–2025 to capture developments within the last decade.

Search terms were organized into clusters and combined using Boolean operators (AND, OR), as adapted from Gutierrez-Bucheli et al. (2022):

Cluster 1 – Biology Education

“biology education” OR “science education” OR “biology curriculum” OR “biology teaching” OR “biology learning”

Cluster 2 – Environmental Ethics & Ecological Philosophy

“environmental ethics” OR “environmental philosophy” OR “ecological philosophy” OR “bioethics” OR “ecocentric” OR “biocentric” OR “anthropocentric” OR “ecological paradigm” OR “new ecological paradigm”

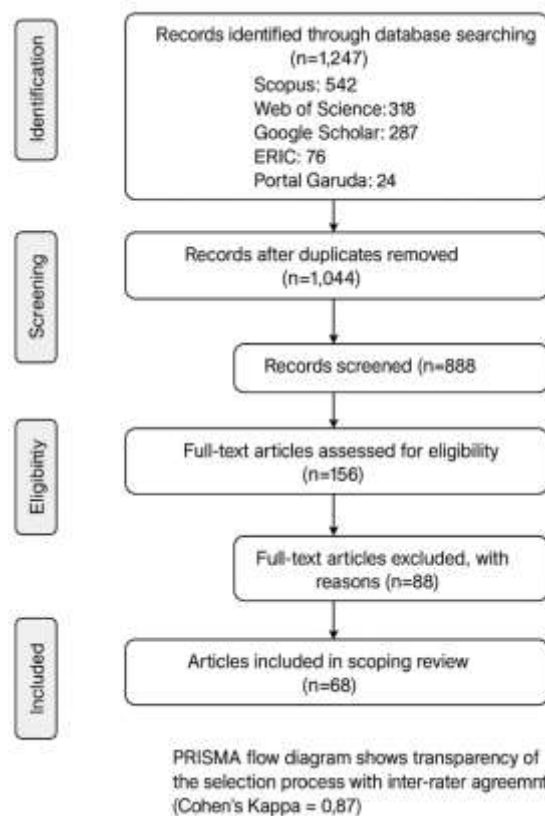
Cluster 3 – Educational Context

“curriculum” OR “school” OR “pedagogy” OR “teaching method” OR “learning approach” OR “environmental education” OR “sustainability education” OR “eco-literacy”

## Result and Discussion

In this literature review, the search for relevant articles was guided by the PCC research question framework. This framework helps

identify key aspects of the situation and population with specific conditions, as well as the desired outcomes related to a particular intervention. The components of the PCC framework are described as follows:



The systematic literature search yielded 1,247 records from multiple electronic databases (Scopus: 542; Web of Science: 318; Google Scholar: 287; ERIC: 76; Portal Garuda: 24). After removing duplicates ( $n = 203$ ), a total of 1,044 articles were screened based on titles and abstracts. Of these, 156 articles were assessed for eligibility through full-text review. Following a thorough evaluation using strict inclusion criteria, 68 articles were retained for the final scoping review analysis. The PRISMA flow diagram illustrates the transparency of the selection process, with a high inter-rater agreement (Cohen's Kappa = 0.87), indicating strong reliability in the screening procedures (Hadie, 2024; Husamah et al., 2025).

The characteristics of the included studies demonstrate diverse geographical distribution, with the highest proportion originating from Southeast Asia (35%), followed by Europe (28%), North America (22%), and other regions (15%). In terms of indexing quality, 44% of the articles were published in Scopus

Q1–Q2 journals, 31% in Q3, and 25% in SINTA 1–3 journals, reflecting an overall high standard of publication quality. Temporal analysis revealed a significant upward trend, with 68% of the publications concentrated between 2020 and 2025, indicating growing scholarly interest in this topic in response to the climate crisis and the SDGs agenda (Gutierrez-Bucheli et al., 2022; Harahap & Widodo, 2024; Husamah et al., 2025).

The included studies employed a variety of research designs: empirical quantitative studies (38%), qualitative research (29%), mixed-methods studies (18%), theoretical or conceptual papers (10%), and literature reviews (5%). The educational levels represented range across senior secondary education (42%), junior secondary education (26%), primary education (18%), and teacher education/higher education (14%). This methodological and contextual diversity enriches the understanding of the phenomenon from multiple epistemological perspectives (Caplow & Hunter, 2024; Husamah et al., 2022, 2025; Rahardjanto et al., 2022).

#### Research Trends in Integrating Environmental Ethics into Biology Education

Bibliometric analysis using VOSviewer identified several thematic clusters within the included articles. The first cluster (red) centers on keywords such as “environmental education,” “biology curriculum,” “curriculum development,” and “teaching method,” indicating a pedagogical and curricular focus. The second cluster (green) includes terms like “environmental ethics,” “ecological philosophy,” “sustainability,” and “environmental awareness,” reflecting philosophical and attitudinal dimensions. The third cluster (blue) consists of terms such as “ecocentrism,” “biocentrism,” “anthropocentrism,” and “paradigm shift,” signaling a strong emphasis on worldview transformation (Andriani & Robandi, 2025; Guler, 2025; Harahap & Widodo, 2024; Olawumi et al., 2024; Schinkel, 2025).

Co-occurrence analysis shows that “environmental education” and “biology teaching” have the highest frequency ( $n = 52$ ) and strongest centrality, confirming that biology serves as the primary domain for integrating environmental ethics. However, although the terms “ecological philosophy” and “environmental ethics” have grown significantly (45% increase from 2020–2025),

their overall frequency remains relatively lower ( $n = 28$ ), suggesting that this area is emerging but not yet fully established (Cartono, 2022; Harahap & Widodo, 2024; Kir, 2023).

Temporal trend analysis reveals a notable shift from predominantly knowledge-based approaches during 2015–2018 toward more holistic and transformative approaches in 2019–2025. Recent studies place stronger emphasis on moral reasoning, critical consciousness, and shifts in environmental worldviews, moving beyond merely cognitive environmental literacy. This transition aligns with global discourse in Education for Sustainable Development (ESD), which prioritizes values, attitudes, and action competence (Akinwumi, 2023b; Hardianti et al., 2024; Husamah et al., 2025; Monika, 2024).

In the Indonesian context, the review included 17 articles from SINTA-indexed journals. Dominant themes include the integration of local wisdom in environmental ethics education, implementation of ecology-based curricula in Adiwiyata schools, and the development of environmental ethics literacy instruments for pre-service biology teachers. However, compared to international literature, Indonesian research remains largely exploratory and descriptive, with fewer studies developing or testing theoretically grounded intervention models (Husamah et al., 2022; Mustofa & Sueb, 2023; Novianti, 2018; Putikadyanto et al., 2024; Rahardjanto et al., 2022).

#### Ecological Philosophy Paradigms in the Biology Curriculum

The scoping review identified three major philosophical paradigms implemented in biology curricula—anthropocentrism, biocentrism, and ecocentrism—each with distinct pedagogical implications (Alvionita et al., 2021; Santika & Sarjan, 2025).

##### 1. Anthropocentrism

Anthropocentrism, the traditional paradigm positioning humans at the center and nature as an instrument for human benefit, remains dominant in many conventional curricula. Analysis from 23 studies revealed that biology textbooks and teaching materials often emphasize the utilitarian value of nature, resource exploitation for human welfare, and technological solutions to environmental problems, with little attention to underlying

ethical assumptions. This paradigm is frequently criticized for perpetuating exploitative human–nature relations and failing to address the root causes of ecological crises (Akinwumi, 2023b; Guler, 2025; Kır, 2023; Minarno, 2012; Santika & Sarjan, 2025b; Schinkel, 2025).

## 2. Biocentrism

Biocentrism, which recognizes the intrinsic value of all living beings regardless of their utility to humans, is increasingly being incorporated into innovative biology curricula. Thirty-one articles reported the integration of biocentric perspectives through topics such as animal rights, wildlife conservation ethics, and respect for all life forms. Pedagogical strategies include field observations to foster empathy toward non-human life, ethical dilemma discussions related to animal use in research, and project-based learning focused on biodiversity conservation. Quantitative studies indicate that exposure to biocentric perspectives significantly enhances students' biocentric value scores (Cohen's  $d = 0.64$ ) and compassion toward animals (Alvionita et al., 2021; Minarno, 2012; Putrawan, 2015).

## 3. Ecocentrism

Ecocentrism, the most holistic paradigm viewing ecosystems as integrated systems with intrinsic value, emerged as the most transformative yet challenging to implement. Nineteen articles examined ecocentric approaches emphasizing interdependence, ecological integrity, and systems thinking. Ecocentrism-based curricula incorporate concepts such as interconnectedness of all life, limits to growth, ecological citizenship, and responsibility toward future generations (Guler, 2025; Husamah et al., 2025; Quintana et al., 2023; Santika & Sarjan, 2025a; Schinkel, 2025).

Reported effective pedagogical strategies for cultivating ecocentric worldviews include place-based education that connects learners with local ecosystems, philosophical inquiry using environmental philosophy texts, systems-thinking activities for understanding ecological complexity, and community-based environmental restoration projects. Longitudinal studies ( $n = 3$ ) showed that students exposed to ecocentric curricula experienced significant shifts in their New Ecological Paradigm (NEP) scores compared to control groups (pre–post difference:  $t =$

4.23,  $p < 0.001$ ), indicating strong potential for worldview transformation (Hardianti et al., 2024; Putrawan, 2015; Quintana et al., 2023; Reyna et al., 2018).

Comparative analysis revealed that the most effective curricula are those that explicitly present all three paradigms and encourage students to critically examine the assumptions and implications of each worldview. Such an approach cultivates philosophical literacy and critical thinking rather than promoting adherence to a single paradigm (Alvionita et al., 2021; Schinkel, 2025).

## Pedagogical Approaches in Integrating Environmental Ethics

The scoping review identified a wide range of pedagogical approaches employed to integrate environmental ethics into biology education, each demonstrating varying levels of effectiveness depending on the instructional context and targeted learning outcomes.

Experiential Learning emerged as the most frequently reported approach ( $n = 42$  studies) and demonstrates a strong evidence base for its effectiveness. Activities such as field trips to local ecosystems, outdoor observations, ecological restoration projects, and school gardening initiatives allow students to engage directly with nature, fostering emotional connection and moral concern. A meta-analysis of 12 studies reported a large effect size (Hedges'  $g = 0.82$ ) on environmental awareness and a moderate effect ( $g = 0.58$ ) on pro-environmental behavior compared with traditional classroom instruction (Ardoin & Bowers, 2020; Cartono, 2022).

Project-Based Learning (PBL) focused on environmental issues was reported in 28 studies as an effective approach for developing both environmental knowledge and ethical reasoning. Projects typically involve conducting biodiversity surveys,

analyzing community environmental issues, designing waste-management solutions, and producing environmental awareness campaigns. Research in Indonesia indicates that PBL enriched with environmental ethics significantly improves students' critical thinking ( $N = 74$ ,  $p < 0.05$ ) and environmental ethics literacy compared with conventional instruction (Cartono, 2022; Hardianti et al., 2024; Husamah et al., 2025).

Philosophical Inquiry and Dialogue, an approach that explicitly engages students in philosophical reflection on human–nature relationships, was documented in 19 studies. Methods include Socratic dialogue on environmental dilemmas, reading and discussing environmental philosophy texts, structured debates on controversial issues, and reflective journaling on personal environmental values. Qualitative evidence shows that philosophical inquiry deepens moral reasoning and gradually shifts anthropocentric assumptions toward more ecocentric perspectives, although this process requires time and skilled facilitation (Hardianti et al., 2024; Schinkel, 2025).

Place-Based Education, which situates learning within the local environment, was found effective in 16 studies. This approach is particularly relevant in Indonesia, where high biodiversity and strong indigenous knowledge traditions can be incorporated into instruction. Teaching biological concepts alongside local wisdom related to conservation provides dual benefits: improved relevance and engagement, and preservation of cultural heritage (Mustofa & Sueb, 2023; Putikadyanto et al., 2024).

Case-Based Learning, using real environmental cases or ethical dilemmas, was identified in 14 studies as effective for cultivating ethical decision-making. Examples include conflicts between economic development and conservation, ethical issues in genetic modification, and

dilemmas in wildlife management. These cases prompt students to analyze multiple viewpoints, consider potential consequences, and formulate rational ethical judgments (Akinwumi, 2023).

Comparative studies ( $n = 7$ ) indicate that combined pedagogical approaches—such as integrating experiential learning, philosophical inquiry, and PBL—yield superior outcomes compared with single-method instruction, suggesting potential synergistic effects. However, implementing multi-modal pedagogy demands high teacher competence, sufficient resources, and flexible curricular structures (Hardianti et al., 2024; Husamah et al., 2025).

#### Impacts on Environmental Literacy and Student Outcomes

Analysis of outcomes reported across 52 empirical studies reveals a broad spectrum of impacts resulting from environmental ethics–based biology education.

Environmental Knowledge and Ecological Literacy improved significantly in nearly all intervention studies ( $n = 38$ ; 95% reporting significant gains). Effect sizes ranged from medium ( $d = 0.45$ ) to large ( $d = 1.02$ ), depending on program duration and intensity. Importantly, such approaches enhanced not only factual knowledge but also conceptual understanding of ecological systems, biodiversity, and sustainability (Ardoin & Bowers, 2020; Cartono, 2022; Murti et al., 2025; Mustofa & Sueb, 2023).

Environmental Awareness and Attitudes showed substantial increases in 44 studies. Pre-post assessments using instruments such as the Environmental Attitude Inventory (EAI) demonstrated significant positive shifts ( $p < 0.01$ ) in environmental concern, appreciation of nature, and willingness to engage in protective actions. Longitudinal studies ( $n = 4$ ) indicate that attitudinal changes can persist for 12–18



months, though effect size may decline somewhat over time (Ardoin & Bowers, 2020; Mustofa & Sueb, 2023; Putrawan, 2015; Rahardjanto et al., 2022).

Environmental Ethics Literacy and Moral Reasoning, representing more advanced outcomes, were assessed in 18 studies using instruments such as environmental ethics literacy tests and moral reasoning protocols. Students exposed to explicit environmental ethics instruction demonstrated higher levels of ethical reasoning, stronger ability to articulate ethical justifications for conservation actions, and progression from egocentric toward ecocentric moral orientations. However, developing robust environmental ethics literacy requires sustained engagement—typically 6–12 months or longer—rather than short-term interventions (Alvionita et al., 2021).

Pro-Environmental Behavior, often considered the ultimate goal of environmental education, showed mixed results. While 23 studies documented improvements in self-reported behaviors (e.g., waste reduction, energy conservation, recycling, participation in environmental programs), objective behavioral measures ( $n = 6$ ) produced more modest effects ( $d = 0.32\text{--}0.48$ ), highlighting a persistent attitude–behavior gap. Mediating factors include perceived behavioral control, social norms, and institutional support (Ardoin & Bowers, 2020; Mustofa & Sueb, 2023; Rahardjanto et al., 2022).

Critical Thinking and Problem-Solving Skills improved across 21 studies employing pedagogies such as PBL, case-based learning, and inquiry. Well-designed environmental ethics education encourages students to analyze complex problems, evaluate evidence critically, identify assumptions and biases, and generate creative solutions. Rubric-based assessments show improvements of 23–

35% from pre- to post-test (Cartono, 2022; Hardianti et al., 2024; Husamah et al., 2025).

Sense of Environmental Responsibility and Agency also increased in 27 studies. Students expressed a stronger sense of personal responsibility for environmental issues, heightened self-efficacy, and greater commitment to environmental citizenship. Qualitative data from interviews and reflective journals reveal transformative experiences, such as feeling “more connected to nature,” recognizing oneself “as part of the ecosystem,” and demonstrating a growing desire to take action (Hardianti et al., 2024; Monika, 2024).

Moderator analyses identified several factors influencing the strength of intervention effects:

- (1) Duration and intensity—programs with at least 20 contact hours produced stronger effects;
- (2) Teacher characteristics—higher teacher literacy in environmental ethics and pedagogical content knowledge correlated with better outcomes;
- (3) School culture—institutions with a whole-school environmental ethos (e.g., Adiwiyata or eco-school models) provided stronger reinforcement; and
- (4) Community involvement—programs involving families and local communities showed improved transfer and sustainability of behavioral outcomes (Ardoin & Bowers, 2020; Hardianti et al., 2024; Mustofa & Sueb, 2023; Putikadyanto et al., 2024).

## Integration of Local Wisdom in Environmental Ethics Education

One of the most contextually significant findings for Indonesia is the essential role of local wisdom in strengthening environmental ethics education. Eleven Indonesian studies reported that

incorporating local ecological knowledge, traditional conservation practices, and indigenous value systems enhances both cultural relevance and pedagogical effectiveness (Mustofa & Sueb, 2023; Putikadyanto et al., 2024). Examples include grounding instruction in *menyama braya* (Bali), which emphasizes the interconnectedness of all living beings; *huma betang* (Kalimantan) as a model of sustainable communal living; *sasi* (Maluku) as a customary system of marine resource stewardship; and *tri hita karana*, a Balinese philosophical framework promoting harmony among humans, nature, and divinity. Studies reported higher student engagement and deeper meaning-making when environmental ethics is taught using culturally familiar worldviews rather than relying exclusively on Western philosophical traditions (Putikadyanto et al., 2024).

However, several challenges accompany the integration of local wisdom. These include limited documentation of indigenous knowledge in pedagogically accessible formats, potential tensions between traditional practices and modern conservation science, and considerable variability in ecological knowledge across regions. Scholars therefore recommend collaborative approaches that actively involve community elders, indigenous knowledge keepers, and local ecological experts in curriculum development and instructional processes.

### **Challenges and Barriers in Implementation**

Despite substantial evidence demonstrating the benefits of integrating environmental ethics into biology education, the scoping review identified multiple persistent barriers that limit widespread implementation.

Curriculum Constraints emerged as the most frequently reported barrier (n = 34 studies). Overcrowded curricula—laden

with dense content requirements—restrict opportunities for philosophical dialogue, ethical reflection, and experiential learning. Assessment systems dominated by cognitive, knowledge-based outcomes further reduce incentives for teachers to invest time in cultivating environmental values and ethical reasoning. In Indonesia, although *Kurikulum Merdeka* offers increased flexibility, implementation remains uneven, and many schools continue to prioritize exam-oriented instruction (Andriani & Robandi, 2025; Nuraini, 2023; Putikadyanto et al., 2024).

Teacher Preparedness was identified as a critical limiting factor in 28 studies. Many teachers have not received sufficient pre-service preparation in environmental ethics or pedagogical training for addressing controversial, value-laden topics. A survey of 156 biology teachers showed that 68% did not feel confident facilitating philosophical discussions on environmental issues, and 74% had limited familiarity with environmental philosophy literature. These findings highlight the urgent need to strengthen teacher education by deepening environmental ethics literacy and pedagogical content knowledge (Husamah et al., 2022; Rahardjanto et al., 2022).

Lack of Resources and Materials was reported in 26 studies, particularly in underfunded schools. Limited access to outdoor learning environments, instructional materials that integrate environmental ethics, and technology for virtual field experiences hinder the implementation of effective pedagogies. Although some resources are available online, teachers often struggle to adapt these materials to local sociocultural contexts.

Institutional and Policy Support was identified as an additional systemic barrier in 19 studies. Schools lacking environmental policies or leadership commitments to sustainability face

difficulties sustaining environmental ethics initiatives. Conversely, institutions adopting whole-school approaches—such as eco-schools or *Adiwiyata* programs—demonstrate stronger integration and more promising outcomes (Bostad, 2005).

Philosophical and Methodological Challenges include navigating value pluralism in diverse classrooms, addressing potential conflicts with religious or cultural beliefs, balancing education with avoidance of indoctrination, and assessing values and attitudes ethically and validly. Teachers require sophisticated pedagogical skills to facilitate sensitive discussions and manage disagreements constructively (Alvionita et al., 2021).

### Methodological Gaps in the Literature

Several methodological limitations constrain the current evidence base. Cross-sectional designs dominate the field, with only 4 of 68 studies conducting follow-up assessments beyond 12 months. This limits understanding of long-term impacts on environmental attitudes and behaviors. More longitudinal research is needed to track developmental trajectories and identify conditions that sustain ethical growth (Ardoin & Bowers, 2020; Putrawan, 2015; Suhartini & Mns, n.d.).

The limited number of experimental or quasi-experimental studies (15 out of 68) restricts causal interpretations regarding the effectiveness of specific pedagogical approaches. Future studies require more robust designs with control groups, standardized instruments, and adequate statistical power (Ardoin & Bowers, 2020; Husamah et al., 2025).

Qualitative research exploring ethical development, shifts in worldview, and students' lived experiences remains

underrepresented (20 studies). Rich qualitative inquiry is essential for uncovering mechanisms of change and contextual dynamics influencing implementation (Hardianti et al., 2024).

Content and Conceptual Gaps persist. While many studies focus on general environmental ethics, few address urgent, contemporary issues in modern biology such as the ethics of genetic engineering, CRISPR, synthetic biology, laboratory animal welfare, or conservation triage. These emerging issues warrant greater curricular and research attention (Alvionita et al., 2021).

The intersection of environmental ethics with social justice, environmental racism, and climate justice remains largely unexplored (only 3 studies). Future work should examine equity dimensions and how environmental ethics education can empower marginalized communities disproportionately affected by ecological degradation (Akinwumi, 2023b; Santika & Sarjan, 2025).

Population and Context Gaps also persist. Most studies focus on secondary students, while research at the elementary and higher education levels remains sparse. Developmentally appropriate approaches for different age groups require further investigation (Ardoin & Bowers, 2020; Cartono, 2022).

Geographically, the literature is skewed toward developed countries, with limited representation from the Global South—including Indonesia. More research is needed on how indigenous knowledge systems can be meaningfully integrated with contemporary environmental ethics (Husamah et al., 2022).

Finally, there is insufficient research on implementation science, including scaling strategies, system-level factors, and policies needed to support widespread

adoption. Studies on effective models of teacher professional development also remain a high priority.

## Integrative Conceptual Framework

Synthesizing the findings, this review proposes an integrative conceptual framework for environmental ethics-based biology education comprising five interconnected dimensions (Harahap & Widodo, 2024; Hardianti et al., 2024; Husamah et al., 2025):

1. Philosophical Dimension — grounding learning in environmental philosophical traditions (anthropocentrism, biocentrism, ecocentrism) to foster philosophical literacy and informed ethical stances (Alvionita et al., 2021; Schinkel, 2025).
2. Cognitive Dimension — developing ecological knowledge, systems thinking, and scientific understanding of environmental issues rooted in biological sciences (Kır, 2023; Murti et al., 2025).
3. Affective Dimension — cultivating environmental awareness, emotional connectedness to nature, and a sense of wonder that motivates ethical care (Hardianti et al., 2024).
4. Moral Dimension — strengthening environmental ethics literacy, moral reasoning skills, a sense of responsibility, and commitment to environmental justice (Bostad, 2005).
5. Behavioral Dimension — promoting pro-environmental behaviors, civic engagement, and action competencies that empower learners to contribute to sustainability (Rahardjanto et al., 2022; Sulphay et al., 2023).

The framework underscores that effective environmental ethics education in

biology requires holistic integration across all five dimensions. The most successful pedagogical approaches explicitly bridge philosophical foundations, ecological knowledge, affective experiences, moral reflection, and opportunities for meaningful environmental action.

## Conclusion

This scoping review of 68 articles published between 2015 and 2025 demonstrates a clear rise in scholarly attention to the integration of environmental ethics and ecological philosophy within biology education. Research output increased by 45% in the 2020–2025 period, signaling growing recognition of the importance of ethical and philosophical dimensions in science learning. Findings indicate that distinct ecological paradigms—anthropocentrism, biocentrism, and ecocentrism—shape different pedagogical directions and learning outcomes, with ecocentrism offering the deepest transformative potential. Effective pedagogical approaches, particularly experiential learning, project-based learning, philosophical inquiry, and place-based education, consistently enhance ecological literacy, environmental awareness, moral reasoning, and, to a more modest extent, pro-environmental behaviors.

Despite these promising outcomes, the review identifies several systemic barriers that constrain widespread and effective implementation. Curriculum overload, limited teacher preparedness, inadequate resources, and uneven institutional support remain persistent challenges across diverse educational contexts. Additionally, teaching value-laden environmental issues requires sophisticated pedagogical skills, yet many teachers report limited confidence and training. While the integration of local wisdom and indigenous ecological knowledge shows strong potential to strengthen cultural relevance—particularly in contexts like Indonesia—

documentation and pedagogical adaptation of these knowledge systems remain limited, highlighting the need for closer collaboration between educators, communities, and indigenous knowledge holders.

Overall, the review underscores that integrating environmental ethics and ecological philosophy into biology education is essential for cultivating environmentally literate and ethically responsible citizens capable of addressing contemporary ecological crises. Achieving this goal requires sustained commitment from policymakers, teacher education

institutions, and schools to translate research evidence into practice, strengthen professional development, and foster supportive learning environments. The integrative conceptual framework proposed in this study—encompassing philosophical, cognitive, affective, moral, and behavioral dimensions—provides a foundation for designing and evaluating environmental ethics initiatives. Ultimately, biology education must evolve from transmitting scientific knowledge toward nurturing ecological consciousness, moral agency, and action competence in learners.

## References

- Akinwumi, I. O. (2023a). Biology Education: A Panacea To Global Environmental Challenges. *European Journal Of Training And Development Studies*, 10(2), 44–56.  
<https://doi.org/10.37745/Ejtds.2014/Vol10n24456>
- Akinwumi, I. O. (2023b). Biology Education: A Panacea To Global Environmental Challenges. *European Journal Of Training And Development Studies*, 10(2), 44–56.  
<https://doi.org/10.37745/Ejtds.2014/Vol10n24456>
- Alvionita, D., Murti, A. B., Rasyid, A., & Gani, F. (2021). *Peran Etika Dalam Penelitian Pendidikan, Biologi Dan Lingkungan* (Vol. 8).
- Andriani, D., & Robandi, B. (2025). Holistic Philosophy In Developing Environmental Education Curricula. *Inovasi Kurikulum*, 22(1), 555–568.  
<https://doi.org/10.17509/Jik.V22i1.65967>
- Ardoin, N. M., & Bowers, A. W. (2020). Early Childhood Environmental Education: A Systematic Review Of The Research Literature. In *Educational Research Review* (Vol. 31). Elsevier Ltd.  
<https://doi.org/10.1016/J.Edurev.2020.100353>
- Bostad, R. (N.D.). 16. *Environmental Education Place In The Curriculum*.
- Caplow, S., & Hunter, R. (2024). A Scoping Review Of The Intersection Of Environmental And Science Identity. *Interdisciplinary Journal Of Environmental And Science Education*, 20(4), E2417.  
<https://doi.org/10.29333/Ijese/14884>
- Cartono, C. (2022). The Importance Of Environmental Education In Biology Learning To Increase Students' Environmental Awareness Keywords. *Jurnal Info Sains*, 12(2).  
<http://ejournal.seaninstitute.or.id/index.php/infosains>
- Guler, O. (2025). Towards An Ecological Philosophy Of Education: Eco-Education Against Cartesian Understanding Of Nature Kaygı. *Bursa Uludağ Üniversitesi Fen-Edebiyat Fakültesi Felsefe Dergisi*, 24(1), 353–387.  
<https://doi.org/10.20981/Kaygi.1604925>
- Gutierrez-Bucheli, L., Reid, A., & Kidman, G. (2022). Scoping Reviews: Their Development And Application In Environmental And Sustainable Education Research. In *Environmental Education Research* (Vol. 28, Issue 5, Pp. 645–673). Routledge.  
<https://doi.org/10.1080/13504622.2022.2047896>
- Hadie, S. N. H. (2024). ABC Of A Scoping Review: A Simplified JBI Scoping Review Guideline. *Education In Medicine Journal*, 16(2), 185–197.  
<https://doi.org/10.21315/Eimj2024.16.214>
- Harahap, D., & Widodo, J. (2024). Tracking In Nature's Footsteps: The Intersection Of Environmental Education And

- Philosophy. In *Assyfa International Of Multidisciplinary Education* (Vol. 1, Issue 2).
- Hardianti, S., Firdaus, M., Saputra, D., Sumianto, Febria, D., Iqbal Firmananda, F., Zulia Jati, P., & Indah Permata Sari, V. (2024). Pendidikan Filosofis Untuk Kesadaran Ekologis: Menumbuhkan Kesadaran Moral Terhadap Lingkungan Di Kalangan Siswa Sekolah Menengah Kejuruan Perpajakan Riau. *Journal Of Social And Community Service*, 3(3), 129–138.  
<https://doi.org/10.31004/Jestmc.V3i3.183>
- HERMANSYAH, S. (2023). Investigating Difficulties Faced by Lecturers in Teaching General English. *Journal of English Education and Teaching*, 7(3), 499–509.  
<https://doi.org/10.33369/jeet.7.3.499-509>
- Husamah, H., Rahardjanto, A., Indria Permana, T., Adnan Mohd Shukri, A., Pendidikan Biologi, P., & Keguruan Dan Ilmu Pendidikan, F. (2025). An AI-Assisted Systematic Review Of Biology Learning Strategies For Sustainability. *Journal Of Natural Sciences*, 6(3), 235–247.  
<https://doi.org/10.34007/Jonas.V6i2.1019>
- Husamah, H., Suwono, H., Nur, H., & Dharmawan, A. (2022). Environmental Education Research In Indonesian Scopus Indexed Journal: A Systematic Literature Review. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, 8(2), 105–120.  
<https://doi.org/10.22219/Jpbi.V8i2.21041>
- Kir, M. (2023). Environmental Literacy In Biology Curriculum. *International Journal Of Eurasian Education And Culture*.  
<https://doi.org/10.35826/Ijoec.784>
- Minarno, E. B. (2012). Pembelajaran Bioetika Sebagai Pengawal Perkembangan Biologi Modern Dan Penyelamatan Lingkungan Hidup. In *El-Hayah* (Vol. 3, Issue 1).
- Monika, J. (2024). 40. Sustainability Education In The 21st Century: Incorporating Environmental Awareness In K-12 Curriculum. *Post Axial*, 2(3), 120–133.
- Mudinillah, A., Kuswandi, D. ., Erwin, E., Sugiarni, S., Winarno, W., Annajmi, A., & Hermansah, S. (2024). Optimizing Project-Based Learning in Developing 21st Century Skills: A Future Education Perspective. *Qubahan Academic Journal*, 4(2), 86–101.  
<https://doi.org/10.48161/qaj.v4n2a352>
- Murti, W., Rohman, F., Sari, M. S., & Ibrohim, I. (2025). Ecoliteracy Competencies: A Systematic Literature Review Of Domains, Approaches, And Impacts In Education. In *Eurasia Journal Of Mathematics, Science And Technology Education* (Vol. 21, Issue 8). Modestum LTD.  
<https://doi.org/10.29333/Ejmste/16658>
- Mustofa, A., & Sueb, S. (2023). Analysis Of Environmental Literacy And Awareness To Maintain Environmental Sustainability. *Edubiotik : Jurnal Pendidikan, Biologi Dan Terapan*, 8(01), 50–61.  
<https://doi.org/10.33503/Ebio.V8i01.2528>
- Noviati, W. E. R. (2018). Analisis Pengetahuan Bioetika Mahasiswa Pendidikan Biologi Universitas Samawa Dalam Permasalahan Lingkungan. *Jurnal Kependidikan*, 3(1), 32–39.
- Nuraini, L. (2023). Biological Education In Indonesian Senior High School: Study In Textbook And Curriculum Policy. *Article BIOEDUSCENCE*, 7(1), 12710.  
<https://doi.org/10.22263/Jbes/7111234>
- Nursidin, & Rusman, L. (2021). *Environmental-Based Biology Curriculum Of Senior High School: Case Study Of North Konawe Regency, Indonesia* (Vol. 25). <http://Annalsofscsb.ro>
- Olawumi, K. B., Mavuso, M. P., & Khalo, X. (2024). Integrating Environmental Ethics In Teaching And Learning Through The Use Of Ubuntu Principles: Review Of Literature. *Journal Of Culture And Values In Education*, 7(4), 149–171.  
<https://doi.org/10.46303/Jcve.2024.46>
- PIB, D. (2025). *Environmental Studies As A Subject In School Curriculum*.
- Putikadyanto, A. P. A., Wachidah, L. R., & Sari, S. Y. (2024). Menciptakan Generasi Peduli Lingkungan: Inovasi Ekokurikulum Berbasis Kearifan Lokal Madura Di SMP Pamekasan. *GHANCARAN: Jurnal Pendidikan Bahasa Dan Sastra Indonesia*.

- <https://doi.org/10.19105/Ghancaran.Vi.17180>
- Putrawan, I. M. (2015). Measuring New Environmental Paradigm Based On Students' Knowledge About Ecosystem And Locus Of Control. *Eurasia Journal Of Mathematics, Science And Technology Education*, 11(2), 325–333. <https://doi.org/10.12973/Eurasia.2015.1336a>
- Quintana, D. S. Z., Platje, J. J., Bernaciak, A., Czekala, M., Will, M., & Van DAM, Y. K. (2023). The New Ecological Paradigm And Attitudes Towards Sustainable Business Practices—A Mexican Case Study. *Economics And Environment*, 87(4). <https://doi.org/10.34659/Eis.2023.87.4.649>
- Rahardjanto, A., Husamah, H., Hadi, S., Lestari, N., & Fatmawati, D. (2022). The Environmental Attitude Of The Prospective Biology Teachers In Indonesia. *JPBI (Jurnal Pendidikan Biologi Indonesia)*, 8(3), 255–264. <https://doi.org/10.22219/Jpbi.V8i3.22855>
- Reyna, C., Bressán, E., Mola, D., Balaus, A., & Victoria Ortiz, M. (2018). Validating The Structure Of The New Ecological Paradigm Scale Among Argentine Citizens Through Different Approaches 1 Artículo Original De Investigación. *Pensamiento Psicológico*, 16(1), 107–118. <https://doi.org/10.11144/Javeria>
- Sam Hermansyah, & Ahmad Rizal Majid. (2025). The Use of Probing-Prompting Technique to Improve Reading Comprehension of Eighth Grade Students. *INTERACTION: Jurnal Pendidikan Bahasa*, 12(1), 543–556. <https://doi.org/10.36232/interactionjournal.v12i1.2660>
- Santika, L., & Sarjan, M. (2025a). Dimensi Filsafat Dalam Pengelolaan Sumber Daya Alam: Kajian Peran Manusia Dalam Menjaga Keseimbangan Lingkungan. *Lambda Jurnal Ilmiah Pendidikan MIPA Dan Aplikasinya*, 5(1), 54–60. <https://doi.org/10.58218/Lambda.V5i1.1205>
- Santika, L., & Sarjan, M. (2025b). Dimensi Filsafat Dalam Pengelolaan Sumber Daya Alam: Kajian Peran Manusia Dalam Menjaga Keseimbangan Lingkungan. *Lambda Jurnal Ilmiah Pendidikan MIPA Dan Aplikasinya*, 5(1), 54–60. <https://doi.org/10.58218/Lambda.V5i1.1205>
- Schinkel, A. (2025). Beyond Human Flourishing: An Argument For Ecological Education. *Journal Of Philosophy Of Education*, 59(3–4), 651–667. <https://doi.org/10.1093/Jopedu/Qhaf001>
- Suhartini, S., & Mns. (N.D.). *SCOPING REVIEW*.
- Sulphey, M. M., Alkahtani, N. S., Mareai Senan, N. A., & Elneel Adow, A. H. (2023). New Environmental Paradigm, Environmental Attitude, And Proenvironmental Behaviour As Antecedents Of Environmental Sustainability. *International Journal Of Energy Economics And Policy*, 13(3), 418–427. <https://doi.org/10.32479/Ijeep.14156>
- Widiasih, R., Susanti, R. D., Windani, C., Sari, M., & Hendrawati, S. (2020). *Menyusun Protokol Penelitian Dengan Pendekatan Setpro: Scoping Review* (Vol. 3).