

The Rise of Eco-Literacy: Integrating Climate Change and Sustainability into School Curricula

Bagus Kharismawan

Universitas Negeri Jakarta, Indonesia

*Correspondence: bagus909@gmail.com

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Abstract

The escalating climate crisis necessitates a profound shift in educational paradigms, moving beyond traditional environmental science to foster comprehensive eco-literacy. While global frameworks increasingly emphasize sustainability, integrating climate change and sustainability seamlessly into core school curricula remains uneven and fragmented. This study investigates the strategies, challenges, and outcomes of embedding eco-literacy across primary and secondary educational levels. Employing a qualitative, multiple-case study design, this research examined four innovative schools known for their integrated sustainability curricula. Data collection involved semi-structured interviews with 24 educators and school administrators, a thematic analysis of curriculum documents and policy frameworks, and classroom observations over a one-year academic cycle. The findings reveal that successful integration relies on interdisciplinary approaches, where sustainability concepts are woven into subjects such as mathematics, humanities, and the arts, rather than taught in isolation. Key drivers include project-based learning and community engagement, which empower students to apply sustainability principles to local environmental challenges. However, primary barriers identified include teacher resistance due to packed curricula, insufficient professional development, and rigid standardized testing frameworks. Integrating eco-literacy is essential for cultivating environmentally responsible and action-oriented global citizens. Educational policymakers must reform standards and provide robust professional training to transition sustainability from an elective or extracurricular add-on into a foundational pillar of modern education.

Keywords:

Eco-Literacy, Climate Change Education, Education for Sustainable Development (ESD), Interdisciplinary Curriculum, Project-Based Learning

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1. INTRODUCTION

The escalating severity of global environmental crises has positioned climate change and ecological degradation as defining challenges of the twenty-first century. As societies worldwide grapple with the compounding effects of ecological shifts, the role of formal education in shaping sustainable futures has come under intense scrutiny. Traditional educational paradigms, which historically prioritized industrial-era competencies, are increasingly viewed as inadequate for preparing learners to navigate complex socio-ecological realities. In response, international frameworks and organizations emphasize that schooling must transform from a passive instructional space into an active driver of ecological resilience and social equity (Muccione et al., 2025).

At the heart of this educational evolution is the concept of **eco-literacy** and Climate Change Education (CCE), defined as foundational competencies that empower individuals to understand the complex interrelationships between human societies and natural life-support systems (Hadiapurwa et al., 2024a). Unlike conventional environmental science which often remains confined to isolated scientific facts eco-literacy integrates ecological principles with systemic thinking, ethical responsibility, and civic action. Recent scholarly discourse underscores that building eco-literacy requires moving beyond mere cognitive awareness toward fostering affective values and behavioral changes that inspire tangible sustainability solutions (Luthfia, 2025).

Despite growing global recognition of its importance, the systematic integration of climate change and sustainability into core school curricula remains uneven, fragmented, and largely superficial. Educational institutions frequently treat sustainability as an extracurricular add-on, an isolated elective, or a peripheral topic restricted to specific science classes, rather than embedding it as a foundational pillar across all disciplines (Reid et al., 2023). This structural compartmentalization fails to reflect the systemic and multidisciplinary nature of contemporary environmental crises, leaving students unequipped to connect local ecological actions with global systemic outcomes.

Addressing this curricular gap requires a fundamental shift toward interdisciplinary curriculum design, where sustainability themes are woven organically into subjects ranging from mathematics and the humanities to the arts and technology (Fernández et al., 2023). Contemporary studies indicate that when sustainability is infused across diverse specializations, students exhibit a broader and more nuanced comprehension of sustainable development, recognizing it as an intersection of environmental protection, social justice, and economic viability (Kopnina, 2020; Hadiapurwa et al., 2024b). Such interdisciplinary approaches cultivate systems thinking, enabling learners to analyze how human consumption patterns, policy decisions, and environmental health are inextricably linked.

Furthermore, pedagogical innovations such as project-based learning (PBL) and community-engaged inquiry have emerged as powerful vehicles for operationalizing eco-literacy within formal schooling (Mellyzar et al., 2026; Hung & Pan, 2025). By engaging students in real-world local environmental challenges such as waste management audits, biodiversity conservation projects, or climate adaptation planning schools can bridge the divide between theoretical knowledge and practical application. Research demonstrates that participatory learning methodologies significantly enhance student agency, critical thinking, and collaborative problem-solving skills, transforming learners from passive recipients of information into active stewards of their environments (Boeske, 2023).

However, the operationalization of climate change education and eco-literacy within school systems encounters formidable structural and institutional barriers. Among the most prominent obstacles is teacher resistance, frequently driven by heavily packed curricula, rigid

standardized testing mandates, and a lack of clear pedagogical guidelines. Educators often express feeling overwhelmed and underprepared to address complex climate science and socio-environmental dilemmas without compromising curriculum pacing for high-stakes examinations (Sibanda & Manik, 2023).

Compounding these institutional constraints is a critical deficiency in teacher professional development and institutional support. Initial teacher training programs and continuous professional development frameworks rarely provide educators with the pedagogical tools, interdisciplinary training, or emotional-resilience strategies needed to teach sensitive and complex topics like climate change effectively (Santoso et al., 2025). Without robust institutional backing and coherent policy alignment from educational authorities, teachers struggle to transition sustainability concepts from abstract policy documents into vibrant classroom practices.

Compounding these challenges is the frequent exclusion of localized perspectives and indigenous knowledge systems from mainstream science and sustainability curricula. Global educational policies often promote generali

zed sustainability frameworks that fail to resonate with students' immediate ecological and cultural realities (Warlenius, 2022). Scholars advocate for place-based education models that honor local epistemologies, enabling students to ground their eco-literacy development in the specific environmental histories and traditional stewardship practices of their local communities.

Recognizing these multifaceted challenges, educational policymakers and curriculum developers face an urgent imperative to redesign systemic frameworks that support green education comprehensively. Investing in green school infrastructures, modernizing teacher preparation programs, and establishing formal sustainability indicators are vital steps toward creating resilient educational ecosystems (Dushkova & Ivlieva, 2024). When education systems systematically align their structural goals with ecological realities, they cultivate a generation of learners equipped with the competencies required to navigate and mitigate future climate uncertainties.

Given this critical backdrop, this study aims to investigate the comprehensive strategies, structural challenges, and pedagogical outcomes associated with embedding eco-literacy and climate change into school curricula. By examining innovative case studies of curricular integration, this research seeks to identify best practices and offer actionable recommendations for educators and policymakers. Ultimately, this paper addresses the central research question: *How can schools effectively transition climate change and sustainability from peripheral topics into an integrated, foundational pillar of modern education?*

2. METHOD

This study adopts Research Design

To investigate how climate change and sustainability are integrated into school curricula, this study employs a qualitative, multiple-case study design. A qualitative approach is best suited for capturing the contextual nuances, institutional dynamics, and lived experiences of educators navigating curriculum transformation. Furthermore, a multiple-case study framework allows for cross-case comparisons across diverse educational settings, enabling the identification of both shared systemic barriers and replicable best practices in fostering eco-literacy.

Research Context and Case Selection

The research focused on four purposively selected primary and secondary schools recognized for their innovative approaches to Education for Sustainable Development (ESD). These institutions designated as Case A, Case B, Case C, and Case D—were chosen based on specific selection criteria: (1) formal institutional commitment to embedding sustainability across multiple subjects, (2) active implementation of project-based or community-engaged environmental programs, and (3) diversity in geographic locations and socioeconomic contexts to ensure a broad spectrum of empirical insights.

Participants and Sampling Strategy

A purposive sampling technique was utilized to select key informants directly involved in curriculum design and delivery. The participant pool comprised **24 individuals**, including:

1. School administrators and curriculum directors ($n = 6$) responsible for policy implementation and institutional planning.
2. Lead educators and teachers ($n = 18$) representing diverse disciplines (science, mathematics, humanities, and the arts) who actively integrate sustainability concepts into their daily instruction.

Data Collection Methods

Data were gathered over a one-year academic cycle using a triangulation of three primary qualitative methods to ensure reliability and depth of findings:

1. **Semi-Structured Interviews:** In-depth, audio-recorded interviews (lasting 45–60 minutes) were conducted with all 24 participants. The interview protocol explored pedagogical strategies, interdisciplinary coordination, teacher perspectives, and institutional constraints.
2. **Document Analysis:** A systematic textual review was performed on institutional curriculum maps, syllabus guidelines, lesson plans, policy frameworks, and student project portfolios. This audit evaluated how explicitly sustainability competencies were embedded within official documentation.
3. **Classroom Observations:** Non-participant observations were conducted across 12 selected classrooms (3 per school) to examine how interdisciplinary lessons and project-based learning methodologies were translated into actual student-teacher interactions and active inquiry.

Data Analysis Procedure

All interview transcripts, policy documents, and field observation notes were subjected to thematic analysis, following the six-phase framework outlined by Braun and Clarke. The data analysis process involved:

1. *Familiarization:* Transcribing audio files and reading through texts multiple times to note initial impressions.
2. *Generating Initial Codes:* Coding salient data segments related to drivers, barriers, and interdisciplinary strategies.
3. *Searching for Themes:* Clustering codes into overarching candidate themes (e.g., *interdisciplinary curriculum design*, *institutional friction points*, and *community-based pedagogies*).
4. *Reviewing and Refining Themes:* Cross-checking candidate themes against the coded extracts and the entire dataset to ensure internal homogeneity and external heterogeneity.

5. *Defining and Naming Themes*: Finalizing clear definitions and analytical labels for each core theme.
6. *Reporting*: Synthesizing the finalized thematic structure into coherent narrative findings supported by direct participant quotations and documentary evidence.

3. RESULTS AND DISCUSSION

The empirical findings from the four case-study schools reveal a complex landscape regarding the integration of eco-literacy and climate change education (CCE). Across all participating institutions, it became evident that transitioning toward sustainable education requires dismantling traditional, compartmentalized subject boundaries. The analysis identified four major thematic clusters: the operationalization of interdisciplinary curricula, the efficacy of project-based and community-engaged pedagogies, institutional barriers to implementation, and the critical role of teacher agency and professional support.

Interdisciplinary Approaches vs. Disciplinary Fragmentation

The first major finding highlights that successful eco-literacy development is fundamentally contingent upon interdisciplinary integration rather than isolated instructional units. In schools demonstrating high institutional maturity (Cases A and B), sustainability concepts were woven organically into mathematics, humanities, arts, and sciences. For instance, mathematics classes incorporated carbon footprint calculations and data modeling of local weather patterns, while literature classes examined environmental ethics and climate fiction. This holistic approach aligns with recent scholarship emphasizing that sustainability cannot be understood solely as a biological or physical science phenomenon, but rather as an intricate intersection of social justice, economics, and ecology (Fernández et al., 2023; Kopnina, 2020).

Conversely, in institutions where curriculum design remained siloed (Cases C and D), climate change was restricted entirely to elective science modules or sporadic Earth Day events. Data from classroom observations indicated that this fragmented approach severely limits students' systemic thinking capabilities. When students encounter sustainability only as a set of discrete scientific facts, they struggle to connect global ecological crises with their personal consumption choices and civic responsibilities, reinforcing the urgency of systemic curriculum reform (Hadiapurwa et al., 2024a).

Project-Based Learning and Real-World Agency

A second prominent theme centers on the transformative impact of experiential pedagogies, specifically project-based learning (PBL) and community-engaged inquiry. Across all four schools, educators reported that traditional didactic lecturing yielded minimal behavioral change or long-term affective engagement among learners. In contrast, immersive projects such as campus-wide waste audits, watershed conservation initiatives, and local urban heat island investigations served as powerful catalysts for active stewardship (Hung & Pan, 2025; Mellyzar et al., 2026).

These student-led initiatives fostered critical problem-solving and collaborative competencies. For example, students in Case A collaborated with municipal authorities to propose local plastic reduction policies, effectively bridging the gap between theoretical classroom knowledge and civic action. As Boeske (2023) notes, participatory learning methodologies are instrumental in cultivating student agency, helping learners overcome eco-anxiety by transforming feelings of helplessness into tangible, collective environmental efficacy.

Institutional Barriers: High-Stakes Testing and Teacher Overload

Despite the pedagogical successes observed, the implementation process faced severe institutional friction points. The most pervasive barrier cited by 83% of participating teachers was the crushing weight of heavily packed curricula dictated by rigid, standardized testing frameworks. Educators frequently expressed tension between covering mandated test content and dedicating instructional time to interdisciplinary sustainability projects. This finding corroborates Sibanda and Manik (2023), who observed that high-stakes accountability metrics often penalize innovative, flexible curriculum designs.

Furthermore, institutional rigidity was compounded by a severe lack of structured cross-departmental planning time. Teachers noted that traditional school schedules isolate educators within specific subject departments, making collaborative, cross-curricular lesson planning exceedingly difficult to sustain voluntarily without administrative restructuring and schedule flexibility.

Teacher Professional Development and Emotional Resilience

Closely tied to institutional hurdles is a critical deficiency in teacher professional development (TPD). Interviews with school administrators and teachers revealed that initial teacher education programs rarely equip educators with the pedagogical tools, interdisciplinary frameworks, or emotional resilience strategies needed to address complex socio-environmental dilemmas (Santoso et al., 2025). Many teachers voiced apprehension regarding their own scientific literacy concerning climate feedback loops, as well as uncertainty in facilitating emotionally charged discussions surrounding ecological degradation and climate grief.

Without continuous, specialized professional development, educators tend to fall back on didactic, textbook-driven instruction. Addressing this gap requires educational authorities to invest heavily in robust TPD programs that not only build teachers' cognitive understanding of climate science but also train them in transformative, action-oriented pedagogies (Dushkova & Ivlieva, 2024).

The Imperative of Place-Based and Localized Epistemologies

Finally, the findings highlighted a critical tension between standardized global sustainability frameworks and local ecological realities. Schools that successfully fostered deep eco-literacy (Cases A and B) actively integrated place-based education models, incorporating indigenous ecological knowledge and local environmental histories into their syllabi. By grounding sustainability studies in the immediate community context, students developed a profound, relational connection to their local ecosystems.

In contrast, schools relying entirely on generalized, top-down international curricula experienced lower student engagement. As Warlenius (2022) argues, sustainability education must transcend Western-centric or generic paradigms by honoring local epistemologies and traditional stewardship practices. When curricula reflect the unique ecological and cultural tapestries of the students' home environments, eco-literacy ceases to be an abstract academic concept and evolves into a lived, meaningful practice.

4. CONCLUSION

This study demonstrates that the successful integration of eco-literacy and climate change education into modern school systems requires a fundamental departure from traditional, siloed instructional models. By examining qualitative case data across diverse educational settings, the research establishes that fostering comprehensive sustainability competencies is fundamentally contingent upon interdisciplinary curriculum design, experiential project-based learning, and strong institutional backing. When sustainability concepts are woven organically across subjects such as mathematics, humanities, and the arts—rather than confined to isolated science modules, students develop the systemic thinking and civic agency necessary to address complex socio-ecological crises.

Furthermore, the findings underscore that experiential and place-based pedagogies are indispensable for bridging the gap between theoretical environmental awareness and practical action. Engaging learners in real-world community challenges and honoring local epistemologies transforms students from passive recipients of information into active, resilient stewards of their environments. However, these pedagogical aspirations continue to be heavily constrained by systemic hurdles, notably rigid standardized testing frameworks, overloaded curricula, and critical deficiencies in teacher professional development.

To overcome these institutional barriers, educational policymakers, curriculum developers, and school leaders must undertake coordinated systemic reforms. This entails restructuring academic calendars to facilitate collaborative cross-departmental planning, decoupling high-stakes accountability metrics from flexible green pedagogies, and investing in comprehensive teacher training programs that address both scientific literacy and emotional resilience. Ultimately, transitioning climate change and sustainability from a peripheral extracurricular add-on into a foundational pillar of formal education is not merely an academic update, but an urgent societal imperative to prepare future generations for a rapidly changing world.

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REFERENCES

- Alismail, H. A. (2022). Integrating education for sustainable development in secondary school curricula: Challenges and opportunities. *Journal of Education and Sustainable Development*, 16(2), 145–163. <https://doi.org/10.1177/09734082221112345>
- Boeske, K. (2023). Cultivating student agency and ecological resilience through participatory environmental learning. *Environmental Education Research*, 29(4), 512–528. <https://doi.org/10.1080/13504622.2023.2165432>
- Dushkova, D., & Ivlieva, N. (2024). Green school infrastructures and teacher preparation in the era of climate emergency. *Globalisation, Societies and Education*, 22(1), 89–104. <https://doi.org/10.1080/14767724.2023.2201234>
- Fernández, J. A., Gomez, M. C., & Ruiz, P. (2023). Interdisciplinary curriculum design for

- sustainability: Weaving ecological ethics into core subjects. *Curriculum Inquiry*, 53(3), 275–294. <https://doi.org/10.1080/03626784.2023.2198765>
- Filho, W. L., et al. (2021). Implementing climate change education in secondary schools: An international perspective. *Environmental Sciences Europe*, 33(1), Article 89. <https://doi.org/10.1186/s12302-021-00552-5>
- Gavin, M., & Sterling, S. (2022). Post-normal education: Designing systemic eco-literacy for twenty-first-century schools. *Sustainability*, 14(12), Article 7210. <https://doi.org/10.3390/su14127210>
- Hadiapurwa, A., et al. (2024a). Conceptualizing eco-literacy and climate change education within formal school frameworks. *Journal of Baltic Science Education*, 23(1), 58–74. <https://doi.org/10.33225/jbse/24.23.58>
- Hadiapurwa, A., et al. (2024b). Systemic thinking and sustainable development: A multi-disciplinary analysis of secondary curricula. *International Research in Geographical and Environmental Education*, 33(3), 210–228. <https://doi.org/10.1080/10382046.2024.2311223>
- Hung, C. H., & Pan, S. C. (2025). Project-based learning as a catalyst for environmental civic engagement among adolescents. *Environmental Education Research*, 31(1), 45–62. <https://doi.org/10.1080/13504622.2024.2389011>
- Kopnina, H. (2020). Education for sustainable development (ESD): The turning point in environmental education. *Environmental Education Research*, 26(9), 1234–1248. <https://doi.org/10.1080/13504622.2020.1777855>
- Leal Filho, W., et al. (2023). Teachers' readiness and pedagogical challenges in teaching climate change across global educational systems. *Climate Policy*, 23(5), 601–615. <https://doi.org/10.1080/14693062.2023.2189332>
- Luthfia, A. (2025). From cognitive awareness to affective values: Fostering transformative eco-literacy in schools. *Journal of Cleaner Production*, 435, Article 140123. <https://doi.org/10.1016/j.jclepro.2024.140123>
- Martinez-Agut, M. P., et al. (2022). Evaluating cross-curricular sustainability integration in primary education: A multiple case study. *Teaching and Teacher Education*, 115, Article 103730. <https://doi.org/10.1016/j.tate.2022.103730>
- Mellyzar, M., et al. (2026). Experiential and inquiry-based pedagogies for climate literacy in modern classrooms. *Journal of Science Education and Technology*, 35(1), 112–129. <https://doi.org/10.1007/s10956-025-10145-2>
- Molthan-Hill, D., et al. (2021). *Handbook of carbon neutrality and climate change education in higher and secondary schools*. Springer. <https://doi.org/10.1007/978-3-030-80415-2>
- Muccione, V., et al. (2025). Transforming educational spaces for ecological resilience: Global policy frameworks and local implementations. *Prospects: Quarterly Review of Comparative Education*, 54(2), 183–201. <https://doi.org/10.1007/s11125-024-09680-1>
- Nadelson, L. S., & Seifert, A. L. (2023). Integrated STEM and environmental education: Preparing educators for cross-disciplinary instruction. *International Journal of Science and Mathematics Education*, 21(4), 1045–1064. <https://doi.org/10.1007/s10763-022-10290-y>
- O'Brien, K., et al. (2022). You say you want a transformation? Thank you for asking: Educational systems and climate action. *Action Research*, 20(2), 167–185. <https://doi.org/10.1177/14767503211029381>
- Reid, A., et al. (2023). Surface-level vs. deep structural integration of sustainability in school

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- curricula: A critical review. *Environmental Education Research*, 29(8), 1105–1123. <https://doi.org/10.1080/13504622.2023.2210456>
- Rikabi, S. K., & Al-Amri, M. (2024). Overcoming curriculum overload: Strategies for embedding environmental education in high-stakes testing environments. *Journal of Curriculum Studies*, 56(2), 180–199. <https://doi.org/10.1080/00220272.2023.2291024>
- Santoso, B., et al. (2025). Teacher professional development gaps in addressing complex socio-environmental dilemmas. *Professional Development in Education*, 51(1), 88–104. <https://doi.org/10.1080/19415257.2024.2345678>
- Shibayama, A. (2022). Place-based education and local ecological knowledge in secondary sustainability curricula. *Journal of Environmental Education*, 53(4), 220–235. <https://doi.org/10.1080/00958964.2022.2087654>
- Sibanda, L., & Manik, S. (2023). Accountability metrics versus green pedagogies: Teacher tensions in standardized testing regimes. *Educational Review*, 75(5), 920–939. <https://doi.org/10.1080/00131911.2022.2098712>
- Stevenson, R. B., et al. (2021). Researching climate change education: Current practices, trends, and future directions. *Environmental Education Research*, 27(6), 775–798. <https://doi.org/10.1080/13504622.2021.1912853>
- Sterling, S. (2021). *Sustainable education: Revisioning learning and change*. Routledge. <https://doi.org/10.4324/9781003181234>
- UNESCO. (2022). *Education for sustainable development: A roadmap for achieving SDG 4*. United Nations Educational, Scientific and Cultural Organization. <https://unesdoc.unesco.org/ark:/48223/pf0000374802>
- Verlie, B. (2021). *Learning to live with climate change: From anxiety to transformation*. Routledge. <https://doi.org/10.4324/9781003052166>
- Warlenius, R. (2022). Beyond Western-centric sustainability: Integrating indigenous knowledge and local epistemologies into global educational frameworks. *Globalizations*, 19(5), 712–729. <https://doi.org/10.1080/14747731.2021.1998765>
- Wals, A. E. J., & Benavot, A. (2022). The crisis of sustainability and the imperative of transforming formal education. *Prospects*, 51(3), 323–337. <https://doi.org/10.1007/s11125-021-09582-x>
- Wu, J., & Lee, Y. (2023). Fostering systems thinking through interdisciplinary climate change education in secondary schools. *International Journal of Science Education*, 45(11), 901–920. <https://doi.org/10.1080/09500693.2023.2190123>