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Implementation of TBL with constructivist and discovery learning approaches to enhance eco-literacy of homeschooling students

Anggarilia Meryantie, Nuril Huda, Victor Maruli Tua L. Tobing, Muhajir
Universitas Dr. Soetomo, Indonesia.
***** Corresponding Author. E-mail: anggarilia@gmail.com

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ABSTRACT

The escalating ecological crisis demands an immediate educational response, especially for younger generations. Eco-literacy, the ability to understand ecological systems, think critically about environmental issues, and adopt responsible behaviors, needs to be cultivated early through contextual and transformative learning. This study explores the implementation of a Technology-Based Learning (TBL) model, grounded in constructivist and discovery approaches, to enhance eco-literacy among homeschooling students aged 10–13 years. Using a descriptive qualitative case study, three homeschooling students and two parents at Rumah Ulin, a family-based learning environment integrating ecological values and digital technology, participated as informants. Data were collected retrospectively through participant observation, semi-structured interviews, student reflections, and documentation of prior learning activities. Findings show significant development in four eco-literacy dimensions: ecological awareness (recognition of human–environment relationships), environmental knowledge (understanding of concepts and issues), ecological attitudes (care, responsibility, and commitment to sustainability), and ecological actions (environmentally friendly practices such as reducing plastic use and managing waste). These results demonstrate that technology-based, learner-centered strategies can foster meaningful ecological understanding in non-formal contexts. Future research with larger, more diverse participants and longitudinal designs is recommended to strengthen generalizability and assess long-term impacts.

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INTRODUCTION

The global environmental crisis is increasingly threatening the sustainability of ecosystems and the survival of humankind. Various serious issues have emerged, such as deforestation to meet market demands, soil and water pollution caused by waste cooking oil disposal and the use of synthetic detergents, air pollution resulting from vehicle emissions and cigarette smoke, as well as the accumulation of plastic waste in various places. The impacts of these problems are not only felt by the present generation but also endanger the well-being of future generations. In this context, ecological education is no longer merely an option but an urgent necessity that must be instilled from an early age in children's education.

Eco-literacy is one of the key concepts in ecological education, encompassing awareness of environmental issues, ecological knowledge, a caring attitude, and the ability to take action in everyday life. This concept consists of four main dimensions: ecological awareness, environmental

knowledge, ecological attitudes, and ecological actions (Disinger & Roth, 1992; Hollweg et al., 2011). These dimensions integrate cognitive, affective, and psychomotor aspects to shape a holistic understanding of the relationship between humans and nature.

Along with the advancement of technology, digital-based learning approaches hold great potential to strengthen environmental literacy outcomes. Recent studies Hajj-Hassan et al., (2024) indicate that digital media such as videos, simulations, and online platforms can enhance the understanding of sustainability, especially when combined with reflective and contextual learning. The theory of connectivism emphasizes that the interconnectedness between learners, digital tools, and real-world issues serves as an essential foundation in 21st-century learning design.

A learning model that integrates ecological values with technology can be applied both in formal schools and in non-formal education. One increasingly popular form of non-formal education is homeschooling, which offers high flexibility and allows for a more personalized and contextual learning process. For example, *Rumah Ulin*, a homeschooling community in Indonesia, combines ecological values with the use of technology through various sustainability projects, such as processing used cooking oil into soap and converting organic waste into an eco-enzyme. Knowledge and skills related to these processes are largely acquired through digital resources such as video tutorials, e-books, and online forums, which not only support learners' understanding but also create opportunities to develop online classes on used cooking oil processing and organic waste utilization. This approach demonstrates how technology can expand the reach of practical, environmentally based learning to a broader audience.

However, despite its great potential, research on the application of Technology-Based Learning (TBL) to enhance eco-literacy in homeschooling in Indonesia remains very limited. Most previous studies have focused on formal schools or examined TBL and environmental education separately (Ninsiana et al., 2024). In contrast, global trends show significant growth in homeschooling in developed countries, where technology integration has supported science and environmental literacy (Hernholm, 2024). Compared to the global context, this approach holds unique characteristics in developing countries such as Indonesia, where access to technology varies and contextual learning practices place greater emphasis on family and community involvement.

Therefore, this study addresses the existing gap by integrating Technology-Based Learning (TBL) through a blended learning approach with constructivist and discovery learning strategies to foster eco-literacy among homeschooling students aged 10–13. This model not only emphasizes cognitive aspects but also activates critical thinking and problem-solving skills through hands-on practices supported by technology.

The novelty of this research lies in two key aspects: (1) the exploration of TBL within the homeschooling context in Indonesia, which has rarely been highlighted in the literature, and (2) the integration of TBL with constructivist and discovery learning strategies to support technology-based ecological education. The contributions of this study include: (1) Theoretical aspect: expanding the body of research on technology-based learning in non-formal education and among adolescents, which has received relatively little attention. (2) Practical aspect: providing implementation guidelines for other homeschooling communities in Indonesia, which can also be adapted to formal schools facing similar challenges in strengthening eco-literacy. This study is also relevant for the development of sustainability-oriented learning models at the global level, particularly in developing countries that face infrastructure limitations yet are rich in local contexts that support environmentally friendly practices.

METHOD

This study employs a descriptive qualitative approach with a single case study design to examine the implementation of Technology-Based Learning (TBL) in enhancing eco-literacy within a non-formal education context, namely *Rumah Ulin*, a family-based homeschooling community. The case study method allows for an in-depth exploration of the dynamic relationships between learners, technology, and ecological learning practices. In qualitative research, even a

single participant can serve as a valid data source if they provide deep contextual insights that are relevant to the phenomenon under investigation (Arikunto, 2010).

This study focuses on participants with extensive reflective experience in applying TBL strategies within a homeschooling environment, particularly in fostering eco-literacy. Part of the data was collected retrospectively by reconstructing the learning experiences of students aged 10–13. Although two of the three participants were 14 and 17 years old at the time of data collection, they had been actively involved in TBL-based learning during the targeted age range. A retrospective approach is commonly used in qualitative research, as it allows researchers to capture the meanings of past experiences that remain relevant to the present.

This approach facilitates the collection of rich and meaningful data through narrative and reflective techniques, including semi-structured interviews, learning documentation, and visual reflections in the form of students' drawings or illustrations. Visual representation is considered effective in revealing students' subjective understanding of environmental issues and ecological values, while also fostering emotional engagement through artistic expression (Heuver, 2023). The case study framework is particularly well-suited for understanding educational phenomena in a holistic and contextual manner.

The study involved three homeschooling students aged 12, 14, and 17, all of whom had participated in eco-literacy learning through the TBL model during the age range of 10 to 13. The research was conducted at Rumah Ulin, a learning environment that integrates ecological values and digital technology within family-based education.

The blended learning approach in this study combines technology-based online learning with hands-on field activities, enabling students to develop contextual and reflective understanding. A similar model was applied by Subastian et al., (2024), who found that project-based blended learning was effective in enhancing visual literacy and student engagement, particularly in the context of applied learning. This reinforces the relevance of the model employed in the present study.

Participants were selected using purposive sampling based on the following criteria, having reached the stage of formal operational cognitive development, which supports abstract and reflective thinking abilities (Piaget, 2009). Possessing at least two years of experience in using digital media for learning. Demonstrating interest and active participation in environmental activities and sustainable living practices.

Data collection was carried out in the home learning environments of each participant as well as through the online learning platforms used during educational interactions. Four main techniques were employed in the data collection process:

- Participatory observation, to capture students' engagement in digital learning activities and their interactions with ecological materials, as well as family facilitators.
- Semi-structured interviews with students and parents, aimed at exploring their perceptions, learning experiences, and reflections on the use of technology and the development of eco-literacy.
- Document analysis, including past learning records, digital learning activity archives (such as screenshots), and creative works related to environmental education.
- Students' visual reflections (in the form of drawings or illustrations), used to uncover their subjective understanding of ecological issues and their lived learning experiences.

Table 1 presents a summary of the profiles of participants involved in this study based on their age, TBL experience, and observed ecological activities.

Table 1. Participant Profiles

No.	Participant Code	Age at Interview (Years)	Age During TBL (Range)	Duration of TBL Experience (Years)	Observed Ecological Activities
1	P1	17	10–13	3	Making soap from used cooking oil, ecobricks, and eco-enzyme
2	P2	14	10–13	3	Video tutorials on soap-making, eco-enzyme, and waste sorting

No.	Participant Code	Age at Interview (Years)	Age During TBL (Range)	Duration of TBL Experience (Years)	Observed Ecological Activities
3	P3	12	10–12	2	Waste sorting, composting, caring for cats, and bringing a tumbler

The instruments used in this study included: an observation guide, focused on indicators of learning engagement, interaction with the environment, and ecological awareness behaviors, and an interview guide, developed based on the four main dimensions of eco-literacy: ecological awareness, environmental knowledge, ecological attitudes, and ecological actions.

The research instruments were designed following the eco-literacy framework, which encompasses ecological awareness, environmental knowledge, ecological attitudes, and ecological actions (Disinger & Roth, 1992; Hollweg et al., 2011). These four dimensions served as the foundation for both instrument development and data analysis to ensure consistency and alignment with the research objectives. Instrument validation was carried out through consultation with experts in ecological education and educational technology, ensuring relevance to the context and developmental characteristics of the participants.

Data were analyzed using a thematic analysis approach (Braun & Clarke, 2006). The process began with transcribing interview and observation results into text, followed by data reduction and coding through the identification of meaning units within participants' narratives. These codes were then grouped into four main thematic domains in line with the dimensions of eco-literacy. The next stage was theme interpretation, where the researcher constructed analytical narratives based on the interrelationships among the identified themes. To ensure the credibility and trustworthiness of the data, triangulation was conducted by comparing information from multiple sources, including interviews, observations, and documentation.

Thematic coding was carried out based on the four dimensions of eco-literacy described earlier. Each data unit was categorized according to these dimensions to construct a holistic thematic narrative, in line with approaches recommended in eco-literacy studies (Hollweg et al., 2011). The analysis process was conducted iteratively to capture the depth and complexity of students' eco-literacy development within the context of technology-integrated learning.

Table 2 presents a summary of the eco-literacy dimensions along with their thematic indicators and data sources used as the basis for analysis in this study.

Table 2. Eco-literacy Dimensions and Thematic Indicators

No.	Eco-literacy Dimensions	Thematic Indicators	Data Sources
1	Ecological Awareness	Recognizing environmental changes, asking critical questions, engaging in in-depth discussions.	Observation, Interview
2	Environmental Knowledge	Explaining recycling, the water cycle, and creating ecobricks.	Reflection, Documentation
3	Ecological Attitudes	Showing empathy toward animals, taking responsibility for leftover consumption.	Interview, Reflection
4	Ecological Actions	Sorting waste, making eco-enzyme, producing soap from used cooking oil, and natural bath soap.	Observation, Documentation

RESULTS

Results

Based on the thematic analysis, four main themes were identified in the development of eco-literacy: ecological awareness, environmental knowledge, ecological attitudes, and ecological actions. The frequency of these four themes across the entire dataset is visualized in Figure 1.

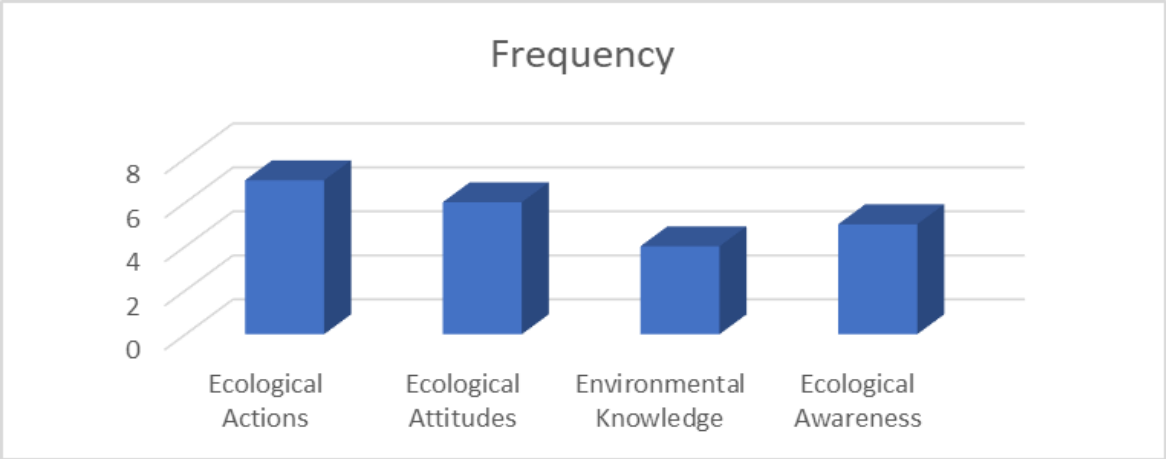

Figure 1. Frequency of Eco-literacy Themes Based on Thematic Coding

As shown in Figure 1, the most frequently emerging themes in the thematic coding are ecological actions and ecological attitudes. This finding indicates a strong behavioral and affective engagement of learners with environmentally friendly practices. The following discussion elaborates on the research findings based on the four established dimensions of eco-literacy.

Discussion

This study reveals that the implementation of the TBL model through blended learning, combined with constructivist and discovery learning approaches, effectively enhances eco-literacy among homeschooling students aged 10–13. The analysis was conducted based on four main themes representing the dimensions of eco-literacy: ecological awareness, environmental knowledge, ecological attitudes, and ecological actions. The findings indicate that ecological actions and ecological attitudes are the two most dominant dimensions, highlighting students' strong affective and behavioral engagement with environmental issues. The following section elaborates on the findings according to these four dimensions.

Ecological Awareness

Participatory observations and interviews revealed an increase in students' awareness of the environmental conditions around them. For example, students were able to identify the impacts of river pollution near their homes and relate them to everyday household activities. This awareness developed gradually through exposure to short documentary videos on YouTube showing the effects of domestic waste on river water color and aquatic life, further reinforced by digital simulations and reflections from direct field experiences. These findings align with constructivist perspectives, which emphasize the importance of authentic experiences in building new awareness (Bruner, 2001). Students began to understand that human actions carry tangible ecological consequences..

In addition to digital media, students were also encouraged to conduct direct exploration at a landfill site located about 8 km from their homes. This visit provided a concrete illustration of the impact of domestic waste accumulation on the environment. They observed towering piles of garbage, smelled the stench, and witnessed firsthand how the surrounding environment was affected. This activity became a powerful reflective moment, fostering students' emotional connection to waste management issues.

Furthermore, students demonstrated improved abilities in recognizing environmental changes and articulating ecological concerns in their own words. Orally, they began asking critical questions such as, "Why is the river water dirty and smelly?", "Why is the landfill full of garbage piles?", or "What happens to the trash we throw away?" all of which reflect the development of an inquiry-based ecological mindset.

Some students also reflected on their understanding orally through presentations they independently prepared using PowerPoint or illustrated (written) forms. These presentations not only reflected conceptual comprehension but also demonstrated their ability to organize environmental information logically and communicate ecological concerns to an audience. This activity served as an authentic space for ecological expression while fostering the confidence to speak about environmental issues based on personal observations and reflections.

The shift from passive observation to active questioning emerged as a key indicator of ecological awareness development at this age stage. The role of digital media and contextual exploration proved effective in strengthening students' ability to connect abstract concepts with real-life situations in their everyday lives.

Environmental Knowledge

Learning documentation and student reflections revealed a deepening understanding of environmental concepts, particularly those related to sustainable practices. Students were able to identify and explain various types of inorganic waste, such as paper, plastic, glass, and cans, as well as understand the basic principles of recycling. They also demonstrated knowledge of water conservation practices such as rainwater harvesting and were able to verbally describe different waste management techniques, including composting, the water cycle, ecobrick-making, and methods of household waste sorting**.**

To strengthen conceptual understanding through real-life experiences, students were taken to visit a waste bank managed by a local community under the supervision of the Department of Environment (DLH). During this visit, they directly learned about the processes of sorting, weighing, and reusing various types of inorganic waste. In addition, students gained insights into the economic value of recyclable materials and understood the role of institutions in supporting sustainable waste management systems at the community level.

In their family's daily routines, students also took part in recycling used cooking oil into environmentally friendly laundry soap and producing natural bath soap free from harmful chemicals. This learning process was not only hands-on but also enriched with digital learning through instructional videos from YouTube, which served as the main reference for systematically understanding the stages of soap-making. The children were not only participants but also became content creators; one of them was even assigned to produce a simple tutorial video on how to make laundry soap from used cooking oil as both a reflection activity and a contribution to digital environmental literacy.

In addition, students were also encouraged to utilize organic kitchen waste, such as fruit peels, to be processed into an eco-enzyme. This activity was carried out collaboratively as part of ecological experiments at home. Through the process, they learned about fermentation, decomposition time, and the benefits of eco-enzyme liquid for household cleanliness and small-scale organic farming. The activity fostered patience, accuracy, and provided direct understanding of ecological principles and circularity in organic waste management.

These various activities instilled the understanding that household waste does not always end up as garbage but can instead be transformed into useful products. Through this practice, students grasped the principles of reduce-reuse-recycle (3R) in an applied manner and were able to connect them with the concepts of water pollution and sustainable liquid waste management. Such activities served as an important bridge linking household practices with community-based environmental management systems, thereby expanding students' understanding from the micro to the macro context.

This learning process was built through a combination of independent exploration with the support of digital tools, reflective discussions with parents, and direct field experiences. These findings reinforce the view that technology can serve as an enhancer in conceptual learning when combined with reflection and contextual experiences (Laurillard, 2013). Other studies also emphasize the importance of integrating technology into community-based environmental literacy education (Baek et al., 2023). Their research shows that curricula combining eco-literacy and data literacy through technology-based community approaches can enhance students' understanding and active participation in local sustainability issues. This aligns with the findings of the present study,

where the use of digital tools such as videos, simulations, and online platforms also strengthened family engagement in the environmental learning process.

Furthermore, students demonstrated the ability to connect local environmental issues with broader ecological systems. For example, they were able to relate improper household waste disposal practices to declining river quality and its impact on aquatic biodiversity. The ability to synthesize knowledge across scales reflects the development of systemic thinking one of the key competencies in environmental education. The combination of digital learning and empirical experiences enabled students to internalize abstract ecological concepts into a personally meaningful and applicable understanding.

Ecological Attitudes

Semi-structured interviews revealed a shift in students' attitudes that reflected an increase in ecological affect. For instance, students expressed empathy toward displaced wildlife, including stray cats they encountered in daily life. In one case, a student felt compassion upon seeing a starving stray cat and asked their parents to adopt the animal. This response not only demonstrated emotional sensitivity toward living beings but also reflected a growing sense of ecological care rooted in direct interaction with both the social and natural environment.

In addition, students expressed feelings of guilt when littering. This awareness was reinforced through narrative-based video content and project-based learning activities that encouraged moral reflection on environmental issues. These findings highlight that contextual and emotionally grounded learning can foster ecological sensitivity from an early age. This aligns with the view that the affective domain is a crucial foundation in transformative ecological education (Vitaloka et al., 2022).

More than just an emotional response, students began to demonstrate a sense of responsibility in their everyday choices, such as reminding family members not to waste water or suggesting alternatives to the use of single-use plastics. These behavioral intentions reflect a maturing value orientation, where empathy is translated into responsible ecological awareness. The integration of narrative, reflection, and real-world problem-solving tasks enabled students to internalize environmental values not merely as conceptual knowledge but as guiding principles for their daily actions. This development underscores the importance of affective engagement in shaping ecological attitudes and fostering long-term ethical awareness.

Ecological Actions

Ecological actions represented the highest indicator of eco-literacy achievement. Documentation and observational data revealed that students consistently engaged in tangible pro-environmental behaviors. Within the daily routines of the Rumah Ulin homeschooling environment, the researcher's children established ecological habits as part of their household responsibilities. These included sorting waste by type, managing organic waste through composting, feeding pets (cats) as a form of care for living beings, and bringing their own food and drink containers (tumblers) when engaging in outdoor activities to reduce single-use waste.

In addition, the family regularly practiced sustainability at home, such as producing laundry soap from used cooking oil and natural bath soap free from harmful chemicals. These practices not only served to reduce household waste and dependence on industrial products but also functioned as direct learning opportunities for the children. They actively participated in the production process, developed an understanding of material reuse cycles, and internalized ecological values through practical, productive activities. This illustrates a concrete example of how ecological actions can be nurtured within the family as a transformative unit of ecological education.

These actions were not incidental activities but had become an integral part of the students' daily routines. Technology-supported learning reinforced these practices by providing impactful visualizations and a deeper understanding of the consequences of everyday behaviors. This finding aligns with studies showing that technology-based learning approaches can enhance students' active participation in pro-environmental actions, especially when combined with field experiences

(Zhao et al., 2021). That research emphasized the importance of integrating digital content with local contexts to foster sustainable ecological behavior.

This finding can also be viewed as an extension of previous studies highlighting the potential of digital media in introducing eco-literacy to young children in formal school settings (Ninsiana et al., 2022). In contrast, the present study demonstrates that a similar approach can be applied more flexibly within a non-formal, family-based learning environment (homeschooling), combining technology and authentic experiences reflectively and sustainably.

These findings reinforce the notion that TBL through blended learning can be effectively applied in non-formal education contexts. The integration of constructivist and discovery learning approaches facilitates the contextual and meaningful internalization of ecological values. This model successfully bridges the gap between digital learning and empirical environmental experiences. Such an approach is supported by recent meta-analyses showing that the integration of mobile devices in learning significantly enhances student performance, particularly when applied in experimental or problem-based exploratory tasks (Sung et al., 2022).

This study also contributes to the body of knowledge in environmental education by demonstrating that TBL, when integrated with blended learning as well as constructivist and discovery approaches, can effectively foster eco-literacy within non-formal learning environments. In contrast to the majority of eco-literacy studies that focus on formal school systems, this research provides empirical insights into how ecological awareness, knowledge, attitudes, and actions can be meaningfully developed within the context of homeschooling.

In addition, this study highlights the pedagogical value of the retrospective qualitative method in capturing long-term learning outcomes, while offering a new approach to evaluating the impact of early environmental education. This contribution carries practical implications for curriculum designers, educators, and policymakers seeking to promote sustainability education through alternative, technology-supported learning models.

The ecological actions carried out by the students not only influenced their family's lifestyle but also generated transformational effects on environmental attitudes and awareness. Active engagement in these practices reinforced a sense of responsibility toward sustainability, encouraged the formation of consistent ecological habits, and expanded the understanding that small household actions can make tangible contributions to the environment. For instance, successfully reducing organic waste, plastic waste, and used cooking oil in their household demonstrated a direct impact on the quality of their micro-environment, while also strengthening the students' confidence in contributing to ecological solutions.

The long-term effect of these habits is the formation of a sustainability-oriented mindset, embedded not only in learning contexts but also in everyday decision-making. Students no longer perceive environmental issues as knowledge detached from daily life but rather as an integral part of their identity and responsibility. This aligns with the goals of Education for Sustainable Development (ESD), which emphasize developing learners' capacity to make decisions and act reflectively, critically, and collaboratively in addressing sustainability challenges (Sanchez et al., 2025).

The limitation of this study lies in its scope, which only involved one homeschooling family, as well as the retrospective nature of the data collection. While this approach provided deep contextual insights, the findings must be generalized with caution. Future research is therefore recommended to involve more homeschooling communities with diverse social and geographical backgrounds. In addition, longitudinal studies on the long-term impact of technology-based learning on the enhancement of eco-literacy are needed to strengthen the validity of the findings and ensure the systemic sustainability of this learning model.

CONCLUSION

The results of this study indicate that the implementation of the TBL model through a blended learning approach, supported by constructivist and discovery learning strategies, is proven effective in enhancing the eco-literacy of homeschooling students aged 10–13 years. All four dimensions of eco-literacy ecological awareness, environmental knowledge, ecological attitudes,

and ecological actions—showed significant improvement, as evidenced by students' engagement in reflective, exploratory, and sustainable practices within their households and local communities. The integration of learning technology with everyday life contexts plays a crucial role in fostering ecological understanding that is not only cognitive but also nurtures affective engagement and tangible behaviors supporting environmental sustainability.

Contextual, participatory, and experiential learning processes demonstrated high effectiveness in non-formal settings such as homeschooling, where learners have flexible and autonomous space to develop a meaningful understanding of ecological issues. These findings confirm that a holistically designed TBL model can bridge the gap between environmental education and digital pedagogy, which are often separated in conventional curricula.

The practical implications of this study emphasize the need to develop technology-based learning strategies that align with local wisdom and facilitate students' active engagement in sustainability practices. Teachers, parents, homeschooling facilitators, and curriculum developers can utilize this model to design learning experiences that integrate digital literacy and ecological literacy in a balanced manner. This model can also be replicated by other homeschooling communities, non-formal educational institutions, and formal schools as an innovative approach to strengthening sustainability-oriented education.

The long-term impact of implementing this model is expected to cultivate a generation of learners with deep ecological awareness, critical thinking skills, and sustainable behaviors internalized in daily life. This has the potential to drive environmentally friendly cultural transformation at the family, community, and broader societal levels. Further research is recommended to explore the adaptation of this model in formal education contexts, communities with diverse socio-cultural backgrounds, and various age groups, in order to reinforce intergenerational eco-literacy through transformative and sustainable approaches.

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REFERENCES

Arikunto, S. (2010). *Research procedures: A practical approach (revised ed.)*. Rineka Cipta.

Baek, C., Saito-Stehberger, D., Jacob, S., Nam, A., & Warschauer, M. (2023). Computer science framework to teach community-based environmental literacy and data literacy to diverse students. *arXiv, 1*, 1-31. https://doi.org/10.48550/arXiv.2309.14098

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Bruner, J. S. (2001). The process of education (Sahat Simamora, trans.). Intermasa.

Disinger, J. F., & Roth, C. E. (1992). Environmental education research news. *The Environmentalist*, *12*, 165-168. https://doi.org/10.1007/BF01267599

Downes, S. (2016). *Open education and personal learning*. Retrieved from https://www.downes.ca/post/63745

Hajj-Hassan, M., Chaker, R., & Cederqvist, A. M. (2024). Environmental education: A systematic review on the use of digital tools for fostering sustainability awareness. *Sustainability*, *16*(9), 3733. https://doi.org/10.3390/su16093733

Hernholm, S. (2024). The rise of homeschooling and its transformative impact on education. Retrieved from https://www.forbes.com/sites/sarahhernholm/2024/04/30/rise-of-homeschooling-and-its-transformative-impact-on-education/

Heuver, A. (2023). Eco-art education: Enhancing ecological awareness in primary school students through artistic reflection. University of Twente.

Hollweg, K. S., Taylor, J. R., Bybee, R. W., Marcinkowski, T. J., McBeth, W. C., & Zoido, P. (2011). *Developing a framework for assessing environmental literacy*. North American Association for Environmental Education.

Laurillard, D. (2013). *Teaching as a design science: Building pedagogical patterns for learning and technology*. Routledge. https://doi.org/10.4324/9780203125083

Ninsiana, W., Septiyana, L., & Suprihatin, Y. (2024). Introducing eco-literacy to early childhood students through digital learning. *Journal of Education and Learning (EduLearn)*, *18*(1), 89–96. https://doi.org/10.11591/edulearn.v18i1.20678

Piaget, J. (2009). *Psychology and education (Soedjarwo, trans.)*. Grasindo.

Sanchez, S. J., Guzman, Y. P., Sosa-Molano, J., Robertson, D., Ahern, S., & Garza, T. (2025). Systematic literature review: A typology of sustainability literacy and environmental literacy. *Frontiers in Education*, *10*, 1-11. https://doi.org/10.3389/feduc.2025.1490791

Subastian, E., Nursalim, M., & Bachri, B. S. (2024). The effect of project based blended learning on visual literacy skills. *Journal of Ecohumanism*, *3*(8), 1970–1979. https://doi.org/10.62754/joe.v3i8.4858

Sung, Y. T., Chang, K. E., & Liu, T. C. (2022). The effects of integrating mobile devices with teaching and learning on students' learning performance: A meta-analysis and research synthesis. *Computers & Education*, 94, 252–275. https://doi.org/10.1016/j.compedu.2015.11.008

Vitaloka, W., Setyorini, D., & Dilfa, A. H. (2022). Ecological education as a strategy for optimizing education service standards. *Buana Pendidikan: Jurnal Fakultas Keguruan dan Ilmu Pendidikan*, *18*(2), 164–173. https://doi.org/10.36456/bp.vol18.no2.a5244

Zhao, H., Sullivan, K. P. H., & Mellenius, I. (2021). Using technology to enhance environmental education in primary schools: A systematic review. *Environmental Education Research*, *27*(7), 992–1012. https://doi.org/10.1080/13504622.2021.1891653