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Early Ecological Intelligence: Strategies for Introducing Environmental and Sustainability Concepts in Early Childhood Education

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Abstract: Amidst the global ecological crisis, education for sustainable development in early childhood (ECEfS) is crucial, yet it often lacks a holistic and integrated framework. This article aims to fill this gap by proposing a conceptual model for fostering ecological intelligence from an early age. This research employs an integrative literature review method, systematically analyzing and synthesizing relevant international and national literature. The synthesis results show that an effective approach is organized into three fundamental, interconnected dimensions: (1) 'Heart' (building affective connection and empathy for nature), (2) 'Head' (developing cognitive understanding and systems thinking), and (3) 'Hands' (manifesting in tangible action and pro-environmental habit formation). The discussion concludes that these three dimensions are interdependent and must be implemented synergistically within a supportive pedagogical ecosystem to achieve a truly transformative impact.

Keywords: Ecological Intelligence, Early Childhood Education, Sustainability

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1. Introduction

The world is currently facing an unprecedented multidimensional ecological crisis, ranging from accelerating climate change and its catastrophic impacts to the alarming rate of biodiversity loss (IPCC, 2023) . In response to this global urgency, the international community has underscored the central role of education in transforming societies towards a sustainable future. This commitment is explicitly stated in the Education for Sustainable Development (ESD) framework for 2030, which emphasizes the importance of equipping all learners with the knowledge, skills, values, and attitudes to address global challenges (UNESCO, 2021) . This initiative has sparked a wave of curriculum reform and the development of sustainability-focused pedagogies at various levels of education.

However, in academic discourse and ESD policy implementation, the primary focus tends to be concentrated on primary, secondary, and tertiary education (Sumantri et al., 2019) . The fundamental role of Early Childhood Education (ECE) has historically received insufficient attention, a phenomenon observed both globally and nationally (Davis, 2015) . This neglect is ironic, given that evidence from neuroscience and developmental psychology indicates that the early childhood period (0-6 years) is the most critical formative phase. During these early years of life, the foundations for values, attitudes, habits, and cognitive frameworks are laid, which will significantly influence an individual's behavior and decision-making in adulthood (Shonkoff & Phillips, 2000) . Therefore, neglecting ECD in ESD strategies means missing a golden opportunity to plant the seeds of ecological awareness at its most fertile time (Yulsyofriendi et al., 2021) .

Recognition of the importance of early childhood environmental education is indeed growing among academics and practitioners (Lestari & Wibowo, 2020) . However, there is a significant gap between these theoretical aspirations and pedagogical realities on the ground. International literature indicates that many early childhood education educators feel underprepared and underresourced to implement ESD effectively (Siraj-Blatchford & Pramling Samuelsson, 2016) . In Indonesia, research highlights similar challenges, where teachers often struggle to translate abstract sustainability concepts—such as ecosystem interdependence or waste management—into concrete, meaningful, and developmentally appropriate learning activities (Rohaeti et al., 2020) . There is a lack of comprehensive, flexible, and empirically tested strategic frameworks that can effectively guide educators. This gap motivated this research.

Therefore, this article aims to bridge this gap by proposing and analyzing a strategic framework for fostering ecological intelligence in early childhood. In the context of this article, ecological intelligence is defined as an individual's ability to recognize and understand fundamental patterns in nature, and to use this understanding to live harmoniously and sustainably with the environment, an adaptation of the concept popularized by (Goleman, 2009) . By synthesizing child development theories (Piaget, Vygotsky), the theory of connection with nature (Wilson, 1984) , and core principles of ESD, we present a practical pedagogical model. The main contribution of this article is the provision of a holistic framework that goes beyond the mere transfer of cognitive knowledge (knowing

environmental facts), and integrally develops the affective domain (cultivating empathy and concern for nature) and psychomotor (building pro-environmental habits and behaviors) (Wiyani, 2014) .

To achieve these objectives, this article is structured as follows. The next section will review relevant literature on ESD in the context of early childhood education (ECE) and the theory underlying ecological intelligence. We will then present a proposed strategic framework, followed by an elaboration of concrete and implementable pedagogical strategies. Finally, the article concludes with a discussion of the theoretical and practical implications of this framework for future educators, policymakers, and researchers, and concludes with a conclusion that affirms the transformative role of ECE in shaping a generation of change agents for global sustainability (Rohaeti et al., 2020).

2. Method

This study uses an Integrative Literature Review methodology to systematically synthesize theoretical and empirical literature from various disciplines to build a new conceptual framework (Torraco, 2005) . This approach allows for the integration of insights from educational studies, developmental psychology, and environmental science to formulate strategies for developing ecological intelligence in early childhood.

The research process was conducted systematically. First, a comprehensive literature search was conducted in international (e.g., Scopus, ERIC, Web of Science) and national (GARUDA) academic databases for publications between 2004 and 2024. Keywords included "early childhood environmental education," "ecological intelligence," "education for sustainability," "nature pedagogy," and their Indonesian equivalents. Second, a two-stage selection process (title/abstract screening and full-text evaluation) was applied to select the literature. The main selection criteria were peer-reviewed sources, direct relevance to the topic of sustainability education for children aged 0-8, and clear conceptual or empirical contributions (Whittemore & Knafl, 2005) .

Finally, data from the selected literature was analyzed using thematic synthesis analysis, guided by the principles outlined by (Braun & Clarke, 2006) . This process involved systematic coding of relevant concepts and strategies, followed by a synthesis of key emerging themes. This synthesis served as the basis for constructing the strategic framework proposed in this article, linking a solid theoretical foundation with implementable pedagogical strategies.

1. Result and Discussion

RESULT

Data Description and Prerequisite Tests for Analysis

This section presents the results of a systematic, integrative literature review. Findings from various primary and secondary sources are presented and organized using the "Head, Heart, and Hands" analytical framework. This framework aims to clearly map the three fundamental dimensions of sustainability education for early childhood: cognitive (Head), affective (Heart), and psychomotor/behavioral

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(Hands), along with their supporting factors. These findings are based on an analysis of relevant literature, summarized in the following table.

A rigorous literature search and selection process yielded 20 key sources that served as the primary data for the thematic synthesis process. These sources comprised reputable international books, Scopus-indexed journal articles (Q1), and national journal articles accredited by Sinta 1 and Sinta 2. A summary of these 20 sources, along with their key findings, is presented in Table 1.

Table 1. Table of Key Literature Analysis and Its Relevance to the Research Topic

No.	Researchers & Year	Journal/ Publication Source	Index/ Credibility	Key Findings/ Contributions	Relevance to the Discussion Topic
1	Davis, JM (2015)	Young Children and the Environment	International Books (Cambridge Press)	ECEfS must go beyond simple activities & include critical thinking, participation, and a holistic approach.	Provides pedagogical principles for the Head (critical thinking) & Hands (participation) dimensions.
2	Pramling Samuelsson, I. (2011)	International Journal of Early Childhood	Scopus Q1	Sustainability learning is not a transfer of facts, but the formation of values & empowerment of children as agents of change.	It is the basis of the Heart dimension (values) and provides the ultimate goal for the Hands dimension (child agency).
3	Wilson, E.O. (1984)	Biophilia	Foundational Books (Harvard Press)	Proposing the concept of Biophilia, namely the affinity or innate love of humans for nature as the basis for environmental ethics.	The main theoretical basis for the importance of affective connection with nature (Heart dimension).
4	Louv, R. (2008)	Last Child in the Woods	Influential International Books	Diagnosing the phenomenon of Nature-Deficit Disorder in modern children due to lack of contact with nature.	Underscoring the urgency of stimulating the Heart dimension through direct natural experiences.
5	Chawla, L. (2007)	Children, Youth and Environment	Scopus	Found that free play experiences in nature as a child were the strongest predictor of adult environmental activism.	Provides empirical evidence of the importance of experiences that support the Heart dimension for long-term impact.
6	Sobel, D. (2008)	Childhood and Nature	Books for Educators	Proposing the principle of "love first before saving" (empathy before action).	Provides pedagogical sequence guidance: prioritize Heart before demanding Hands.

No.	Researchers & Year	Journal/ Publication Source	Index/ Credibility	Key Findings/ Contributions	Relevance to the Discussion Topic
7	Cutter-Mackenzie & Edwards, (2013)	Australasian Journal of Env. Education	Scopus Q1	Criticizes the anthropocentric view & proposes a posthumanist perspective (equal relations between humans & non-humans).	Providing philosophical depth to the way of viewing the relationship between nature (Heart) & the interconnectedness of systems (Head).
8	Ärlemalm-Hagsér, E. (2013)	Environmental Education Research	Scopus Q1	Found that teachers' beliefs, competencies & commitment are key factors for successful ECEfS implementation.	Emphasizing the crucial role of educators as part of a supportive Pedagogical Ecosystem.
9	Kellert, (2005)	Building for Life	Foundational Books (Yale Press)	Explains how architectural design that mimics nature (Biophilic Design) improves well-being.	Implications for the importance of designing physical learning environments that support the Heart dimension.
10	Ernst, (2014)	Children, Youth and Environment	Scopus	Empirically demonstrating that nature-based PAUD increases interest in science, social skills, & enthusiasm for learning.	Provides empirical evidence of the effectiveness of an approach that integrates Heart and Head.
11	Malik, A., & Prahmana, RCI (2021)	Journal of Educational Horizons	Sinta 1	Proving that local wisdom-based learning modules (ethnoscience) are effective & culturally relevant.	It is a real example of the contextualization of the Head dimension in the Indonesian educational landscape.
12	Hartini, S., et al. (2022)	Obsession Journal: PAUD Journal	Sinta 2	Implementation of the green school model through programs and habits has been proven to increase children's environmental awareness.	Provides empirical evidence from Indonesia for the success of the Hands dimension approach.
13	Wiyani, NA (2014)	Journal of Child Education	Sinta 2	Emphasizing that early age is a golden period for character formation through habituation and role models.	Supporting the argument of the importance of habituation in the Hands dimension & the role of teachers in the Pedagogical Ecosystem.
No.	Researchers	Journal/	Index/	Key Findings/	Relevance to the

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	& Year	Publication Source	Credibility	Contributions	Discussion Topic
14	Yulsyofriendi, et al. (2021)	Obsession Journal: PAUD Journal	Sinta 2	Found that the implementation of environmental education in many kindergartens is still partial & not integrated.	Emphasizing the urgency and need for a holistic framework such as "Head, Heart, Hands".
15	Sumantri, MS, et al. (2019)	Journal of Early Childhood Education	Sinta 2	Proving that the critical thinking potential of early childhood can be stimulated through appropriate methods.	Supports the feasibility of developing more complex Head dimensions (systems thinking) in children.
16	Setiawati, FA, & Syukri, M. (2021)	Journal of Progressive Education	Sinta 2	Demonstrates how to integrate the values of "morals towards nature" from the Pancasila Student Profile into learning.	Connecting the analytical framework with the Independent Curriculum policy in force in Indonesia.
17	Rusilowati, A., & Subali, B. (2022)	Indonesian Journal of Science Education	Sinta 1	Developing scientific literacy assessment instruments that are valid and sensitive to the context of local wisdom.	Provide direction for the development of assessments that can measure the achievement of Head dimensions.
18	Purnamawati, D., et al. (2020)	Journal of Ecology, Society & Science	Sinta 2	Found that active community participation is key to the success of environmental programs.	Highlighting the importance of the role of the community as part of a supportive Pedagogical Ecosystem.
19	Fajri, M., et al. (2023)	Golden Age Journal	Sinta 2	Demonstrate fairy tales & folktales as effective pedagogical media for instilling environmental values.	Offers concrete pedagogical strategies to stimulate the Heart dimension.
20	Solihat, R., & Zulfitria. (2021)	Early Childhood Education Pelita Journal	Sinta 2	Demonstrating the use of loose parts (used & natural materials) effectively stimulates creativity & the principle of reuse.	Provides real-life examples of strategies for empowering Hands dimension learning.

The thematic analysis of the 20 key literatures produced several main findings which were grouped into three core dimensions and one supporting dimension.

Findings on the 'Heart' Dimension (Affective)

Literature syntheses consistently find that the foundation of ecological intelligence is affective relationships. Key literature such as Wilson (1984) and Sobel

(2008) emphasizes that emotional connection, love, and empathy for nature should be the starting point of all environmental learning. This finding is supported by empirical studies such as Chawla (2007) , which demonstrate a strong correlation between childhood nature experiences and environmental attitudes in adulthood.

Findings on the 'Head' Dimension (Cognitive)

It has been found that effective cognitive learning in ECEfS shifts from fact-based teaching to inquiry-based learning and the introduction of systems thinking. Literature such as (Davis, 2015) and (Pramling Samuelsson, 2011) highlight the importance of stimulating children's ability to question, investigate, and understand cause-and-effect relationships in their surroundings. Contextualization with local culture, such as through ethnoscience (Malik & Prahmana, 2021) , has been found to be an effective strategy for making abstract concepts more relevant.

Findings on the 'Hands' Dimension (Behavioral/Psychomotor)

It has been found that the development of pro-environmental behavior in early childhood relies heavily on habituation, active participation, and a sense of empowerment. A case study of green school implementation in Indonesia (Hartini et al., 2022) demonstrated that structured and routine programs were effective in fostering habits such as waste sorting and gardening. The use of loose parts from used materials was also found to be an effective way to directly instill the principle of reuse in children's play (Solihat & Zulfitria, 2021).

Findings on the Supporting Pedagogical Ecosystem Dimension

The analysis also strongly suggests that the successful integration of the three dimensions above does not occur in a vacuum. It was found that the role of teachers as role models, a supportive school culture, and community involvement are crucial factors. Both international (Ärlemalm-Hagsér, 2013) and national (Purnamawati et al., 2020) literature conclude that without a conducive ecosystem, sustainability learning will be ineffective and isolated

DISCUSSION

The analysis of the literature presented in Chapter 4 not only reveals three separate dimensions but also reveals a narrative about how ecological intelligence can be fostered holistically. This discussion will interpret these findings in more depth, focusing on the synergies between the dimensions and their relevance to educational practice in Indonesia. Dialogue with several case studies from the literature will be used to clarify and strengthen the arguments developed.

The most fundamental starting point emerging from the literature synthesis is the premise that ecological intelligence is rooted in the affective dimension ('Heart'). Before children can understand complex ecological concepts or be motivated to act, they must first establish a positive emotional connection with the environment. This principle is powerfully articulated by David Sobel (2008) in his

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work *Childhood and Nature*, where he proposes the pedagogical sequence of "love first before you ask to save." Without a foundation of love, empathy, and awe, environmental education risks becoming merely a sterile academic exercise. These findings confirm that direct sensory experiences, free play in nature as advocated by (Louv, 2008) , and the introduction of value-rich cultural narratives such as fairy tales (Fajri et al., 2023) are not supplementary activities, but rather essential foundations of the entire learning process.

However, this affective connection, while essential, requires structure to develop into deeper understanding. This is where the cognitive dimension ('Head') plays a crucial role, namely by giving a name, meaning, and framework to the feelings that have developed. Learning does not stop at "I like this tree," but continues to ask, "Why is this tree important to birds and insects?" A study by Malik & Prahmana (2021) in the Cakrawala Pendidikan Journal (Sinta 1) provides a relevant example. Their success in using ethnoscience is not only due to the local nature of the material, but also because they connect cognitive knowledge (e.g., number concepts or patterns) with cultural objects and practices already known and valued by the children. This process demonstrates a powerful synergy: 'Heart' (a sense of belonging to culture) opens the door for 'Head' (conceptual understanding) to enter and develop meaningfully.

This cognitive understanding rooted in the heart then becomes the foundation for authentic and meaningful actions ('Hands'), not merely mechanical behavior. This is clearly seen in the case study of green school implementation by (Hartini et al., 2022) in the Obsesi Journal (Sinta 2). Habitual programs such as sorting waste or gardening ('Hands') become much more effective because they are not taught in isolation. These actions become the culmination of a process: children develop a sense of concern for their school environment ('Heart') and begin to understand basic concepts about waste or plant growth ('Head'). Without the previous two dimensions, these actions might be carried out only because of teacher instruction. This underscores the finding by (Yulsyofriendi et al., 2021) that many environmental education programs in Indonesia are still partial, often focusing only on the 'Hands' dimension (e.g., community service activities) without building a strong foundation of 'Heart' and 'Head'.

Ultimately, this synergy between 'Head, Heart, and Hands,' which distinguishes transformative education from mere training, depends heavily on the environment in which it develops. This is where the role of the pedagogical ecosystem becomes crucial. A study by (Ärlemalm-Hagsér, 2013) in Environmental Education Research (Scopus Q1) clearly demonstrates that teacher beliefs and competencies are key factors. A teacher who lacks a 'Heart' connection to nature will struggle to facilitate such experiences in their students. Therefore, teachers are not only transmitters of information, but also primary role models. This environment is furthered by the overall school culture and community support, which emphasizes that cultivating ecological intelligence is a collective responsibility.

4. Conclusion

Through an integrative literature review, this study addresses the need for a comprehensive framework for fostering ecological intelligence in early childhood. The synthesis of results, analyzed using the "Head, Heart, and Hands" framework, demonstrates that effective sustainability education must integrate three dimensions in a balanced manner: deep affective connections (the "Heart"), cognitive understanding and systems thinking (the "Head"), and concrete actions and behavioral habits (the "Hands"). The article's primary contribution is the assertion, based on an extensive literature analysis, that these three dimensions are interdependent and must be synergistically woven. This holistic approach offers a more holistic alternative to the partial practices that have been dominant in the field.

The implication is that educators and curriculum makers are challenged to design learning experiences that consciously engage children's hearts, minds, and hands simultaneously. While it is acknowledged that the application of this model requires further empirical validation across contexts, these findings provide a strong theoretical foundation. Therefore, future research should focus on developing and testing pedagogical practices that can measure the impact of this integrated approach. Ultimately, instilling holistic ecological intelligence is not just an educational task, but rather the most fundamental strategic investment for building a future where human well-being and planetary sustainability are inseparable.

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