



Ecopedagogy and Education for Sustainable Development Based on Deep Learning in Strengthening Gender Equality

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ABSTRACT

Ecopedagogy and Education for Sustainable Development (ESD) based on deep learning have a strategic role in strengthening gender equality in Early Childhood Education. This study aims to examine the application of ecopedagogy and Education for Sustainable Development (ESD) based on deep learning in strengthening gender equality in Early Childhood Education. The focus of the study is directed at understanding how a sustainability-oriented learning approach and deep learning can instill the value of gender equity from an early age. The research location was carried out at Angkasa Lanud Adisucipto Yogyakarta Kindergarten group B with a sample of 30 people. Data collection used observation, documentation and interviews. Data analysis techniques used data triangulation including three stages starting from data collection, reduction presentation and drawing conclusions. The results of the study indicate that the application of

ecopedagogy and Education for Sustainable Development (ESD) based on deep learning through the activity of making compost from wet leaves has a positive impact on strengthening gender equality in Kindergarten. Boys and girls are actively involved in all stages of the activity. This activity can foster an understanding that every child has the same opportunities and role in protecting the environment without any discrimination based on gender.

INTRODUCTION

The issues of sustainable development and gender equality are a major concern in the 21st Century global agenda, as reflected in the Sustainable Development Goals (SDGs), particularly goal 4 on quality education and goal 5 on gender equality (Malik et al., 2025a); (Malik et al., 2025b). Education is seen as a strategic instrument for instilling the values of sustainability and social justice from an early age. Based on the education for sustainable development (ESD) framework, educational institutions are required not only to transmit knowledge but also to shape attitudes and values that support sustainability and equality (Inga & Pereira, 2021); (Grosseck et al., 2019); (Tafese & Kopp, 2025); (Roncovic & Rieckmann, 2025a).

The deep learning approach to learning emphasizes the active involvement of students in building meaningful understanding through direct experience, reflection and collaboration (Mandasari et al., 2025); (Maulidiya et al., 2025). In the context of early childhood, deep learning is relevantly implemented through concrete activities that allow children to explore their surroundings holistically. This approach aligns with the demands of 21st-century learning, which emphasizes character development, social skills, and global awareness, ensuring that learning goes beyond superficial knowledge to encompass values and attitudes.

Various studies show that the implementation of deep learning in PAUD institutions is generally focused on developing children's cognitive abilities, creativity and problem solving through project-based and experiential learning (Rahmat et al., 2025); (Jayawardana, 2025a); (Rahman & Cahyatiwati, 2025); (Novitasari et al., 2025). On the other hand, studies on gender equality in PAUD have focused more on the role of teachers, curriculum, and parenting practices in preventing gender stereotypes (Ismiati, 2024); (Bastian & Novitasari, 2022); (Rini et al., 2022). However, gender equality in these studies is often positioned as a normative principle or institutional policy, and has not been fully studied as the result of a structured and in-depth experience-based learning process.

In line with this, the ecopedagogy and Education for Sustainable Development approaches in early childhood education have been developed through environment-based activities such as gardening, recycling, and waste management (Saputri & Waluyo, 2024); (Sari et al., 2025); (Adinda et al., 2025). These studies confirm that environmentally-based learning is effective in fostering ecological awareness and social responsibility in children. However, research simultaneously integrating deep learning, ecopedagogy, and gender equality strengthening approaches within a single early childhood education framework remains relatively limited, particularly through composting activities as a learning medium.

This research offers a novel approach through the integration of deep learning-based ecopedagogy as a strategy to strengthen gender equality in early childhood through composting activities in early childhood education institutions. The novelty of this research lies in positioning gender equality as a learning outcome built through direct experience, equal collaboration, and meaningful reflection, while also linking it to the global issue of Education for Sustainable Development. Thus, this research is expected to provide theoretical and practical contributions to the development of early childhood education models that are oriented towards sustainability and social justice from an early age.

METHOD

This research uses a qualitative approach with a case study design that aims to gain an in-depth understanding of the implementation of environment-based learning activities in early childhood within the framework of education for sustainable development (ESD). The research was conducted at the Angkasa Lanud Adisucipto Kindergarten in Yogyakarta, with 30 children in group B as subjects. The research subject determination technique used saturated sampling, meaning the entire population of children in group B was involved in the study. The research took place over five days, from Monday to Saturday, May 20-25, 2024.

The learning activities in this study were designed by integrating the principles of deep learning that emphasize meaningful, contextual and participatory learning as well as the value of gender equality through the involvement of all children without distinction of roles based on gender. The stages of learning activities include: (1) children participate in activities watching educational videos about types of waste and how to process them; (2) children collaboratively select and sort waste found in the school environment; (3) children are divided into several heterogeneous groups to carry out compost making activities which begin with the teacher giving examples; (4) children work together in painting used gallons as a planting medium; (5) children use the compost that has been made in the planting containers provided; and (6) children take turns conducting routine observations of the condition of plants that have been given compost as a form of habituation to environmentally friendly behavior.

The data analysis in this study used the Miles and Huberman interactive analysis model, which includes three main stages: data reduction, data presentation, and drawing and verifying conclusions. The analysis process was conducted simultaneously and continuously throughout the study to ensure data validity, the depth of findings, and the relevance of the research results to the principles of education for sustainable development, deep learning, and strengthening gender equality values in the context of Early Childhood Education.

FUNDING

The research results show that the implementation of ecopedagogy and Education for Sustainable Development (ESD) based on deep learning in PAUD has a positive impact on strengthening the values of gender equality in early childhood. Children begin to show changes in attitudes in viewing gender roles more equally, especially in environmental-based learning activities. Through activities such as sorting waste and recycling projects, boys and girls are actively involved without stereotypical gender roles. The deep learning process that emphasizes meaningful, reflective, and contextual learning enables children to understand that the responsibility to protect the environment and work together are universal values that can be carried out by anyone regardless of gender.

Furthermore, observations and interviews with educators indicate that an ecopedagogical approach integrated with ESD principles encourages teachers to be more aware of gender-sensitive

learning practices. Teachers no longer unconsciously reproduce stereotypes, such as directing girls to domestic activities or boys to solely physical activities. Instead, teachers provide equal opportunities for all children to explore various roles and skills. A deep learning approach plays a crucial role in this process because it encourages teachers to design learning experiences that foster children's deep understanding, empathy, and critical thinking skills regarding social and environmental issues from an early age.

Further discussion shows that the integration of ecopedagogy and ESD based on deep learning not only contributes to strengthening gender equality but also to the development of sustainable character in children. Children begin to demonstrate mutual respect, cooperation, and care for the environment and others. This aligns with the goals of ESD, which emphasize balance between environmental, social, and economic dimensions. In the context of gender, experiential learning and simple reflection help children understand that gender differences are not a basis for injustice or role limitations. Thus, the value of gender equality is naturally embedded through a holistic and meaningful learning process.

The implications of these findings indicate that the implementation of ecopedagogy and deep learning-based ESD in early childhood education (PAUD) is an effective and relevant strategy in supporting the sustainable development agenda, particularly the goal of gender equality. This approach emphasizes the importance of early childhood education as a foundation for building social awareness and values of justice from an early age. Therefore, policy support, teacher training, and curriculum development that explicitly integrates ecopedagogical principles, ESD, and deep learning are needed so that gender equality strengthening practices can be implemented sustainably and systematically in PAUD institutions. Based on observations and interviews with teachers and children, the first day of activities, Monday, May 20, 2024, began with a group video viewing in the school hall.



Figure 1. Children watch videos together in the hall

The activity in the picture shows the children's enthusiasm in watching a video related to the types of organic and inorganic waste, how to manage waste, and the dangers of waste in the environment. Teachers and students watched the educational video together in the hall of the Angkasa Lanud Adisucipto Yogyakarta Kindergarten. Before the educational video viewing activity began, the teacher first conducted a brief question and answer session with the children regarding what types of waste the children already knew. Then, based on the children's responses

and answers, the teacher selected an appropriate video. This joint viewing activity lasted for 30 minutes with the video being shown twice. After watching the video, the teacher again conducted a brief question and answer session related to the video content that had been watched together. Some children responded very enthusiastically, some were even able to explain the contents of the video in detail.

Table 1. Aspects seen from video watching activities

Aspects observed	Component	Indicator	Data collection technique
Pedagogical aspects	Environmental awareness	Children are able to recognize the concept of organic and inorganic waste	Observation of viewing and discussion activities
	Environmental care attitude	Children show interest in maintaining cleanliness	Observation of behavior after watching the video
	Contextual learning	Video material related to the environment around children	Teacher interview
Aspects of Education for Sustainable Development (ESD)	Integration of sustainability values	Children understand the importance of sorting waste	Questions and answers and observations
	Active participation	Children are actively involved when watching and responding.	Participatory observation
	Holistic learning	Learning includes cognitive, affective and social aspects	Interviews and observations
Learning aspects of deep learning	Meaningful understanding	Children are able to explain the contents of the video again	Questions and answers and observations
	Emotional involvement	Children are focused, enthusiastic and interested	Observation
	Simple reflection	Children relate videos to everyday experiences	Class discussion
Aspects of gender equality	Equal access	Boys and girls participate in activities together	Observation
	Equal participation	Boys and girls actively ask and answer questions	Participatory observation
	Gender representation	The video shows children's roles without gender bias	Video content analysis
	Inclusive attitude	Teachers do not differentiate treatment based on gender	Observation and interviews

After listening to the children's explanations, the teacher then explained the activities the children would undertake in the school environment. The children were directly involved in school environmental management activities through the practice of sorting organic and inorganic waste as part of ongoing learning. Each child was divided into several small groups with equal responsibilities for boys and girls. Each child was tasked with going around carrying a large bag for each different type of waste. Some aspects examined in this activity were:



Figure 2. Children work together to select and sort waste in the school environment.

The activity of selecting and sorting waste by type involved all children at Angkasa Lanud Adisucipto Kindergarten in Yogyakarta. Children actively helped protect the school environment under teacher supervision. They worked together, showing responsibility, participation, and environmental awareness. This activity reflects experiential learning, where children learn directly through practice. It also supports social-emotional development, including empathy, cooperation, communication, and helping others. Through direct involvement, children begin to build environmentally conscious character from an early age. With proper guidance, this activity becomes holistic learning that balances moral, social, and cognitive development. Observations from this activity are summarized in the following table:

Table 2. Aspects Observed from Activity 2

Aspects observed	Variables	Indicator	Description of child behavior	Data collection techniques
Ecopedagogy	Environmental awareness	Introduction to environmental cleanliness	Children understand the importance of a clean environment through direct practice.	Observation
	Ecological action	Participation in collecting garbage	Children actively pick up and put trash into black bags.	Participatory observation
	Contextual learning	Learn from real environment	Activities carried out in the school environment	Documentation
Aspects of Educator for Sustainable Development (ESD)	Sustainability values	Social responsibility	Children show concern for shared cleanliness	Observation
	Active participation	Involvement of all children	All children are involved without coercion	Observation
	Cooperation	Collaboration in groups	Children work together to collect trash	Observation
Deep learning	Active involvement	Focus and enthusiasm	Children are directly involved in activities	Observation
	Meaningful understanding	Conscious action	Children understand the purpose of the activity (maintaining cleanliness)	Questions and answers and observations
	Simple reflection	Connecting experiences	Children are able to explain activities again	Interview

Gender equality	Equal access	Involvement of men and women	Boys and girls do the same tasks	Observation
	Equal participation	There is no gender-based division of roles	All the children picked up trash and held bags.	Observation
	Inclusive interactions	Cross-gender collaboration	Children help each other without discrimination	Observation

In the next activity, the children will practice making compost from wet leaves. The teacher will first provide an explanation and provide a hands-on example of how to make compost. This activity can be seen in the following image:



Figure 3. Children make compost from wet leaves divided into small groups.

The children's enthusiasm and interest in making compost from wet leaves was high. This was evident in their focused attention and active responses during the hands-on practice session. The children were divided into small groups of 5-6. Each child was assigned the same role and task. Each child was directly involved in the composting activity. The first activity began with chopping the leaves into smaller pieces.

This aims to facilitate the decomposition process more quickly. Next, fill the bottom layer of the container with the prepared soil. Then, add small, chopped leaves and cover them with a little more soil. The children repeat this activity until all the material is used, alternating leaves and soil. After completing this project, cover the container with a sack and store it in a shaded area. The children monitor the fertilizer daily, taking turns. Some of the things the teacher observes during this activity include:

Table 3. Observation Indicators

Ecopedagogy Indicators
<ol style="list-style-type: none">1. Children recognize natural materials (leaves, grass and soil) as materials from the living environment.2. Children show concern for the environment by not damaging plants.3. Children are able to sort and group natural materials according to the teacher's instructions.4. Children use natural ingredients wisely and not excessively.5. Children show curiosity about natural processes (touching, observing and asking questions).
Education for Sustainable Development (ESD) Indicators
<ol style="list-style-type: none">1. Children work together in groups without differentiating between friends.2. Children learn to share tools and materials fairly.3. Children show responsibility for the tasks given.4. Children understand that nature needs to be protected for the future.5. Children follow activities from start to finish in an orderly manner.
Deep Learning Learning Indicators
<ol style="list-style-type: none">1. Children are able to explain the activities they do again.2. Children connect activities with everyday experiences.3. actively ask questions and try independently.4. Children demonstrate simple problem solving (e.g., selecting the correct leaf).5. Children are able to work together and make simple decisions in groups.
Indicators for Strengthening Gender Equality
<ol style="list-style-type: none">1. Boys and girls are actively involved in the same activities.2. There is no division of tasks based on gender.3. Children respect each other's opinions without differentiating gender.4. Teachers provide equal opportunities to all children.5. Children show an attitude of helping each other without discrimination.

The next activity is preparing planting media for each child using used bottles, as seen in the picture below:





Figure 4. Several groups of children paint used bottles as a planting medium.

Thursday's activity involved children collaboratively creating planting containers for spinach seedlings using reused bottles. They took turns painting bottles outdoors for 30 minutes as part of a core, ongoing activity. Teachers had prepared the bottles beforehand. All children participated equally. From an Education for Sustainable Development (ESD) perspective, this activity applied reduce, reuse, and recycle principles. It reduced plastic waste and fostered early ecological awareness. Socially, it encouraged cooperation, responsibility, and care. Culturally, it supported clean and environmentally friendly habits. Economically, children learned efficiency and the value of reusing materials, promoting creativity, resourcefulness, and reduced reliance on new resources.

The next activity involves waiting for the compost to ferment for a week, after which it can be used as a planting medium. Each group of children participates in putting the compost into previously prepared used bottles. The activity is as follows:



Figure 5. Children put compost into the planting medium.

The implementation of ecopedagogy and Education for Sustainability (ESD) in early childhood is reflected in wet leaf composting activities. Children actively fill decorated reused bottles with compost they made. This contextual activity introduces environmental values early. It aligns with ESD principles by balancing environmental, social, and character development. From a deep learning perspective, the focus is on meaningful processes rather than outcomes. Children gain real experiences by processing natural materials, maintaining cleanliness, and understanding human–nature relationships. Through hands on involvement observing, discussing, and solving

problems children develop critical thinking, collaboration, responsibility, and stronger environmental awareness, rather than merely memorizing concepts.



Figure 6. Condition of spinach after 4 days

The learning outcomes of making compost from wet leaves by students at Angkasa Lanud Adisucipto Kindergarten in Yogyakarta can be seen in the image above. The planting medium filled with compost that has been stored for a week makes the spinach plants fertile and grow abundantly. The selection and use of compost from wet leaves is suitable for use with early childhood because it utilizes organic waste that is easily found in the environment. This helps reduce waste while also teaching the concepts of recycling and sustainable agriculture. Seen from the concepts of ecopedagogy and deep learning in the context of early childhood education, it introduces children directly to the values of environmental concern.

Ecopedagogy is an education that instills ecological awareness from an early age through real-life experiences, not just theory. Children learn and discover that wet leaves, usually considered trash, can actually be recycled into something beneficial for plant life. Linked to the concept of deep learning in early childhood, this activity encourages meaningful and in-depth learning. Children not only observe the plants growing luxuriantly but also participate in the process. This process fosters critical thinking, curiosity, patience, and responsibility, as children learn about cause and effect.

DISCUSSION

1.1. Education for Sustainable Development in Context of Education

Education for Sustainable Development (ESD) is an educational approach that aims to equip students with the knowledge, skills, values and attitudes needed to understand and respond to complex sustainable development challenges, such as environmental, social and economic issues (Roncovic & Rieckmann, 2025b). ESD is not only emphasizing the transfer of knowledge, but also instilling critical thinking skills, problem solving and a commitment to acting for a more sustainable (Riess et al., 2022); (Ekamilasari et al., 2021).

In the educational context, ESD serves as a framework for integrating sustainability principles into all aspects of learning, from elementary to higher education. Several literature

reviews have shown that implementing ESD in schools contributes to increased environmental literacy and student awareness of sustainability issues, particularly when combined with active learning approaches such as problem-based learning (PBL) (Xiong et al., 2025); (Zulfah et al., 2024); (Fadilah & Faizah, 2025a) (Fadilah & Faizah, 2025b).

In addition, the literature review on ESD in education emphasizes that the implementation of sustainability principles must involve changes in curriculum design, learning strategies, learning media and evaluation of learning outcomes (Thoriq & Mahmudah, 2023); (Bascope et al., 2019a). ESD integration requires supporting learning resources, such as educational videos, contextual modules, and hands-on activities that can connect learning content to students' social and environmental realities. A systematic literature review also found that ESD is relevant not only to science learning but also to various other subjects, with the aim of developing students' critical thinking skills, collaboration, and active participation in sustainable actions (Gonzales-Salamanca et al., 2020); (Berg & Verster, 2023).

1.2. Ecopedagogy as Strengthening Gender Equality in Early Childhood

Ecopedagogy is essentially an educational approach that focuses on the relationship between humans, the environment and society (Monem, 2024a). This aims to develop ecological awareness while integrating the values of inclusivity into the learning process (Hijriyanah & Sutarna, 2025); (Hidayat et al., 2025). In the scope of early childhood education, ecopedagogy is believed to be able to become a transformational framework that not only instills concern for the environment, but also facilitates the strengthening of gender equality from the earliest stages of a child's development.

An educational approach that is sensitive to the environment and society encourages children to understand the relationship between the physical environment and the social structures around them (Indrayanti et al., 2025); (Febriani et al., 2025); (Wardatussa'idah et al., 2024). Although specific scholarly articles on ecopedagogy and gender in early childhood education are still relatively limited, several sites support the idea that gender-responsive and ecological learning can be mutually reinforcing. For example, research conducted by (Ardiansyah & Saqjuddin, 2025) highlights the importance of inclusive learning systems that actively challenge gender stereotypes in early childhood education settings, including the use of teaching materials, teacher interactions, and classroom cultures that encourage free exploration without gender boundaries. This approach aligns with ecopedagogy, which emphasizes the integration of ecological awareness with social justice values, including gender equality, in early childhood education.

In the context of early childhood education, gender-aware education has been identified as a crucial aspect in creating a just and equitable education. Various studies have shown that although traditional pedagogical practices still contain gender stereotypes, such as the division of play and treatment based on gender, gender-aware education can minimize these biases (Li, 2023); (Feierabed et al., 2024).

Ecopedagogy itself, although more often associated with environmental education and ecological awareness, has a holistic approach, namely integrating social ethical values with ecological literacy that aligns with the goals of education for sustainable development. The ecopedagogic learning model that combines personal skills and social awareness as previously explained shows that this approach improves students' abilities not only in ecological understanding but also in developing social attitudes towards the common good (Putri et al., 2025). Several studies in early childhood education also point to the need for systematic interventions in the context of gender learning. For example, research on gender education strategies emphasizes the importance of developing gender-sensitive curricula and creating non-gendered activities to prevent the internalization of stereotypes from an early age (Judaini & Sari, 2024); (Londen et al., 2025).

1.3. Implementation of Ecopedagogy and Education for Sustainable Development Based on Deep Learning in Strengthening Gender Equality

Contemporary pedagogical approaches in early childhood education increasingly emphasize the integration of ecological awareness (ecopedagogy) and education for sustainable development (ESD) with modern learning strategies such as deep learning which are able to stimulate in-depth understanding, active involvement and social awareness in children (Bascope et al., 2019b); (Dwijantie, 2025); (Kusumawardani & Kuswanto, 2020); (Daboti et al., 2025). Ecopedagogy is a learning approach that integrates environmental values and social justice into educational practices, with the aim of fostering awareness that humans are part of an interconnected ecological system and strengthening inclusive values such as gender equality from an early age (Siregar et al., 2025); (Melendez et al., 2024); (Monem, 2024b).

Several research studies have shown that environmental and gender equity education in early childhood education can be implemented together to foster awareness of sustainability and social justice in children. For example, research conducted by (Hendrawati et al., 2023) This study demonstrates that the integration of environmental education and gender equality can be achieved through school policies and flagship programs that foster environmentally friendly behavior and treat children without gender stereotypes.

Meanwhile, studies related to the deep learning approach in early childhood education (PAUD) show that this approach focuses on meaningful, contextual, and interactive learning, so that children not only receive superficial information but also develop a deeper understanding of concepts through real-life experiences, educational games, social collaboration, and reflection on the learning process. The application of deep learning can increase children's emotional, behavioral, and cognitive engagement through exploration and project-based learning that encourages curiosity, creativity, and communication (Dwijantie, 2025); (Jayawardana, 2025b). This method is relevant to the goals of ESD and ecopedagogy because both emphasize a holistic and contextual learning process, where children not only understand the concepts of environment and sustainability but are also expected to internalize social values such as justice and equality.

1.4. Gender Challenges and Opportunities for Implementing Ecopedagogy and Education for Sustainable Development Based on Deep Learning in Strengthening Gender Equality

Ecopedagogy is a critical educational approach that emphasizes ecological awareness, social justice, and sustainability through reflective and transformative learning processes. In the context of Early Childhood Education, ecopedagogy serves as an initial foundation for instilling values of environmental awareness, social empathy, and fairness toward others, regardless of gender (Ardoin & Bowers, 2020); (Casey et al., 2025); (Melis et al., 2026). Meanwhile, Education for Sustainable Development (ESD) emphasizes the integration of environmental, social and economic aspects in education to shape a sustainable generation from an early age.

Although conceptually, ecopedagogy and deep learning-based ESD hold great potential, their implementation in early childhood education (ECE) still faces various challenges. One of the main challenges is the limited understanding of ECE educators regarding the concept of gender equality integrated with sustainability issues. Many learning practices still reproduce gender stereotypes, whether through the selection of ECE, the assignment of play roles, or the use of language in classroom interactions.

Furthermore, the Indonesian early childhood education curriculum has not explicitly integrated ecopedagogy and deep learning-based ESD to strengthen gender equality. Implementation remains sporadic and relies on individual teacher initiative. Another challenge is the lack of ongoing professional training for early childhood education educators that focuses on critical pedagogy, reflective learning, and gender-sensitive transformative approaches.

CONCLUSION

The ecopedagogical approach teaches children to learn about and love the environment directly through real-life experiences such as managing organic waste, planting, and caring for the environment. These activities foster ecological awareness and a sense of responsibility for nature as a gift from life. The implementation of Education for Sustainable Development (ESD) based on deep learning makes the learning process more meaningful, as children not only receive information but also experience, understand, and reflect on the learning as a whole. Children learn to think critically, collaborate, solve problems, and understand cause-and-effect relationships in everyday life. This process fosters the development of environmentally conscious character and sustainable attitudes from an early age.

Every child has an equal opportunity to actively participate, explore, and take responsibility for completing each stage of the activity, which is part of gender equality. Therefore, integrating ecopedagogy with deep learning-based education for sustainable development to strengthen gender equality in early childhood education environments is a crucial foundation for developing a generation that cares about the environment, thinks critically, has an inclusive character, and is ready to face the challenges of sustainable development in the future.

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