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Implementation of Deep Learning–Based Instruction in the Farming Method to Optimize Young Children's Naturalistic Intelligence

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ABSTRACT

Objective: This study aims to examine the effectiveness of the farming method based on deep learning in developing naturalistic intelligence among early childhood learners. **Method**: The research employed a Classroom Action Research (CAR) design conducted in one cycle with several learning activities such as planting water spinach, understanding the phenomenon of tsunamis, observing clouds, and studying the process of rainfall. Data were collected through systematic observations using indicators of interest, knowledge, skills, and environmental awareness. **Results**: The findings show a notable improvement in children's naturalistic intelligence after the implementation of the method. Children who initially showed greater interest in artificial objects demonstrated increased engagement in farming activities, improved understanding of natural phenomena, and heightened empathy and environmental care. **Novelty**: This study highlights a unique integration of deep learning–based instruction within the farming method, where learning activities are deliberately structured to promote conceptual understanding, active meaning-making, reflection, and the application of knowledge, core principles of deep learning pedagogy. By aligning experiential farming activities with these instructional components, the approach goes beyond routine hands-on learning and supports children in connecting natural phenomena with prior knowledge, reasoning, and environmental values. This integration offers an innovative and theoretically grounded strategy to cultivate naturalistic intelligence in early childhood settings, providing a practical model for teachers seeking meaningful experiential learning that fosters cognitive depth and environmental awareness.

INTRODUCTION

A nation's strength is not solely measured by the abundance of its natural resources but also by the quality of its human capital. Young learners represent the next generation responsible for sustaining environmental preservation. Their active involvement in environmental practices is expected to help prevent and address ecological problems. Daily routines embedded in the school environment can positively shape children's habits and lifestyles; therefore, cultivating environmental care as a core character value is essential for nurturing future generations who appreciate and protect nature.

As a developing country, Indonesia continues to face challenges related to character education, which significantly affects everyday life (Fatria et al., 2024). Public awareness regarding environmental stewardship must be fostered from an early age, beginning at home and in early childhood education institutions (Altun, 2019). Character formation related to environmental concern can be strengthened through environmentally oriented learning. Such learning experiences are expected to help children develop a sense of responsibility and awareness toward nature and their surroundings (Uludağ, 2021).

Aligned with this perspective, other scholars emphasize that promoting environmentally responsible behavior can be achieved through environmental education. Environmental education equips learners with knowledge, awareness, attitudes, and responsible actions toward the reciprocal relationship between humans

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and nature. One of its key objectives is to cultivate love and care for the environment. Ideally, this formation should begin in early childhood, as this period is the optimal foundation for attitude development (Pelima, 2014). Introducing environmental education from an early age is essential because the "golden age" is a critical stage in which children develop character through the stimulation they receive (Safira, 2020).

Education must position children as subjects of learning, acknowledging their unique needs and recognizing play as the primary medium for creativity. The surrounding natural environment offers rich opportunities for exploration and serves as an ideal learning context for nurturing environmental awareness (Pelima, 2014). Instilling environmental care is challenging and requires the active involvement of educators as mentors and role models. Teachers are responsible for guiding learners in recognizing and addressing environmental issues, especially in early childhood settings where the foundation of environmental empathy must be laid. Children can be guided and encouraged to carry out tasks requiring commitment and responsibility (Dynia et al., 2018). Unfortunately, environmental education remains underemphasized in many educational systems (Zaman et al., 2024). The lack of early exposure to environmental cleanliness and stewardship further affects children's personality development, even though early childhood is a phase in which children tend to imitate adult behavior (Parker L & Prabawa-Sear K, 2019).

Given the crucial role of environmental education in shaping sensitivity, interest, and environmentally responsible behavior later in life, early childhood environmental education is expected to adopt unique, nature-based approaches grounded in experiential learning. Nature-based environmental programs provide direct experiences that strengthen children's appreciation and understanding of the natural world (Nicole M. Ardoin & Bowers, 2020). Individuals who show strong appreciation for nature are considered to possess high naturalistic intelligence. This type of intelligence should be nurtured early, as children are in their optimal developmental period during the golden age (Zaman et al., 2024).

However, current realities show that many young children still lack adequate exposure to environmental education. Their low sensitivity toward nature is reflected in everyday behaviors, such as littering on desks, under chairs, or around classrooms, and in their limited ability to identify plants around their school due to the absence of outdoor learning experiences. These issues highlight the low development of naturalistic intelligence, signaling the need for intentional pedagogical strategies to enhance it (Saripudin, 2017).

This article aims to examine the importance of early childhood environmental education by incorporating pedagogical strategies designed to strengthen naturalistic intelligence. Its originality lies in addressing contemporary issues in environmental education for young children, particularly within the context of the Industrial Revolution 4.0, where technological advancement influences teaching practices and necessitates innovative learning strategies capable of nurturing naturalistic intelligence.

Naturalistic intelligence, one of Gardner's multiple intelligences, refers to the individual's ability to recognize, understand, classify, and show concern for natural objects, living organisms, and environmental phenomena. For young children, this intelligence is closely linked to environmental sensitivity and the development of positive attitudes toward living things. Yet preliminary observations in many early childhood institutions indicate that children are more attracted to artificial objects than natural ones,

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demonstrating the need for strategies that stimulate curiosity, observation skills, and empathy toward the natural world.

In pedagogical terms, deep learning refers to an instructional approach that emphasizes meaningful understanding, active knowledge construction, and the ability to apply concepts in real-life contexts, rather than surface-level memorization (Biggs & Tang, 2011). Deep learning occurs when learners engage cognitively and reflectively with learning experiences, allowing them to connect new information with prior knowledge and develop lasting conceptual understanding. Within early childhood education, this approach supports learning designs that integrate exploration, reflection, discussion, and application in developmentally appropriate ways. Such pedagogical principles align with constructivist learning perspectives, where learning is viewed as an active process of meaning-making, and are particularly relevant for nurturing naturalistic intelligence, which requires children not only to experience nature directly but also to understand, interpret, and respond thoughtfully to natural phenomena.

Recent empirical studies have increasingly highlighted the importance of early childhood environmental education in shaping pro-environmental attitudes and behaviors. Research published over the past decade indicates that nature-based and experiential learning approaches significantly enhance children's environmental awareness, ecological sensitivity, and sense of responsibility toward the natural world (Ardoin & Bowers, 2020; Dynia et al., 2018; Uludağ, 2021; Zaman et al., 2024). Furthermore, recent literature emphasizes that integrating reflective and inquiry-oriented pedagogies in early childhood settings supports deeper engagement with environmental concepts and strengthens the development of naturalistic intelligence (Biggs & Tang, 2011; Saripudin, 2017). These findings suggest that contemporary environmental education for young children should move beyond incidental exposure to nature and adopt structured, research-informed learning models.

Based on the above rationale, this study is directed to address a clear pedagogical question concerning early childhood environmental education. Specifically, this research investigates how a deep learning based farming method can be implemented in early childhood settings to strengthen children's naturalistic intelligence. The study focuses on examining the extent to which such an approach influences three core dimensions of naturalistic intelligence: environmental knowledge, practical skills in interacting with nature, and affective attitudes toward environmental care. Accordingly, the research is guided by the following question: *to what extent and in what ways does a deep learning based farming method enhance early childhood naturalistic intelligence in terms of knowledge, skills, and attitudes?*

RESEARCH METHOD

This study employed a Classroom Action Research (CAR) approach. CAR is recognized as a systematic effort conducted by educators within the school setting to improve the quality of teaching practices and strengthen their professional responsibility in managing learning activities (Sanjaya, 2009). As a problem-solving strategy, CAR aims not only to address issues that arise during instruction but also to enhance the overall learning process. Muslich (2010) explains that the objective of CAR is to improve instructional quality through planned actions that solve learning problems while simultaneously fostering professional growth among teachers. In line with this purpose, the actions

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implemented in CAR must be creative, innovative, and oriented toward continuous improvement.

This study adopted a collaborative CAR design in which the teacher acted as the implementer of the intervention, while the researcher served as the primary data collector. Collaboration was necessary because the researcher was not one of the teachers in the participating class. Such teamwork allowed the research process to run more efficiently and ensured that the intervention was implemented authentically within the classroom context. The primary rationale for conducting CAR in this study was to improve and refine teaching practices, particularly instructional strategies aimed at enhancing naturalistic intelligence among early childhood learners.

The CAR procedure followed the Kemmis and McTaggart model, which consists of recurring stages within each cycle: planning, acting, observing, and reflecting. These stages are repeated across cycles based on the results of the reflection phase, continuing until the identified problems are sufficiently resolved. The general flow of the CAR implementation in this study is illustrated in the following figure:

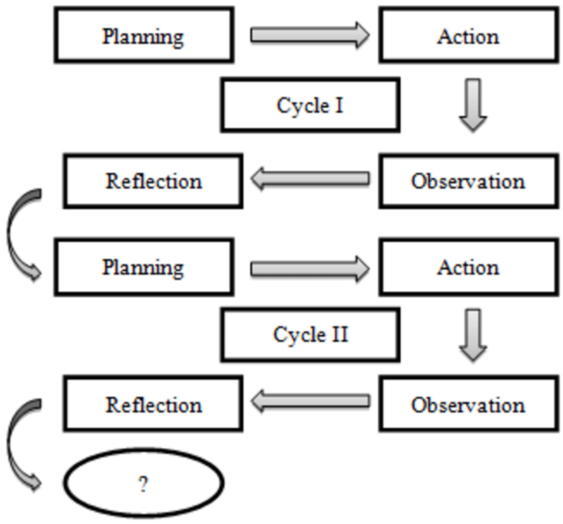

Figure 1. Classroom Action Research Cycle (Kemmis & McTaggart Model)

The population of this study included all kindergarten children in the Sukasari District of Bandung for the 2024/2025 academic year. The sample was selected using a purposive sampling technique, with the consideration that the chosen school functioned as a model kindergarten capable of transferring its learning innovations to other institutions in the district. Based on this criterion, TK Laboratorium UPI was selected as the research site. The study focused on one class, Group B1, as the subject of the classroom action research, where the learning intervention was implemented and evaluated throughout the research cycle.

Group B1 consisted of 12 kindergarten children aged 5–6 years, comprising 7 boys and 5 girls, who were enrolled in the 2024/2025 academic year at TK Laboratorium UPI. At the initial observation stage, most children demonstrated limited engagement with natural objects and outdoor learning activities, which was reflected in low levels of curiosity, environmental awareness, and basic classification skills related to plants and animals. Group B1 was selected because its developmental characteristics represented typical conditions of early childhood learners at the kindergarten level and showed clear instructional needs related to the enhancement of naturalistic intelligence. The following

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table presents the indicators of naturalistic intelligence in early childhood used in this study:

Aspect	Indicators	Source / Reference
Cognitive	Recognizing and understanding basic natural concepts (plants, animals, weather); understanding relationships between living things and their environment; identifying life cycles of plants and animals; understanding ecosystem concepts and ecological balance.	Braund M & Reiss M, (2012)
Motor	Identifying and classifying plants/animals; conducting nature-related activities such as planting, caring, observing; using nature-related tools (trowel, bucket, magnifying glass).	Gustiana, (2021)
Social–Emotional	Demonstrating curiosity and interest in nature; collaborating in nature-related activities; showing responsibility and care for the environment; expressing thoughts and feelings about nature.	Kılıçoğlu G, (2018)
Language	Using nature-related vocabulary; expressing ideas or feelings about nature orally or in writing; listening to and understanding information about nature.	Gustiana et al., (2023)
Creativity	Generating creative ideas related to nature; producing nature-themed artworks (painting, sculpture, crafts); developing creative solutions to environmental problems.	Hartati et al., (2022)

Data analysis in this study combined qualitative observation with simple descriptive quantitative techniques. Children's naturalistic intelligence was assessed through structured observation sheets based on predefined indicators across cognitive, motor, social–emotional, language, and creativity aspects. Each indicator was scored using a four-point scale, where 1 = not yet developed, 2 = beginning to develop, 3 = developed as expected, and 4 = very well developed. Scores for each child were summed and divided by the number of indicators to obtain mean values for each aspect. The mean scores were then calculated at the class level for each cycle to identify changes and improvements resulting from the implemented actions. Qualitative field notes from observations were used to support and interpret the quantitative trends observed across cycles.

RESULTS AND DISCUSSION

Results

1. Pre-Implementation Activities

In the pre-implementation stage, children were given the opportunity to take three photographs of any objects that caught their attention, either inside or outside the school environment. This preliminary activity in Cycle I aimed to identify the extent to which children naturally paid attention to elements of nature such as plants, animals, or features of the surrounding environment, prior to receiving any form of nature-based learning.

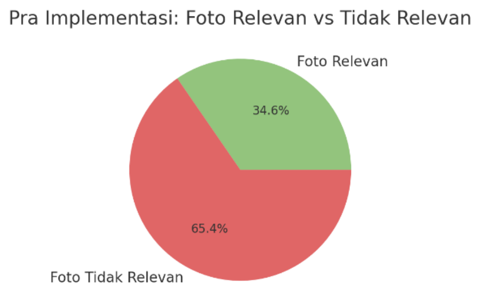

Figure 2. Pre-Implementation Results

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Figure 2 presents the results of the pre-implementation stage, showing children's initial attention toward objects in their surrounding environment. The findings indicate that 65.4% of the photographs captured by children represented artificial or man-made objects, while only 34.6% were related to natural elements, such as plants, trees, flowers, or animals.

This pattern demonstrates that, prior to the intervention, children tended to focus more on non-natural objects within the school environment. Consistent with this distribution, observational records revealed that only 7 out of 12 children selected nature-related objects, while several children did not capture any natural elements at all. These results suggest that children's initial naturalistic intelligence, particularly in terms of environmental sensitivity and spontaneous attention to nature, was still relatively limited at the pre-implementation stage.

2. Cycle I Implementation – Activity 1

The research findings revealed a significant improvement in children's naturalistic intelligence following the implementation of Activity 1 in Cycle I, namely the planting of spinach. During the pre-implementation stage, most children showed a stronger preference for artificial objects over natural elements, indicating relatively low sensitivity toward nature prior to the intervention.

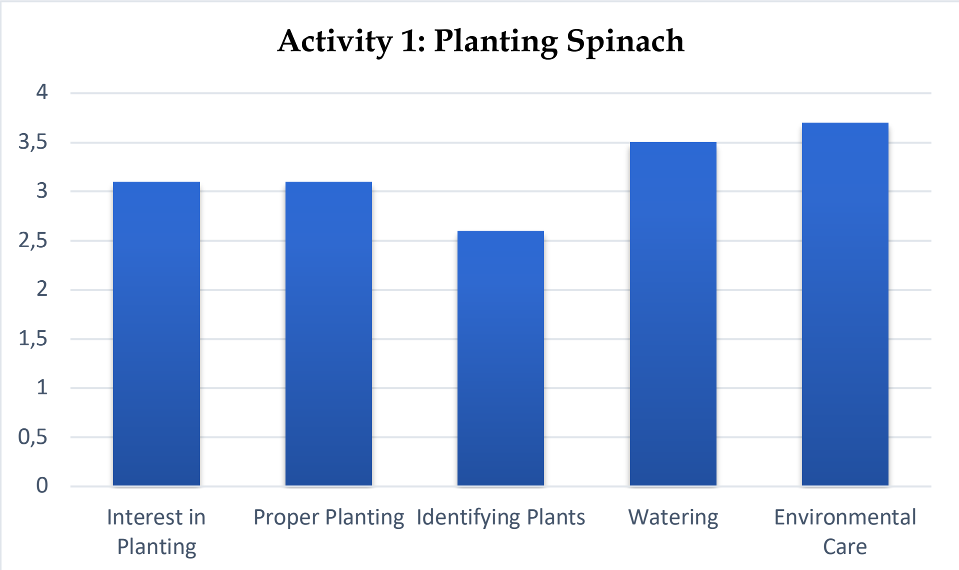

Figure 3. Results of Activity 1: Planting Spinach

This figure presents the mean scores of children's naturalistic intelligence indicators observed during the planting activity, including interest in planting, planting accuracy, identifying plants, watering practices, and environmental care.

After the completion of Activity 1, a clear improvement was observed. During the water spinach planting activity, most children demonstrated strong interest in planting (mean score 3.1), were able to water the plants properly (3.5), and showed notable care for the plants (3.7). These findings indicate that direct involvement in simple farming activities effectively enhanced children's engagement with natural elements and fostered positive attitudes toward environmental care.

Overall, the results demonstrate that the planting activity successfully fostered children's sensitivity toward plants while nurturing a sense of responsibility and care for living things. From the perspective of naturalistic intelligence, children began to

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recognize plants, understand basic growth processes, and participate meaningfully in plant maintenance activities. Thus, Activity 1 in Cycle I provides evidence that the deep learning–based farming method contributed positively to the development of naturalistic intelligence in early childhood.

3. Cycle I Implementation – Activity 2

In Cycle I Activity 2, the learning theme focused on natural phenomena with a specific subtheme on natural disasters, particularly "Understanding the Process of a Tsunami." This activity aimed not only to introduce children to the term tsunami but also to help them understand its causes, impacts, and the importance of showing care toward disaster victims—including humans, animals, and the surrounding environment.

The implementation consisted of several stages. First, the children watched an instructional video illustrating the process of a tsunami, beginning with underwater seismic activity that triggers oceanic waves and followed by its effects on coastal areas. Second, the teacher conducted an interactive discussion, prompting the children to recall and articulate the definition, causes, and consequences of a tsunami. Third, the children participated in a simple experiment simulating the formation of a tsunami, enabling them to grasp the concept in a concrete and meaningful way.

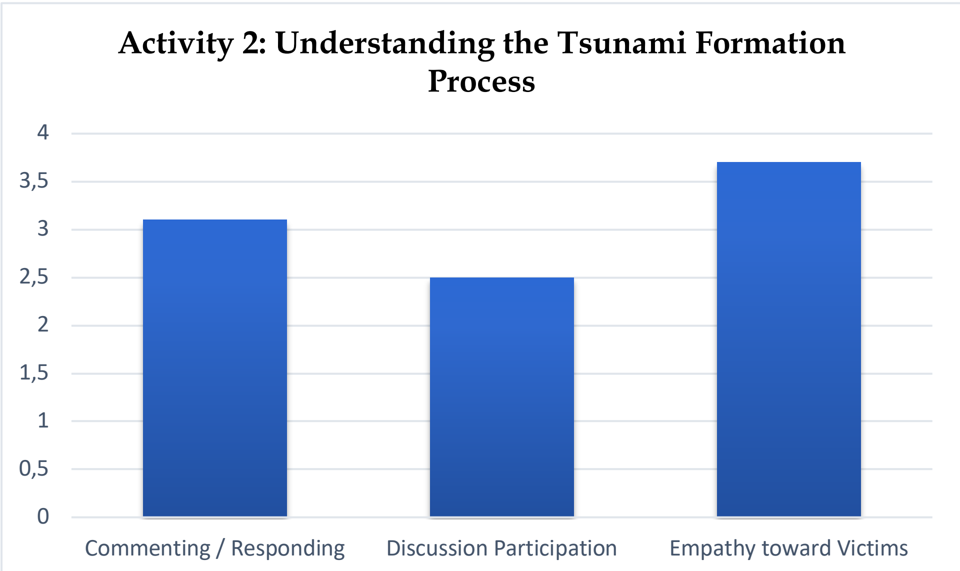

Figure 4. Results of Activity 2: Understanding the Tsunami Formation Process

The observation results presented in Figure 3 indicate a generally positive response from the children. The average score for commenting or reacting to the disaster event reached 3.1, suggesting that the children were able to connect the information from the video to their own simple reasoning. The score for participation in the teacher-led discussion was 2.5, indicating that some children were still hesitant to express their opinions. However, the most important indicator—empathy toward disaster victims—recorded an average score of 3.7, showing that most children demonstrated concern and compassion for the victims depicted in the video.

These findings reveal that through a deep learning approach, the children did not merely memorize factual information about tsunamis; rather, they internalized humanitarian values such as empathy and care. Thus, the second activity made a meaningful contribution to nurturing the affective dimension of naturalistic intelligence,

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particularly the ability to show concern for living beings and the environment affected by natural phenomena.

4. Cycle I Implementation – Activity 3

In Cycle I, the subtheme "Clouds" aimed to help children understand how clouds are formed, recognize different cloud types, and identify their characteristics. The activity was carried out using a variety of learning media, including watching instructional videos, observing the sky using a cloud hunter tool, participating in teacher-guided discussions, and creating cloud-themed artwork using cotton to represent cloud shapes.

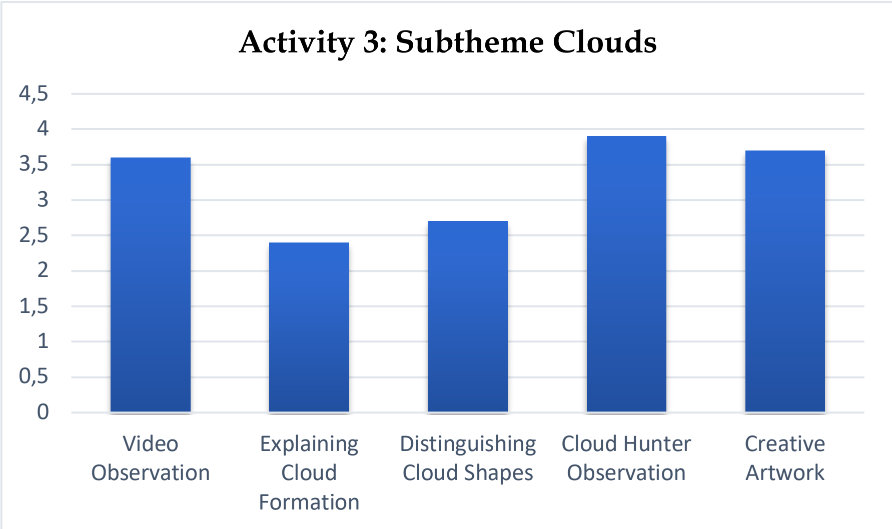

Figure 5. Results of Activity 3: Subtheme Clouds

The observation results show an improvement in children's naturalistic intelligence indicators related to the cloud subtheme. The indicator measuring attentiveness to the instructional video reached an average score of 3.6, indicating that most children were able to focus on the visual material. The indicator related to sky observation using the cloud hunter tool obtained the highest average score of 3.9, reflecting strong enthusiasm and observational engagement during direct interaction with natural phenomena. In addition, the indicator assessing the completion of cloud-themed artwork recorded an average score of 3.7, suggesting that children were able to represent cloud forms creatively. However, the indicator measuring the ability to verbally explain the cloud formation process showed a relatively lower average score of 2.4, as some children experienced difficulty expressing abstract concepts verbally.

5. Cycle I Implementation – Activity 4

In Cycle I Activity 4, the learning focused on the natural phenomenon of rain under the subtheme "Rain." The main objectives of this activity were to help children understand the process of rainfall, identify types of rain clouds, recognize tools used during rainy weather, and comprehend the possible impacts of continuous rainfall as well as the consequences of prolonged absence of rain.

The activity was carried out through several stages. First, the children watched an instructional video about rain and listened to the teacher's explanation. Second, they sang a song about the water cycle while performing accompanying movements, making the learning experience more enjoyable and engaging. Third, the children conducted a simple experiment simulating the formation of rain, allowing them to grasp scientific concepts

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that are typically abstract at their age. Finally, the children brought rain gear (umbrellas, raincoats, jackets) and participated in role-play activities to practice responding to rainy conditions.

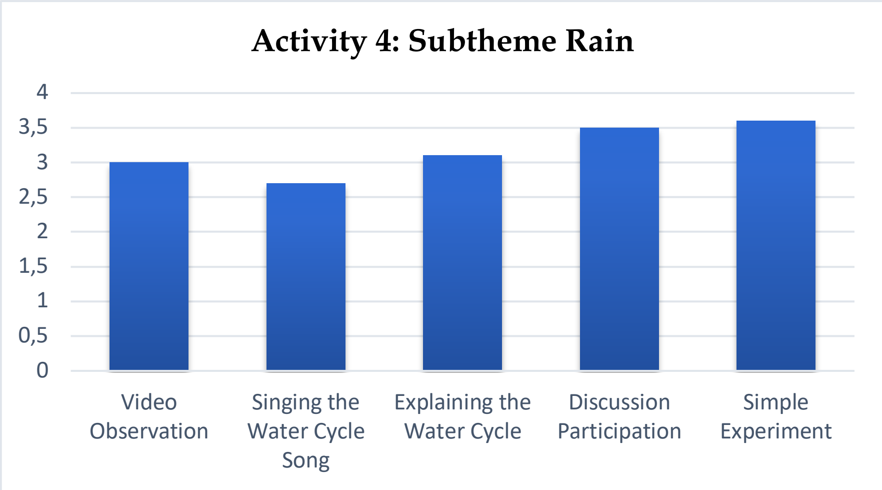

Figure 6. Results of Activity 4: Subtheme Rain

The observation results show variations in children's engagement and understanding across different indicators. The indicator measuring attentiveness to the instructional video obtained an average score of 3.0. Participation in singing the water cycle song showed a lower average score of 2.7, as not all children were confident in performing the activity. The ability to explain the basic stages of the water cycle reached an average score of 3.1. In addition, active participation in discussion achieved a higher average score of 3.5. The highest score was observed in the indicator related to explaining the rain process through a simple experiment, which reached 3.6, indicating strong understanding when children engaged in hands-on activities.

Discussion

From a developmental interpretation perspective, the observed patterns can be understood through Piaget's theory of cognitive development (Santrock, 2020). The findings of this study demonstrate a substantial improvement in young children's naturalistic intelligence after the implementation of the farming method based on a deep learning approach. Prior to the intervention, most children exhibited minimal interest in natural objects, as evidenced by the pre-implementation activity in which they were asked to photograph items that captured their attention. The majority selected artificial objects, slides, goalposts, toys, or school buildings, while only a few photographed trees, flowers, or animals. This pattern aligns with Piaget's view (Santrock, 2020) that children in the preoperational stage tend to focus on familiar, concrete objects closely associated with their daily play. However, this phenomenon cannot be attributed solely to developmental stages; it also reflects a broader pedagogical issue in which early childhood learning environments often lack ecological stimulation. Thus, children's initial low attention to natural elements highlights a structural gap in nature-based exposure within conventional early childhood education settings.

Following the intervention, through activities such as planting water spinach, observing clouds, conducting simple experiments on rainfall, and learning about tsunamis, the children demonstrated a significant shift in their interests, observational

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patterns, and conceptual understanding. They developed heightened sensitivity to natural phenomena, improved cause–effect reasoning, and greater empathy toward living organisms and disaster victims. Notable improvements included higher scores in cloud observation (3.9), understanding simple rainfall experiments (3.6), discussion participation (3.5), and caring for plants (3.7). These results indicate that the shift in naturalistic intelligence was not merely cognitive but also involved affective and psychomotor domains. Such changes provide strong evidence that learning rooted in direct, meaningful experiences effectively redirects children's attention from artificial objects toward deeper engagement with the natural environment.

The deep learning approach played a central role in driving this transformation. Biggs and Tang (2011) distinguish between surface learning, which emphasizes rote memorization, and deep learning, which involves meaning-making, integration of ideas, reflection, and the application of concepts to real-life contexts. In this study, deep learning occurred when children connected their experiences such as planting seeds or performing rainfall simulations with broader ecological concepts. The children did not simply "know" that plants grow or that rain comes from clouds; they understood why and how these processes occur. This depth of understanding is achieved when learning is contextual, experiential, and guided, rather than delivered through verbal explanations alone. The high performance on hands-on indicators, such as recognizing cloud patterns with cloud hunters (3.9) and explaining rain through experiments (3.6), affirms the effectiveness of the deep learning model in fostering conceptual depth among young children.

Kolb's experiential learning model (1984) further supports these findings. Kolb identifies four stages, concrete experience, reflective observation, abstract conceptualization, and active experimentation. All four stages were evident throughout the learning process. For example, in the planting activity, children touched soil and watered plants (concrete experience), reflected on the process through guided discussion (reflective observation), formed simple scientific concepts about plant growth (abstract conceptualization), and practiced caring for plants independently (active experimentation). When learning follows this experiential cycle, knowledge becomes internalized rather than memorized. The study's findings, such as the children's ability to understand rainfall processes and classify cloud types, reflect the successful application of experiential learning principles.

From a constructivist perspective, the growth in naturalistic intelligence observed in this study is an outcome of children's active construction of meaning through interaction with real-world phenomena. Constructivism posits that children do not passively absorb information; rather, they build meaning by engaging with, manipulating, and reflecting upon their environment. During cloud observation activities, for example, children were not simply seeing shapes in the sky; they were interpreting differences in density, color, and formation, and linking them to weather patterns. This interpretive process is fundamental to constructivist learning and provides a foundation for deeper ecological understanding.

However, meaningful learning does not occur solely through experience. Vygotsky's sociocultural theory adds a critical dimension, emphasizing that learning is mediated by social interaction within the Zone of Proximal Development (ZPD). In this study, the teacher served as the more knowledgeable other, providing scaffolding that allowed children to move beyond their initial understanding. This scaffolding was especially

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important when discussing abstract concepts, such as tsunami formation, the water cycle, or cloud types. The improvements in disaster empathy (3.7) and conceptual explanation (3.1–3.6) show that guided dialogue, questioning, and collaborative interactions played an essential role in helping children internalize scientific and environmental concepts. Without scaffolding, experience alone may not have led to the deep-level conceptual change observed in this study.

Gardner's theory of multiple intelligences (1983) is also relevant, particularly the naturalistic intelligence dimension, which involves recognizing patterns, classifying natural objects, and showing sensitivity to ecological systems. The farming method strengthened these dimensions by enabling children to interact directly with living organisms, weather patterns, and environmental events. The increase in observational accuracy, empathy, and classification skills demonstrates that naturalistic intelligence is highly malleable and responsive to well-designed environmental education interventions. This finding challenges the notion that naturalistic intelligence is purely innate and suggests instead that it can be intentionally cultivated through structured, meaningful experiences.

Despite its demonstrated effectiveness, the application of a deep learning approach in early childhood education is not without limitations. Deep learning requires carefully designed scaffolding, sufficient time allocation, and teachers who possess strong pedagogical competence to guide reflection and meaning-making processes. Without appropriate support, young children may experience cognitive overload, particularly when engaging with abstract concepts such as natural disasters or cyclical environmental processes. Additionally, children's limited language development may constrain their ability to verbally articulate understanding, even when conceptual comprehension is emerging. These considerations suggest that deep learning approaches must be developmentally adapted and flexibly implemented to align with children's cognitive and emotional readiness, ensuring that experiential learning remains supportive rather than overwhelming.

Pedagogically, this study provides strong evidence that experiential and nature-based learning should be considered core components of early childhood curricula. Environmental education in early childhood settings is often treated as supplementary rather than essential; however, the results of this study show that systematic exposure to natural phenomena fosters cognitive, affective, and psychomotor development simultaneously. Traditional worksheet-based or verbal instruction fails to develop ecological sensitivity, a foundational competency needed in the era of climate change and environmental degradation. Therefore, a shift from teacher-centered, content-driven learning toward experience-rich, constructivist, and deep-learning-oriented pedagogy is imperative.

While this study demonstrates the effectiveness of a deep learning–based farming method in enhancing early childhood naturalistic intelligence, it also opens important directions for future research. Further studies may explore new pedagogical methods that integrate digital tools, such as augmented reality supported nature exploration, virtual field observations, or sensor-based environmental learning, to complement direct farming activities. In addition, future research could examine the long-term impact of deep learning oriented environmental education on children's ecological attitudes and behaviors beyond the immediate classroom context.

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Methodologically, subsequent studies may adopt quasi-experimental or mixed-method designs to compare the farming method with other nature-based or inquiry-based approaches across diverse early childhood settings. Investigating the role of teacher competence, parental involvement, and school environmental design may also provide deeper insight into how naturalistic intelligence can be systematically cultivated. These future directions would strengthen the empirical foundation of early childhood environmental education and extend the applicability of deep learning approaches across different educational contexts.

CONCLUSION

This study concludes that the farming method based on a deep learning approach is highly effective in enhancing young children's naturalistic intelligence. The intervention generated substantial improvements across cognitive, affective, and psychomotor dimensions, shifting children's initial preference for artificial objects toward meaningful engagement with natural elements and environmental phenomena. Children demonstrated stronger observational skills, a deeper understanding of basic scientific processes, increased empathy toward living organisms, and greater responsibility in caring for nature. These findings affirm the central thesis of this study: that deep learning, when grounded in direct experience and reflective inquiry, has transformative potential in early childhood environmental education.

In terms of pedagogical implications, the results indicate that integrating deep learning principles into nature-based activities offers a powerful strategy for strengthening foundational environmental competencies in early childhood. The study underscores the significance of guided reflection and teacher scaffolding in helping children internalize complex natural concepts within meaningful learning contexts. Accordingly, early childhood curricula should move beyond surface-level environmental topics and prioritize experiential, constructivist, and ecologically grounded instructional designs.

Regarding limitations, this study was conducted in a single early childhood institution, which may limit the generalizability of the findings across different sociocultural contexts. The reliance on observational assessments introduces potential subjectivity, and the relatively short duration of the intervention restricts the ability to evaluate long-term conceptual retention and behavioral sustainability. Moreover, the study did not explore the influence of home environments or parental involvement, which may also shape the development of naturalistic intelligence.

With respect to future research directions, further studies should expand investigations across diverse early childhood settings and employ longitudinal designs to examine the durability of children's learning and behavioral change over time. Comparative studies between farming-based deep learning and other experiential or technology-enhanced environmental education approaches could provide deeper insight into effective pedagogical alternatives.

In closing, this study highlights the transformative potential of deep learning integrated with farming activities as a meaningful, developmentally appropriate, and ecologically grounded pedagogical approach. By fostering curiosity, empathy, responsibility, and scientific understanding, this model provides a promising foundation for nurturing environmentally conscious future generations in an era where ecological literacy is increasingly essential.

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