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The Effect of Nature Based Learning Model On The Computational Thinking of Early Childhood

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Abstrak
Computational thinking has become an essential competency in 21st-century education, yet its integration into early childhood learning remains limited. This study aimed to examine the effect of the nature based learning model on the computational thinking abilities of children aged 5–6 years. A quantitative approach with a quasi-experimental, non-equivalent control group design was employed involving 32 children selected through purposive sampling. Data were collected using performance-based assessments, observation, and documentation, and analyzed using descriptive statistics and the Wilcoxon Signed-Rank Test. The results revealed a significant improvement in children's computational thinking following the intervention ($Z = -3.563$, $p = .007$). These findings indicate that the nature based learning model effectively promotes computational thinking through authentic learning experiences and may serve as an alternative instructional approach for strengthening 21st-century skills in early childhood education.

Keywords: *Computational Thinking Skills; Early Childhood Education; Nature Based Learning; Quasi Experimental Study; 21st Century Education*.

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1. INTRODUCTION

The rapid advancement of digital technology in the twenty-first century has brought significant changes to the ways people acquire knowledge, perform their work, communicate, and address problems encountered in everyday life. These changes have consequently increased the need for higher-order thinking abilities that are relevant to the demands of contemporary society (Wing, 2006). Within the field of education, computational thinking (CT) has emerged as an important competency associated with twenty-first-century learning. Rather than being limited to computer programming, CT refers to a systematic approach to understanding and solving problems by breaking complex situations into manageable parts, identifying relationships and patterns, selecting relevant information, and developing ordered procedures for reaching a solution (Wing, 2006). Previous studies have further emphasized that computational thinking represents a general way of reasoning that can be applied beyond technological contexts, including everyday situations and different areas of learning (Bers et al., 2022; Ching et al., 2018). For this reason, introducing computational thinking during the early years of education is considered important for establishing the foundational thinking and problem-solving abilities that children can develop further as they progress through later stages of learning.

The development of computational thinking in early childhood can contribute to several cognitive abilities that support children's learning and development. When children engage in CT-related activities, they are encouraged to examine situations carefully, recognize recurring patterns, organize information, determine appropriate sequences of actions, and make decisions when attempting to solve problems (Bers et al., 2022). Such learning experiences are also associated with the development of executive functioning skills, including the ability to plan actions, adapt thinking when circumstances change, regulate behavior, and retain and manipulate information in working memory (Relkin et al., 2021). In addition to cognitive development, computational thinking activities can create opportunities for children to express ideas, explore alternative solutions, cooperate with peers, and communicate their reasoning during problem-solving processes (Ching et al., 2018). Consequently, fostering computational thinking at an early age should not be viewed solely as preparation for children's future engagement with digital technology. More broadly, it provides children with fundamental ways of thinking that can support learning, decision-making, creativity, and problem-solving across a variety of contexts.

Although the urgency of computational thinking has been recognized globally, its development in Indonesia still faces various challenges that require serious attention. The results of the Bebras Challenge in 2023 showed that as many as 87% of students scored below the minimum threshold with an average score of 56.25, indicating that the ability in the core components of computational thinking has not developed optimally (Fitriyah et al., 2024). The low level of achievement cannot be attributed to gender differences alone, but is more likely associated with broader challenges within the educational system. These challenges include the limited incorporation of computational thinking into learning curricula, insufficient teacher capacity to design and facilitate activities that foster CT development, and the lack of learning experiences that encourage children to investigate, experiment, and address problems drawn from real-life situations. This situation suggests that inadequate opportunities to develop computational thinking during the early years may have implications for its development at subsequent educational levels. Therefore, learning practices that are responsive to the developmental characteristics, learning needs, and experiences of young children are needed to establish a stronger foundation for computational thinking from an early age.

Previous research has identified a number of ongoing obstacles to the development and implementation of computational thinking within early childhood education. One of the most notable challenges is that many early childhood educators still have insufficient pedagogical understanding of how computational thinking can be incorporated into developmentally appropriate learning experiences and confidence in integrating computational thinking into classroom activities because they often perceive it as synonymous with programming or digital technology (Bers et al., 2022). Second, learning activities designed to foster computational thinking remain predominantly technology-oriented, relying on robotics or coding applications that are often inaccessible for schools with limited technological resources (Martins et al., 2023). Third, opportunities for children to engage in authentic problem-solving experiences that naturally develop decomposition, abstraction, pattern recognition, and algorithmic thinking are still relatively limited, as classroom instruction frequently emphasizes academic readiness rather than inquiry-based exploration (Paraskevopoulou-Kollia et al., 2025). Finally, although unplugged approaches have demonstrated promising outcomes, empirical evidence regarding learning models that systematically integrate computational thinking into children's everyday experiences remains scarce, particularly within early childhood education settings in developing countries (Rehder et al., 2024).

A growing body of research suggests that young children's computational thinking can be fostered through hands-on, meaningful, and play-oriented learning experiences, without requiring the use of digital devices or technology. This approach is considered more suitable for the learning characteristics of young children, which rely on direct experiences, environmental exploration, and manipulation of real objects in building understanding (Paraskevopoulou-Kollia et al., 2025). Research on unplugged learning shows that non-digital activities can provide effective learning experiences in developing basic computational thinking concepts in early childhood. Simple activities such as following step-by-step instructions help children understand algorithm concepts and correct errors through the debugging process that naturally occurs during the activity (Lee & Junoh, 2019). These findings are reinforced by research showing that non-digital activities based on real experiences, such as arranging procedural sequences and solving simple problems, can develop decomposition and abstraction skills in early childhood if supported with appropriate scaffolding from teachers (Rehder et al., 2024). In addition, unplugged activities are considered easily accessible and suitable for children's developmental needs because they can foster the ability to recognize patterns, understand sequences, and think logically through play and the use of concrete objects without dependence on digital devices (Ballard & Haroldson, 2022). These various findings indicate that the development of computational thinking through concrete experiences is an effective pedagogical approach to be applied in early childhood education (Ballard & Haroldson, 2022; Rehder et al., 2024).

Against this backdrop, nature-based learning offers a promising educational approach for fostering computational thinking in young children. By engaging children directly with natural environments, this approach creates opportunities to observe phenomena, identify patterns, explore relationships, and work through problems using concrete and meaningful experiences. Such learning experiences can provide a context in which computational thinking skills are developed naturally through exploration, inquiry, and problem-solving rather than through technology-based activities alone in early childhood because it positions nature as the main learning resource, rich in authentic and multisensory experiences (Nopiana, 2025). Through exploration of the natural environment, children gain opportunities to perform observation, investigation, experimentation, and problem-solving that naturally arise during the learning process. Various studies show that the natural context can serve as a powerful medium in stimulating the development of components of computational thinking in early childhood. Nature care play activities designed using the principles of computational thinking have been proven to facilitate children in identifying problems, recognizing patterns, simplifying information, and arranging problem-solving steps systematically (Alé & Rodríguez-Donoso, 2026).

Other research shows that the characteristics of nature play naturally can trigger the processes of pattern recognition, decomposition, and sequencing of steps, which are main components of computational thinking (Om et al., 2023). In addition, guided play activities with a nature theme through forest school programs have has been found to strengthen children's ability to organize sequences and develop solutions to problems through direct interaction with various natural elements available in the learning environment (Critten et al., 2025). These findings show that learning experiences in nature not only support general cognitive development but also provide significant opportunities to develop computational thinking skills from an early age.

Nature based learning supporting Introducing computational thinking at an early age is particularly relevant because its principles can be incorporated into learning experiences that correspond to how young children naturally learn and develop. When presented through age-appropriate activities, computational thinking can be integrated into children's everyday experiences, allowing them to develop systematic ways of thinking through exploration, play, and problem-solving which learn through concrete experiences and direct interaction with their surroundings (Wilson, 2008). Nature provides various stimuli that are difficult to find in the classroom, such as variations in texture, shape, pattern, natural phenomena, and living materials that can stimulate curiosity, observation skills, and problem-solving abilities in children. When children interact with the natural environment, they naturally engage in observation, classification, pattern recognition, information simplification, and action strategy formulation, which align with the main components of computational thinking (Om et al., 2023). Nature based learning has the potential to be an effective means of integrating the development of computational thinking skills with the learning needs of early childhood, which are active, explorative, and contextual.

Nevertheless, literature reviews indicate that research on computational thinking in preschool-aged children is still dominated by the use of robotics, digital applications, programming, and various computer-based technologies implemented in classroom settings (Martins et al., 2023). Research that specifically explores nature based learning experiences as a medium for developing computational thinking is still relatively limited, leaving a significant area for further investigation. This gap is also evident in the Indonesian context, where research on nature based learninggenerally focuses more on the development of creativity, early science skills, or children's social skills rather than the specific development of computational thinking (Amiliya & Aminah, 2020; Sunanik, 2018). As a result, there is still a limited amount of empirical evidence regarding how a nature based learning model can be designed and implemented systematically to develop the core components of computational thinking in early childhood in Indonesia.

Based on these conditions, research on the influence of the nature based learning model on computational thinking in early childhood is important to conduct because it seeks to fill existing research gaps both at the international and national levels. This study is expected to provide theoretical contributions in broadening the study of the integration of computational thinking and nature based learningin early childhood education, as well as provide practical contributions in the form of an alternative learning model that is contextual, meaningful, and in accordance with child development characteristics. Through this research, it is hoped that empirical evidence will be obtained regarding the effectiveness of nature based learning in developing computational thinking in early childhood, so that it can become one of the alternative learning strategies that support the development of 21st-century competencies in a more meaningful and contextual manner.

2. METHODS

The statistical treatment of the data was carried out in two stages. The first stage involved descriptive analysis, which was intended to provide an overall picture of the children's computational thinking performance in each group. The analysis included the mean, minimum and maximum values, standard deviation, and variance of the scores obtained during the assessment. The second stage involved inferential procedures to determine whether the learning intervention resulted in meaningful changes and whether the improvement observed in the experimental group differed from that of the control group.

Before selecting the appropriate inferential procedures, the distribution of the data was examined using the Shapiro–Wilk normality test. The results indicated that the data did not satisfy the assumption of normality. Therefore, non-parametric statistical procedures were applied. The Wilcoxon Signed-Rank Test was used to examine changes in computational thinking scores within each group by comparing the results obtained before and after the learning process. This test was appropriate because the measurements were obtained from the same participants at two different points in time. In addition, the Mann–Whitney U Test was applied to compare the gain scores between the experimental and control groups. The gain score represented the change in children's computational thinking performance from the pre-test to the post-test. This analysis was conducted to determine whether the improvement achieved by children who experienced Nature Based Learning was significantly different from the improvement observed among children in the comparison group. Statistical significance was evaluated using an alpha level of 0.05.

The implementation of the study followed a sequential procedure beginning with the identification of the children's initial abilities. Preliminary observations were first conducted to obtain information regarding the children's existing computational thinking skills and to establish the suitability of the participants for inclusion in the study. Following this stage, the pre-test was administered to children in both groups using the same performance-based assessment. The pre-test results served as baseline information for describing the children's computational thinking abilities prior to the intervention.

The intervention was subsequently implemented with the two groups receiving different learning experiences. Children assigned to the experimental group participated in activities organized according to the Nature Based Learning model. The learning process involved direct interaction with the natural environment and provided opportunities for children to observe, explore, investigate, represent their findings, discuss their experiences, and reflect on the activities undertaken. These activities were designed to create meaningful situations in which children could practice decomposition, pattern recognition, abstraction, and algorithmic thinking through concrete experiences. Meanwhile, the control group continued to participate in the learning activities ordinarily provided by the classroom teacher.

After the intervention had been completed, a post-test was administered to both groups using the same assessment framework. The post-test results were then compared with the corresponding pre-test scores to determine changes in children's computational thinking performance. The resulting scores were processed to obtain gain scores, which were subsequently examined using the appropriate non-parametric statistical procedures. Through the comparison of changes within and between groups, the analysis was intended to determine whether the implementation of Nature Based Learning contributed to a significant improvement in computational thinking among children aged five to six years.

The entire research process can therefore be summarized into four principal phases, as presented in Figure 1. The first phase consisted of participant identification and preliminary observation. The second phase involved the administration of the pre-test to establish the children's initial computational thinking performance. The third phase comprised the learning intervention, with Nature Based Learning implemented in the experimental group and the existing classroom learning approach maintained in the control group. The final phase consisted of post-test administration, data processing, and statistical analysis. The findings obtained from these stages provided the basis for evaluating the extent to which Nature Based Learning influenced the development of computational thinking in early childhood.

Figure 1. Research Flow

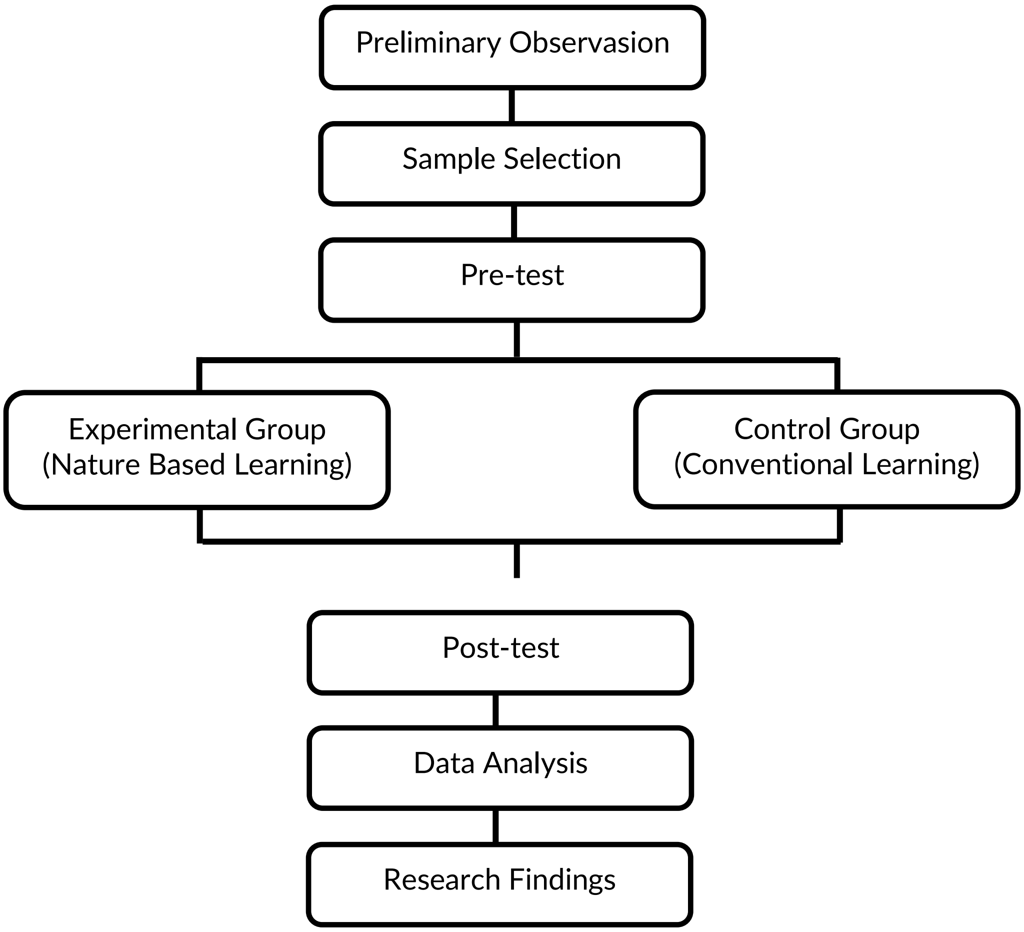

Figure 1 illustrates the sequence of the research procedures, beginning with participant selection and pre-test administration, followed by the intervention, post-test, and data analysis.

3. RESULT AND INTERPRETATION

The analysis focused on 16 children who participated in the experimental group. An initial descriptive analysis was conducted to illustrate changes in their computational thinking performance across the pre-intervention and post-intervention assessments. The Wilcoxon Signed-Rank Test was subsequently applied to establish whether the difference between the two sets of scores reached statistical significance.

Table 1. Results of the analysis of the influence of the nature based learning model on computational thinking

Descriptive Statistics						
	N	Minimum	Maximum	Mean	Std. Deviation	Variance
Experimental Pre-test	16	28	36	31.31	2.414	5.829
Experimental Post-test Eksperimen	16	36	44	40.25	2.769	7.667
Valid N (listwise)	16					

Before the implementation of the intervention, the experimental group demonstrated an average computational thinking score of 31.31, accompanied by a standard deviation of 2.414. Individual scores varied from 28 to 36, indicating some differences in the children's initial performance. Overall, these findings suggest that the participants entered the study with computational thinking abilities that were still developing and could be classified within the moderate level. After participating in the Nature Based Learning activities, the post-test scores increased substantially, ranging from 36 to 44, with a mean score of 40.25 (SD = 2.769). The average score increased by 8.94 points, while both the minimum and maximum scores also increased. These findings indicate that nearly all children experienced improvement in computational thinking after participating in the learning activities. Overall, the descriptive statistics presented in Table 1 indicate a positive shift in children's computational thinking performance following the implementation of the Nature Based Learning model.

Table 2. *Wilcoxon Signed Ranks Test*

Test Statistics[a]	
	Post-test Eksperimen - *Pre-test* Eksperimen
Z	-3.563[b]
Asymp. Sig. (2-tailed)	.007
a. Wilcoxon Signed Ranks Test	
b. Based on negative ranks.	

The statistical analysis presented in Table 2 demonstrates a significant difference between the children's computational thinking performance before and after the intervention. The Wilcoxon Signed-Rank Test produced an Asymp. Sig. (2-tailed) value of 0.007. Since this probability value falls below the predetermined significance threshold of 0.05, the null hypothesis (H_0) was rejected, while the alternative hypothesis (H_1) was supported. The result therefore provides statistical evidence that participation in the Nature Based Learning model was associated with a significant improvement in the computational thinking abilities of children aged 5–6 years.

The observed improvement can be understood from the perspective of Experiential Learning Theory developed by Kolb (2014). From this perspective, learning does not occur merely through the acquisition of information but develops as learners construct knowledge by processing and transforming their experiences. Kolb describes this process as a cyclical sequence involving four interconnected modes: concrete experience, reflective observation, abstract conceptualization, and active experimentation. In the context of Nature Based Learning, children's direct engagement with natural environments can provide the concrete experiences from which they observe, reflect, develop understanding, and subsequently test ideas through further actions. In this study, Nature Based Learning provided authentic experiences by allowing children to interact directly with natural environments through exploration, observation, experimentation, and problem-solving activities. Rather than receiving information passively, children actively constructed knowledge from their experiences, reflected on what they observed, formulated new understandings, and applied these understandings when completing subsequent learning tasks. Consequently, the learning process became more meaningful and encouraged deeper cognitive engagement.

Nature Based Learning reflects the principles of experiential learning because it positions the natural environment as a rich source of authentic learning experiences. During the intervention, children explored leaves, flowers, stones, twigs, and other natural materials, compared their characteristics, discussed their observations with peers, and tested different strategies to complete contextual tasks. The learning process can be interpreted through Kolb's experiential framework, in which understanding develops through an ongoing interaction between doing, reflecting, conceptualizing, and trying out ideas in subsequent situations. Within this process, children are given opportunities to derive meaning from their own experiences and encounters with the surrounding environment, rather than depending primarily on information transmitted by the teacher. This perspective is also in line with constructivist views of learning, which regard children as active participants in the formation of knowledge as they engage directly with their environment and make sense of what they experience. Likewise, Pamungkas and Sunarti (2018) explained that experiential learning encourages learners to acquire knowledge through direct experience, reflection, conceptualization, and active application. Similarly, Suryaningsih (2024) emphasized that experiential learning creates meaningful learning experiences capable of promoting higher-order thinking and other twenty-first-century competencies in early childhood.

As children engaged repeatedly in these experience-based activities, their ability to apply the fundamental processes of computational thinking became increasingly evident. In accordance with Wing's (2006) framework, these processes encompass breaking problems into manageable parts, recognizing patterns, identifying essential information, and organizing logical steps for reaching solutions, represented by the four core dimensions of decomposition, pattern recognition, abstraction, and algorithmic thinking. Wing emphasized that computational thinking should be understood as a systematic approach to problem-solving rather than merely learning computer programming. Therefore, computational thinking can be developed through meaningful learning experiences without depending on digital technology.

The decomposition component developed when children divided complex environmental tasks into smaller and more manageable steps before completing activities. For example, children first identified the natural materials required, determined the order of activities, and completed each stage systematically. These learning experiences represent concrete experience within Kolb's experiential learning cycle because children directly interacted with real objects before organizing their ideas into structured problem-solving strategies. The pattern recognition component emerged when children compared similarities and differences among natural objects, including leaves, flowers, stones, and twigs based on their colours, shapes, sizes, and textures. During the reflective observation stage, children analyzed their experiences, recognized recurring characteristics, and identified relationships among objects. This reflective process enabled children to recognize patterns that could later be applied when solving similar problems in different situations (Kolb, 2014).

The abstraction component was strengthened when children selected relevant information while ignoring less important details encountered during exploration. As children repeatedly observed various natural phenomena, they learned to focus on essential characteristics needed to complete a task successfully. This process reflects abstract conceptualization, during which concrete experiences are transformed into broader concepts that support logical reasoning and decision-making. The algorithmic thinking component developed when children organized logical sequences of actions while completing exploration activities (Kolb, 2014). For example, children determined the correct order for collecting natural materials, arranging objects according to specific criteria, and solving contextual problems through sequential steps. These activities represent active experimentation, in which newly constructed concepts are applied to different situations. Bers et al. (2022) emphasize that computational thinking in the early years can emerge through meaningful play in which children engage with fundamental ideas such as ordering actions, reasoning logically, and working out solutions to problems. These processes allow computational thinking to develop as part of children's natural learning experiences rather than as a skill taught exclusively through formal programming activities. Therefore, the algorithmic thinking observed in this study demonstrates that computational thinking can develop through authentic environmental exploration without requiring computer programming activities.

The results observed in the current study correspond with patterns identified across earlier empirical investigations. Bers et al. (2022) reported that computational thinking develops more effectively when children participate in authentic and hands-on learning experiences. Similarly, Su and Yang (2023) found that Nature Based Learning encourages children to investigate real-world phenomena, construct knowledge actively, and develop higher-order thinking through meaningful interaction with natural environments. Furthermore, studies on unplugged computational thinking have demonstrated that computational thinking can be effectively developed without digital technologies because children strengthen logical reasoning, sequencing, pattern recognition, and problem-solving skills through concrete experiences using real objects and meaningful activities (Ballard & Haroldson, 2022; Rehder et al., 2024). These findings reinforce the present study by demonstrating that computational thinking is not limited to digital programming contexts but can also emerge through experiential learning in natural environments.

Taken together, the evidence from this study indicates that Nature Based Learning can serve as a meaningful means of fostering computational thinking during the early years. Its contribution is closely associated with the opportunities it provides for children to learn from direct encounters with their surroundings. These experiences can be understood through Kolb's experiential learning perspective, in which learning develops through experiencing, reflecting on what has been encountered, forming an understanding from those experiences, and applying that understanding in subsequent situations. Within this process, children are given repeated opportunities to break down problems, notice recurring patterns, determine relevant information, and organize actions into logical sequences. These processes correspond to the core dimensions of computational thinking, namely decomposition, pattern recognition, abstraction, and algorithmic thinking. The findings consequently suggest that computational thinking can be incorporated into early childhood learning through meaningful interaction with the natural environment without making digital devices or programming activities the primary medium of instruction.

Several considerations should be taken into account when interpreting these findings. The first concerns the duration of the intervention, which was relatively limited and therefore may not provide sufficient evidence regarding the sustainability of changes in children's computational thinking over an extended period. Another consideration relates to the nature of outdoor learning itself. Activities conducted in natural settings are subject to external conditions, including changes in weather and differences in the availability of suitable natural materials, which can influence how consistently particular learning experiences are implemented. Further research could address these limitations by involving a greater number of participants, extending the duration of the intervention, and conducting studies across different types of early childhood education settings. From a practical perspective, teachers can strengthen the learning process by providing purposeful scaffolding while children explore their surroundings. Guiding questions, prompts to compare and identify patterns, encouragement to arrange actions in a meaningful order, and opportunities to discuss and reflect on experiences may help children make greater use of computational thinking during nature-based activities.

4. CONCLUSION

The evidence obtained from this research indicates that incorporating Nature Based Learning into early childhood instruction can contribute substantially to the development of computational thinking among children between five and six years of age. Direct engagement with the natural surroundings created meaningful opportunities for children to investigate, observe changes, and work through problems using their own actions and ideas. Through these experiences, children were able to practice essential computational thinking processes, including breaking problems into smaller parts, identifying recurring patterns, distinguishing relevant information, and arranging actions in a logical sequence. The findings therefore position Nature Based Learning as a feasible pedagogical alternative for fostering computational thinking within early childhood settings without making technology the central medium of learning. Further research should consider recruiting participants from larger populations, extending the duration of the intervention, and conducting studies across varied educational contexts to determine whether the findings remain applicable across different settings.

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