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Bug safari: promoting ecological awareness in early childhood through nature-based learning

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ABSTRACT

This study examines the effectiveness of a nature-based educational program called bug safari, designed to enhance preschool children's attitudes toward small creatures, particularly bugs, and to foster their ecological awareness. Developed within the framework of the Reggio Emilia approach, the program integrates multi-sensory and interdisciplinary learning methods, including observation, drama, storytelling, art activities, and parental involvement. The study was conducted in two preschool classrooms in Balıkesir, Türkiye. In the experimental group, bug safari activities were implemented once a week for six weeks, while the control group continued with the existing preschool curriculum. Data were collected using the 22-item bug awareness and ecological awareness questionnaire, developed by the researcher, and administered as both a pre-test and post-test. A mixed-design analysis of variance (ANOVA) revealed that the experimental group showed statistically significant improvements in bug awareness, understanding of the role of bugs in the ecosystem, and ecological consciousness, whereas no significant changes were observed in the control group. The findings indicated that nature-based programs involving direct experiences and active participation effectively promoted positive environmental attitudes and ecological awareness in early childhood. This study underscores the importance of integrating child centered, experiential, and nature-oriented approaches into preschool education to support cognitive, emotional, and behavioral development.

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1. INTRODUCTION

Early childhood represents a pivotal developmental phase during which children's understandings of nature and other living organisms expand rapidly, accompanied by accelerated cognitive, emotional, and social growth [1]–[3]. Experiences gained in this period shape ecological awareness, responsibility, and attitudes toward nature through continuous interaction with the environment [4]. Between the ages of 2 and 6, heightened curiosity and exploration tendencies foster the emergence of sustainable behaviors in later years [5]–[7], while environmental awareness established during this stage exerts a lasting influence on ecological consciousness across the lifespan [8], [9]. Early engagement with nature strengthens problem-solving, creativity, and cognitive flexibility [10], [11] and supports scientific reasoning through observation, hypothesis formation, and analytical thinking during outdoor play [12]–[14].

Children who encounter nature frequently tend to develop stronger environmental sensitivity and exhibit more conservation-oriented behaviors in adulthood [15]. Accordingly, educational models that

prioritize nature interaction are of central importance. Grounded in the concept of biophilia, this perspective emphasizes children's innate tendency to form connections with the natural world [16]; positive early nature experiences foster environmental awareness, prosocial tendencies, and emotional development [9], [17]–[19]. Conversely, insufficient exposure to nature-often described as nature deficit disorder is associated with difficulties in attention, motor functioning, stress regulation, and social interaction [9], [10], [20], [21].

Within this framework, the Reggio Emilia approach conceptualizes children as competent, inquisitive learners whose development is enriched through active engagement with their surroundings. Nature functions as a "third teacher," cultivating responsibility and aesthetic sensitivity [16], [22]. Preschool practices such as gardening, nature walks, and outdoor play consequently enhance children's understanding of ecosystems and strengthen their sense of connection to nature [2], [3], [23]. In this context, emphasizing the ecological significance of small organisms-particularly bugs-becomes critically important within environmental education [24].

Bugs contribute fundamentally to ecosystem sustainability by supporting pollination, decomposition, soil health, biological control, and continuity within food webs [25], [26]. These ecosystem services sustain environmental balance and benefit diverse sectors ranging from agriculture to medicine and environmental sciences [27], [28]. Despite this, societal awareness remains limited, and education is widely regarded as the most effective strategy to address this gap [29]. Presently, habitat loss, pesticide use, and climate change threaten bug populations [30], diminishing ecosystem services and undermining agricultural sustainability [31]–[33]. Educating children about these ecological roles therefore represents a strategic pathway to strengthening environmental responsibility and conservation awareness.

Insect-focused educational practices help children recognize the interdependence of living systems [24] and stimulate curiosity through direct observation activities such as gardening and nature walks [10], [12]. Early educational experiences that highlight the ecological functions of bugs contribute to environmental literacy and encourage sustained engagement in conservation-related behaviors [23]. Nevertheless, many children display fear or avoidance toward insects-patterns often shaped by adult modeling and urban lifestyles [34]. Cultural misconceptions and limited knowledge intensify these reactions [9], [34], [35]. Programs incorporating guided observation and reflective learning have been shown to enhance curiosity and positive emotional responses to insects [36], while direct, hands-on interactions foster more favorable attitudes and heightened environmental awareness [34], [35], [37], [38]. As familiarity increases, children's perceptions and attitudes toward insects tend to improve [9].

Accordingly, visual materials, story-based approaches, experiential learning activities, and interactive models can effectively support the development of positive connections with bugs [2], [39]. Activities such as nature walks, bug observations, and museum visits reduce negative perceptions while strengthening environmental awareness [34]–[36], [40]; narratives and animated content further stimulate curiosity and reflective engagement with the natural world [18]. The primary aim of this study is to evaluate the effectiveness of the nature-based program bug safari, designed for preschool children, in shaping their perceptions, attitudes, and behaviors toward bugs. The program offers rich sensory and experiential learning opportunities that cultivate ecological awareness from early childhood and draws inspiration from the child-centered, nature-integrated Reggio Emilia framework. Through this model, children are encouraged to build holistic relationships with living beings and participate actively in meaningful, experience-driven environmental learning, thereby clarifying the contribution of nature-based education to ecological awareness and consciousness in early childhood.

2. METHOD

This study employed a quasi-experimental pretest–posttest control group design to examine the effectiveness of the nature-based bug safari education programmed for preschool children aged 4-6. Grounded in child-centered and nature-integrated principles inspired by the Reggio Emilia approach, the programmed aimed to enhance children's perceptions, attitudes, and behaviors toward small creatures in nature, particularly bugs, through sensory and experiential learning experiences. The intervention was implemented with an experimental group, while a control group followed the regular preschool curriculum. Data were collected before and after the intervention using a researcher-developed instrument measuring environmental awareness and ecological sensitivity, enabling the comparison of changes over time and between groups.

2.1. Development of nature-based learning activities

The bug safari training program, which comprises nature-based learning activities, is designed to allow children to experience nature through their senses and interact directly with bugs. This program fosters awareness, sensitivity, and empathy towards the small creatures that inhabit our environment. It aims to

cultivate scientific observation, creative expression, and problem-solving skills while promoting a culture of living in harmony with nature. The activities are integrated through interdisciplinary methods, including observation, dramatic play, creative writing, drawing, design, and empathy.

The Turkey century education model preschool programmed adopts a multidimensional, nature attuned approach to foster early scientific literacy and holistic development [38]. By prioritizing observation-based predictions and the operational definition of scientific phenomena, the curriculum encourages students to engage with their immediate environment through field trips and outdoor learning centers. These experiential settings-facilitated by initiatives such as butterfly gardens and bug hotels-enable children to differentiate between living and non-living entities while developing scientific inquiry and classification skills.

Beyond scientific competencies, the framework integrates seven core skill domains: Turkish language, mathematics, science, social, movement and health, art, and music. Nature-based activities serve as a cross-curricular vehicle to enhance [41]:

- Cognitive skills: early literacy, scientific data interpretation, and reflective thinking.
- Psychomotor and aesthetic skills: active living and artistic appreciation.
- Social-emotional competencies: self-management, social awareness, and responsible decision-making.

Ultimately, the programmed seeks to cultivate adaptability and cooperation by embedding academic and social-emotional learning within authentic environmental contexts. One of the key components of the bug safari education programmed is family participation. Families are actively engaged in various stages of the process, including nature observations, photo exhibitions, and recycling activities conducted at home, as well as emotionally supportive conversations. This approach ensures that children's nature-based learning extends beyond the school environment and is integrated into their home life, facilitating the translation of this learning into behavior. The involvement of families allows children to strengthen their love for nature within a social context.

Six distinct and complementary nature-based activities have been developed for the bug safari education program. Figure 1 shows the images of the six different and complementary nature-themed activities included in the insect safari training program in. In Figure 1 (a), students explore their surroundings and examine the insects they encounter as part of activity 1 (bug observation adventure). In Figure 1 (b), they design safe spaces for insects using recyclable and natural materials as part of activity 3 (designing a safe space for bugs). In Figure 1 (c), during activity 4: I am a bug (dramatic empathy), children assume the role of a bug character and act out situations they encounter in daily life. These activities, each designed to foster various skills, are scheduled to take place once a week. Detailed plans for the activities, which are briefly described in Table 1.

(a) (b) (c)

Figure 1. Six different and complementary nature-themed activities: (a) photos of bug exhibition, (b) designing a safe space, and (c) bug drama activities

2.1.1. Activity 1: bug observation

Adventure, in this introductory activity, children identify and name the bugs they observe at school, at home, and in their natural environment, and create an observation list of these bugs. The data collected is shared in class and used to create an 'bug exhibition'. This activity enhances children's skills in careful observation, comparison, classification, and fosters their interest in nature.

2.1.2. Activity 2: bug diary

Children place themselves in the position of a bug they have observed and create a diary from the bug's perspective. They employ their creativity in descriptions such as, "*I am a ladybug, I woke up on a leaf this morning...*" By transforming their observational data into personal narratives, they cultivate empathy, enhance their sequential narration abilities, and improve their expressive skills.

2.1.3. Activity 3: designing a safe space for bugs

In this activity, children design bug houses using recycled and natural materials, considering the shelter needs of bugs in their natural habitats. The principles of cooperation, creative problem-solving, and sustainability are central to the design process. The completed bug houses are placed in the school garden to foster a direct connection with nature.

2.1.4. Activity 4: I am a bug (dramatic empathy)

Children assume the role of a bug character of their choice and enact a day in its life. Through dramatic play, they convey the events the bug encounters, the threats it faces, and its needs in the natural environment. Role-playing, facial expressions, body language, and emotional awareness are central to this activity, fostering the natural development of empathy.

2.1.5. Activity 5: living with bugs

In this activity, children identify the guidelines they should adhere to while coexisting with bugs during a nature walk. A poster is created featuring phrases such as "*do not harm bugs*" and "*do not litter in nature*". Awareness of living harmoniously with nature, social responsibility, adherence to rules, and the development of decision-making skills.

2.1.6. Activity 6: the story of nature: my bug is talking

In the final activity of the programmed, each child creates a short story from the perspective of a bug, drawing on their previous experiences. The stories are presented orally or through drawings and are subsequently shared with friends and family. This activity fosters the development of storytelling skills, presentation abilities, ecological awareness, and self-confidence in children. Throughout the programmed, families observe and photograph the bugs they have chosen in nature alongside their children. They engage in a 'silent walk, listening to nature' activity during these nature walks, and an informational letter is sent to the family each week.

2.2. Teacher training

This study involved a total of 40 preschool children drawn from two preschool classrooms in the central districts of Altıeylül and Karesi in Balıkesir, Türkiye, with 20 children assigned to an experimental group and 20 to a control group. To determine the schools and classrooms in which the intervention would be implemented, information about the study was disseminated to official kindergartens affiliated with the Ministry of National Education as well as to private preschool education institutions, and volunteer teachers were identified. Among the applicants, two teachers were selected by the researchers based on predefined criteria, including holding a bachelor's degree in early childhood (preschool) education, having at least 10 years of teaching experience, the suitability of the physical conditions and locations of their schools and classrooms, and the similarity of the students' socio-demographic characteristics. One classroom was designated as the experimental group and received the six-week bug safari program, while the other classroom served as the control group and continued with the existing preschool curriculum. Data were collected using the 22-item bug awareness and ecological awareness questionnaire developed by the researcher. The researchers conducted a teaching demonstration for the educators, outlining the purpose and process of the research, providing teaching materials, and sharing activity plans. After sixteen hours of teacher training, the activity plans were reviewed once more with the educators and finalized.

2.3. Parent training

After the classes in which the training would be implemented were identified, informational meetings were held with the parents of the students. During these meetings, details were provided regarding the purpose of the research and training, the activities to be conducted, and the role of parents in the training process.

2.4. Implementation of the training

One of the two teachers chosen from the pool of volunteer teachers was randomly selected to implement the planned activities, while the other teacher continued to deliver the activities outlined in the Preschool Education Programmed within their class. The implementation occurred during April and May of the 2025 Spring term. The bug safari training programmed was conducted over six sessions, held once a week for six weeks. Each session lasted approximately 40 minutes and incorporated outdoor activities, bug observation, gardening tasks, story-based learning, art, and dramatic play, as seen in Table 1.

Table 1. Bug safari weekly program

Week	Activity name	Thematic focus	Parental involvement
1	Bug observation adventure	Observation, classification, nature awareness	Photography, exhibition
2	The bug's diary	Scientific observation, empathy, sequential narration	Observation walks
3	Designing a safe space for bug	Design, recycling, responsibility	Providing materials
4	I am a bug–dramatic empathy	Role-playing, emotional expression, ecological balance	Costume preparation
5	Living with bugs	Respect for habitats, problem-solving	Information board sharing
6	Nature's story: told by my bug	Experience sharing, creative presentation, social awareness	Presentation day, board exhibition

Throughout this process, children were encouraged to engage directly with nature and observe bugs in their natural habitats [10], [42]. The control group did not receive any nature-based education during this process; only activities and lessons from the existing preschool education programmed were continued. This situation was regarded as an important control variable to isolate the educational impact [43].

2.5. Questionnaire preparation

The bug awareness and ecological awareness questionnaire was developed to measure the impact of the bug safari activity on children's awareness of bugs, their knowledge of the roles bugs play in nature, their attitudes towards bugs, and their level of ecological awareness. During the development of the test, scientific measurement tools aimed at fostering environmental awareness in early childhood were employed as a foundation. In this context, while ensuring the content validity of the test, findings from nature education and ecological awareness scales in the literature were taken into account [9], [44].

The questionnaire serves as a comprehensive assessment tool designed to evaluate several dimensions of children's understanding and attitudes toward bugs. Specifically, it measures children's ability to recognize various bug species and differentiate their characteristics, assesses their awareness of the ecological roles bugs play, gauges their attitudes toward bugs, and evaluates the effectiveness of educational interventions aimed at fostering environmental awareness during early childhood. The development of the test content was grounded in scholarly literature from the fields of child development, environmental education, and entomology [6], [45]. Furthermore, scientific studies on the ecological functions of bugs [23], [46] provided a robust scientific foundation for the test. These studies emphasize the importance of bugs in agricultural productivity, soil health, and their vital role as pollinators, all of which informed the construction of test items [25], [46], [47]. Additionally, the assessment takes into account children's attitudes toward bugs and the cognitive implications of these attitudes, drawing upon findings from environmental psychology and child development literature [8], [10]. Empirical evidence suggests that sensory engagement with nature and direct interaction with bugs are critical components in fostering ecological awareness in children [10], [16].

The questionnaire was developed using the "children's connection to nature scale" created by Cheng and Monroe [12], and environmental education models established by Palmer [6]. Additionally, items pertaining to ecological awareness were incorporated based on the 'environmental attitudes and behaviors scale' [42], as shown in Table 2. Once the items were finalized, feedback was solicited from experts in environmental education and early childhood development researchers to ensure content validity. A pilot test was conducted with a small group of students (n=40), leading to the development of the final version of the questionnaire. The overall reliability of this 22-item awareness and eco consciousness questionnaire was α=0.722 (factors; bug awareness=0.705, the role of bugs in the ecosystem=0.745, ecological consciousness and attitude=0.737) and ω=0.715 (factors; bug awareness=0.689, the role of bugs in the ecosystem=0.736, ecological consciousness and attitude=0.729) with α and ω>0.7 considered acceptable [48], [49]. The questionnaire was administered individually to the children as both a pre-test and a post-test before and after the learning activities. Given the preschool age of the participants, the children did not complete the questionnaire independently; instead, data were collected through one-on-one, structured interviews conducted by the researcher.

During each interview, the items were read aloud in a clear and age-appropriate manner, and a visual response system was used to facilitate children's understanding and engagement. Each response option was represented by a colored circle: green for "yes", red for "no", and yellow for "I do not know". After each item was presented, the child indicated their response by pointing to the corresponding-colored circle, and the researcher recorded the response on the questionnaire form. Prior to data collection, children were briefly familiarized with the color-response matching to ensure comprehension. The interviews were conducted in familiar classroom settings or designated play areas to ensure that the children felt comfortable and safe, and each interview lasted approximately 10 to 15 minutes, taking into account the children's developmental characteristics and attention spans. This standardized interview-based procedure was applied consistently across both the experimental and control groups during the pre-test and post-test phases.

Table 2. Bug safari questionnaire items

Items	Category	Source
1. Bees help flowers to grow.	Bug awareness	Cheng and Monroe [12]–*connectedness to nature* (emotional bond, enjoyment in nature)
2. Ants aerate the soil.		Palmer [6] and partially *environmental consciousness scale* (ecological knowledge, environmental education content)
3. Butterflies have different colors and patterns.		Palmer [6] (ecological knowledge)
4. I am not afraid when I see bugs.		Palmer [6] and partially Cheng and Monroe [12] (ecological knowledge, interest in nature/aesthetic awareness)
5. We should not hurt bugs.		Cheng and Monroe [12] (positive emotional attitude towards nature)
6. Bugs need nature to live.		Kaiser *et al.* [42] and *environmental consciousness scale* (environmental protection behavior, attitude)
7. Are bugs bad? (R)		Palmer [6] and *environmental consciousness scale* (ecological knowledge, environmental awareness)
8. Bugs help plants to grow.	The role of bugs in the ecosystem	Cheng and Monroe [12] and Kaiser *et al.* [42] (reverse-scored item measuring negative attitudes; ecological attitude)
9. Bugs are food for some animals.		Palmer [6] (ecological knowledge)
10. Earthworms live in the soil and help it.		Palmer [6] (ecological knowledge, food chain awareness)
11. Mosquitoes are food for some birds and frogs.		Palmer [6] (ecological knowledge)
12. Some animals cannot live without bugs.		Palmer [6] (ecological knowledge, food chain)
13. Bees and butterflies help fruits and vegetables grow.		Palmer [6] and *environmental consciousness scale* (ecological knowledge, environmental awareness)
14. Nature needs bugs to be happy.		Palmer [6] and *environmental consciousness scale* (ecological knowledge, ecosystem functioning)
15. If bugs are gone, nature is not happy.		Palmer [6] and *environmental consciousness scale* (ecological knowledge, environmental awareness)
16. We must take care of bug homes.	Ecological consciousness and attitude	Palmer [6] and *environmental consciousness scale* (ecological knowledge, importance of ecological balance)
17. Do not pick flowers with bugs.		Kaiser *et al.* [42] and *environmental consciousness scale* (environmental protection behavior)
18. Do not hurt bee homes.		Kaiser *et al.* [42] and *environmental consciousness scale* (environmental protection behavior)
19. Let's learn about bugs to help nature.		Kaiser *et al.* [42] and *environmental consciousness scale* (environmental protection behavior)
20. When we see bugs, we must be kind.		Palmer [6] and *environmental consciousness scale* (ecological knowledge, environmental awareness)
21. Bugs are not scary.		Kaiser *et al.* [42] and *environmental consciousness scale* (environmental protection behavior, attitude)
22. Nature needs bugs to stay clean and healthy.		Cheng and Monroe [12] (positive perception of nature, connectedness to nature)

2.6. Analyze

A 22-item environmental awareness questionnaire was administered to 40 students (experimental: n=20; control: n=20) using a pre-test/post-test design. Preliminary analyses confirmed that all variables satisfied the assumptions of normality and homogeneity of variances. To evaluate the intervention's efficacy, a 2x2 (group x time) mixed-design analysis of variance (ANOVA) (split-plot ANOVA) was performed to analyze within-subjects, between-subjects, and interaction effects. Statistically significant main effects for time were further scrutinized using Bonferroni-adjusted pairwise comparisons, while significant interaction effects were explored via follow-up simple effects analyses. All computations were conducted using IBM SPSS statistics 25.0.

2.7. Ethical principles

Ethical committee approval was obtained prior to conducting the research, and the study was carried out in accordance with the permissions granted by the relevant educational institutions (E-19928322-050.04-516876). Additionally, written consent forms were secured from the parents of the children for voluntary participation. Throughout the entire process, actions were taken in accordance with children's rights, ethical principles, and the responsibilities of the researchers [50].

3. RESULTS

3.1. Descriptive statistics

Descriptive statistics for pre-test and post-test scores by group are presented in Table 3. At baseline, both groups demonstrated equivalence in total scores (experimental M=13.30; control M=13.20). Post-intervention, the experimental group showed a substantial increase in total mean scores (M=20.90),

whereas the control group remained nearly stable (M=13.40). This pattern was consistent across all sub-domains: bug awareness, ecological roles, and consciousness. Notably, while the control group showed no growth in "role in ecosystem" or "eco-consciousness," the experimental group achieved significant gains, suggesting the intervention effectively improved participants' knowledge and attitudes.

Table 3. Descriptive statistics for pre-test and post-test scores by group

Measurement	Experimental M (SD)	Control M (SD)
Pre-test	13.30 (0.20)	13.20 (0.20)
Post-test	20.90 (0.06)	13.40 (0.18)
Pre-bug awareness	3.50 (0.21)	4.20 (0.26)
Pre-the role of bugs in the ecosystem	5.25 (0.23)	5.25(0.21)
Pre-ecological consciousness and attitude	4.55 (0.23)	3.75 (0.26)
Post-bug awareness	6.00 (0.25)	4.40 (0.25)
Post-the role of bugs in the ecosystem	7.95 (0.05)	5.25 (0.21)
Post-ecological consciousness and attitude	6.95 (0.05)	3.75 (0.26)

3.2. Multivariate analysis

A significant main effect of time was found, $F(1, 38)=1050.87$, $p<0.001$, partial $\eta^2=0.965$, indicating a large overall improvement in scores across time. A significant time × group interaction was also observed, $F(1, 38)=945.86$, $p<0.001$, partial $\eta^2=0.961$, suggesting that the magnitude of change differed significantly between groups. Specifically, the experimental group exhibited a greater increase in performance over time than the control group. Additionally, a significant main effect of group was detected, $F(1, 38)=313.55$, $p<0.001$, partial $\eta^2=0.892$, indicating that overall performance differed between the two groups across both time points.

3.3. Pairwise comparisons

Pairwise comparisons with Bonferroni correction revealed that the difference in post-test scores between the experimental and control groups was statistically significant, $p<0.001$, with the experimental group outperforming the control group by an average of 3.80 points (95% CI [3.37, 4.23]). No significant difference was found at pre-test. Estimated marginal means indicated that the control group's performance remained relatively stable from pre-test (M=13.20) to post-test (M=13.40), whereas the experimental group showed a notable improvement from M=13.30 to M=20.90, as shown in Figure 2.

The results indicated a strong and statistically significant effect of the intervention. Participants in the experimental group demonstrated substantial gains from pre-test to post-test, while the control group did not. The large effect sizes (partial $\eta^2>0.89$) highlight the practical significance of the findings in addition to their statistical significance.

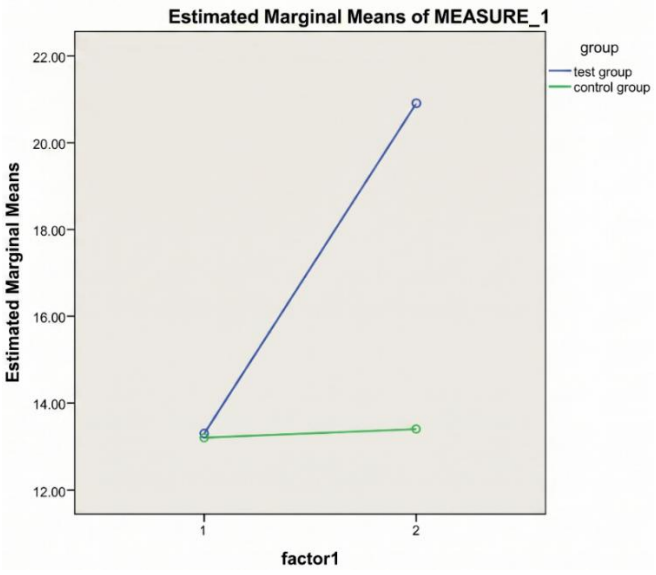

Figure 2. Estimated marginal means by group and time point

4. DISCUSSION

This study examined the effect of a nature-based environmental education programmed called bug safari, which was developed based on the Reggio Emilia approach, on the attitudes of children aged 4 to 6 towards bugs and their level of ecological awareness. The programmed includes direct nature experiences, discovery-based learning, child-centered activities, and structured applications that engage multiple senses. The results of the study indicated that environmental education programmed with these characteristics positively influence young children's connection with the environment in both cognitive and emotional terms.

The findings indicated that for environmental education to be effective, experiential learning environments that allow children to interact directly with nature are essential. At the conclusion of the study, the children in the experimental group exhibited more positive attitudes towards bugs and demonstrated a significant increase in their levels of ecological awareness, whereas no notable change was observed in the control group. This result illustrates that knowledge-based environmental education alone is inadequate, and that programmers which enable children to establish direct relationships with the environment, actively participate, and engage with nature in a meaningful context are more effective [35], [43], [51].

The Reggio Emilia approach is a pedagogical framework that positions the child as an active participant, fostering their curiosity and desire to explore while providing opportunities for multiple modes of expression, often referred to as the "hundred languages of children" [2]. The bug safari programmed, which is integrated with this philosophy, not only supplied children with information but also created a learning environment where they could form emotional connections and construct their own meanings. The children's direct observations of bugs in their natural habitats enabled them to comprehend the biological and ecological roles of these creatures, which, in turn, helped them develop empathy and recognize nature as a valuable system that requires protection.

These findings also support Louv's concept of 'nature deficit disorder' [10]. Louv argues that modern life distances children from nature, which negatively impacts their physical, emotional, and social development. The observation that children who participated in a learning process integrated with nature in the study have strengthened their connection with the environment aligns with this perspective.

In addition, the perception of bugs as 'unwanted' or 'dangerous' creatures within society can lead children to develop negative attitudes towards them. However, this study demonstrates that a structured nature-based programmed can effectively transform such prejudices. Some children in the experimental group identified with the bugs, formed emotional bonds with them by naming them, and gained a better understanding of their roles in nature. This supports the findings of Cutter-Mackenzie and Edwards [14], which indicate that the play-based, holistic, and multi-sensory approach of environmental education contributes to enduring learning.

Findings from the study indicated that children in the control group, who did not receive any form of environmental education, either maintained or reinforced their negative attitudes toward bugs. This outcome underscores the notion that children's environmental attitudes are shaped not solely through cognitive learning, but also through direct experiences and emotionally positive interactions with nature [24], [43]. Accordingly, it is imperative that environmental education begins at an early age and is integrated holistically with children's social, emotional, and moral development [52].

As highlighted by Vecchi [53], sustaining meaningful learning requires more than the transmission of environmental concepts. It necessitates the integration of these concepts with aesthetic sensitivity, ethical awareness, and empathetic engagement. The bug safari programmed exemplified such a multidimensional approach, enabling children not only to acquire knowledge about nature but also to cultivate a sense of care and responsibility toward the environment.

This study underscores the necessity of integrating nature-based, experiential learning into early childhood education to foster early ecological and emotional connections. Findings suggest that practitioners should facilitate outdoor sensory exploration while curriculum developers adopt interdisciplinary frameworks that embed environmental education across science, arts, and ethics. A critical pedagogical shift is also required to reframe negative perceptions of "non-charismatic" species, such as insects, through storytelling and play-based inquiry. By positioning children as active agents-consistent with the Reggio Emilia approach-educators can effectively deconstruct environmental prejudices and promote holistic development.

At the systemic level, policy interventions must support the institutionalization of these practices by allocating funding for infrastructure, such as outdoor learning spaces and eco-gardens, and by providing professional development that transitions teacher training from knowledge-transmission models to experiential facilitation. Furthermore, mitigating "nature deficit disorder" [26], [54] requires fostering partnerships with families and communities to ensure continuity between classroom experiences and a child's broader environmental interactions. Finally, curriculum frameworks and policy initiatives should adopt comprehensive evaluation measures that assess shifts in empathy, attitudes, and pro-environmental behaviors alongside traditional cognitive outcomes to cultivate an ecologically conscious generation.

5. CONCLUSION

This study demonstrates that environmental education practices rooted in nature-based, child-centered, and experiential learning principles are highly effective in promoting ecological awareness and fostering positive environmental attitudes in early childhood. The findings suggest that environmental education should prioritize direct, experience-based engagement, encouraging children's sensory exploration of nature and nurturing an emotional bond with the natural world. Such programmers are crucial in supporting the development of environmentally responsible individuals by contributing not only to cognitive growth but also to emotional and behavioral development.

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AUTHOR CONTRIBUTIONS STATEMENT

This journal uses the Contributor Roles Taxonomy (CRediT) to recognize individual author contributions, reduce authorship disputes, and facilitate collaboration.

Name of Author	C	M	So	Va	Fo	I	R	D	O	E	Vi	Su	P	Fu
Kazım Biber	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓		
Caner Börekci		✓	✓	✓	✓	✓		✓	✓	✓	✓			

C : **C**onceptualization
M : **M**ethodology
So : **So**ftware
Va : **Va**lidation
Fo : **Fo**rmal analysis
I : **I**nvestigation
R : **R**esources
D : **D**ata Curation
O : Writing - **O**riginal Draft
E : Writing - Review & **E**diting
Vi : **Vi**sualization
Su : **Su**pervision
P : **P**roject administration
Fu : **Fu**nding acquisition

CONFLICT OF INTEREST STATEMENT

Authors state no conflict of interest.

INFORMED CONSENT

We have obtained informed consent from all individuals included in this study.

ETHICAL APPROVAL

This study was conducted in Balıkesir, Türkiye. This study has been approved by the Balıkesir University Institute of Social Sciences Ethics Committee (Date: May 12, 2025; Decision No: E- 516876)

DATA AVAILABILITY

The data that support the findings of this study are available from the corresponding author, [KB], upon reasonable request.

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