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The Role of Nature Observations in the Discovery-Based Learning of Biology Concepts: The Case of Forest*

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ABSTRACT

The aim of this study is to examine how secondary school students develop knowledge of the concept of "forest" through guided discovery-based nature observation activities, and to evaluate the applicability of this method in teaching. Participants were 25 tenth-grade students who defined the forest one week before the nature observation (T1) and then engaged in two four-hour observation sessions (T2 and T3) in the forest of Hacettepe University's Beytepe Campus. No prior information about forests was provided; instead, students were asked to record observations in nature that could inform their definitions. Data were analyzed through content analysis with MAXQDA, and codes were compared across the three stages. According to results, the number of codes, words, and characters in T3 increased significantly compared to T1 and T2 ($p < 0.01$). The findings revealed a clear development in perceptions of the forest from T1 to T3. Students' statements mainly reflected general natural elements (tree, conservation) and emotional - perceptual expressions (quiet, dark) at T1. After the second stage (T2), attention shifted to direct observations, including concrete components (trunk, branch, root, leaf, mushroom, ant) and detailed descriptions. These observations were integrated with system-level ecological terms such as "ecosystem," "biodiversity," "water cycle," "carbon," and "environmental balance" at T3. Moreover, expressions related to human impact and environmental ethics - such as "human impact," "logging," "fire," and "economic importance"- became prominent at T3. This developmental trajectory demonstrates that nature observation supported with guided discovery learning initially activates emotional and perceptual awareness, strengthens observational skills during the process, and ultimately contributes to the internalization of abstract forest and related concepts. Importantly, the study also highlights the potential applicability of this approach in formal school settings, particularly within biology curricula, to foster both conceptual understanding and environmental awareness.

Keywords: Conceptual development, biodiversity, outdoor activities, environmental education, environmental sustainability

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1. INTRODUCTION

Biology has emerged as one of the fundamental scientific fields in which the fastest and most intense scientific developments occurred in the 20th and 21st centuries (CNB, 2009). Advances in subdisciplines such as molecular biology, genetic engineering, biotechnology, evolutionary biology, and ecology have transformed biology from being merely a science of studying living organisms into an interdisciplinary field that contributes solutions to many areas, including environmental sustainability, health, artificial intelligence, and agriculture (Das et al., 2023; Arora and Fatima, 2024). In addition to this, some scientists and philosophers have described the 21st century as the "century of biology" (Mayr, 1997; Wilson, 1998). This explosion of knowledge in biology, together with the increasing conceptual density and interdisciplinary nature, has made the content of curricula progressively more complex (Black, 2020; Rodríguez-Muñoz & Huincahue, 2024). Such complexity has posed challenges both for teachers to present the content effectively and for students to make sense of fundamental concepts and related topics (Miller and Yoon, 2023). In response to these difficulties, in the 2010s curricula were restructured based on Constructivist Learning Theory, and more recently on Competency-based Learning Theory (McAteer, Roche & Kelly, 2023). Within biology curricula designed under Competency-based Learning Theory, the primary goal has been set as enabling students to understand core concepts, while technical details are intended to be acquired through practice-oriented activities such as projects, observations, and experimental studies (MEB, 2018; 2024). In this way, students are expected to achieve

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meaningful learning, relate knowledge to daily life, and develop scientific process skills (MEB, 2018; 2024). This approach has also paved the way for the frequent use of active learning strategies in biology education—such as STEM-based instruction, outdoor activities, field trips, environmental education, nature observation, and laboratory work—that enrich the teaching process while contributing to students' scientific thinking, problem-solving, and creative thinking skills (Kelley & Knowles, 2016). Research indicates that these supportive instructional strategies significantly enhance student learning (Behrendt & Franklin, 2014; Freeman et al., 2014).

1.1. Discovery Learning

The discovery learning strategy has a flexible and applicable structure that can be easily integrated with all teaching methods (Karan, 2023). According to Bruner (1961), discovery learning is a process in which students actively construct knowledge through activities such as problem solving, hypothesizing, and conducting research, rather than receiving information directly. In this process, students contribute to learning, experience meaningful learning, and acquire the ability to transfer the knowledge they gain to new situations (Honomichl & Chen, 2012). For example, Wilke and Straits (2001) demonstrated that four discovery-based activities implemented in an undergraduate biology course positively influenced students' achievement and attitudes. Students reported that through this method, they experienced deep learning and acquired scientific skills. Wilke and Straits (2001) suggest that a limited number of discovery learning activities, when combined with traditional instruction, constitute an effective strategy. In another study, Noviyanti, Rusdi, and Ristanto (2019) examined the effects of internet-based and textbook-based guided discovery learning approaches on students' critical thinking skills with different levels of self-concept. The results revealed that both the discovery learning method and self-concept had significant effects on critical thinking, but there was no interaction between the two variables (Noviyanti, Rusdi, & Ristanto, 2019). In his comprehensive review on discovery-based teaching, Mayer (2004) questioned the effectiveness of pure discovery learning methods, which are often associated with constructivist approaches. Mayer (2004) reviewed research in areas such as problem-solving rules, conservation strategies, and programming concepts, showing that pure discovery learning is insufficient in terms of student learning and transfer skills. Therefore, it is emphasized that the guided discovery approach is a more effective method in supporting meaningful learning (Mayer, 2004). Mayer's (2004) findings are further supported by the comprehensive meta-analysis of Alfieri et al. (2011), which included 164 studies examining the effects of discovery-based teaching on learning. The results revealed that guided discovery-based teaching practices significantly increased student achievement, whereas the effects of pure discovery approaches were found to be limited and inconsistent (Alfieri et al., 2011). The study highlights that guided discovery learning can be a strong alternative to traditional methods (Alfieri et al., 2011). In one of the studies conducted in Türkiye, Ünal and Ergin (2006) examined the effects of discovery learning and found that this approach improved students' academic achievement, fostered positive attitudes toward the course, and encouraged a deep learning approach. In another study, Teker, Kurt, and Karamustafaoğlu (2017) investigated the effects of discovery learning on 5th-grade students' academic achievement and attitudes toward science in the topic "Propagation of Light and Sound." Their findings revealed that the method had a significant positive effect on both variables. The study showed that discovery-based activities increased students' participation and interest in the course (Teker, Kurt, & Karamustafaoğlu, 2017). These results support the effective use of constructivist approaches in science teaching and demonstrate that strategies based on active participation make meaningful contributions to the learning process (Teker, Kurt, & Karamustafaoğlu, 2017; Ünal & Ergin, 2006).

1.2. The Forest and Its Concept in the Secondary School Curriculum

Forest ecosystems are of vital importance for the sustainability of a range of fundamental ecological processes, such as the regulation of the carbon cycle, the maintenance of biodiversity, hydrological balance, and soil stability (Bouwman & Leemans, 1995; Fahey et al., 2010). However, anthropogenic factors such as increasing population pressure, the expansion of agricultural lands, urbanization, and industrial activities accelerate the process of deforestation and threaten the integrity of these ecosystems (Allen & Barnes, 1985; Myers, 2023). The destruction of forests affects not only environmental balance but also the continuity of social and cultural structures (Myers, 2023). In this context, fostering awareness among individuals about the functions and significance of forests is possible particularly through nature-based education provided from an early age (Börner, Schulz, Wunder, & Pfaff, 2020). Accordingly, the way the concept of the forest is addressed in educational processes is considered a critical domain for enhancing environmental literacy and promoting sustainable lifestyle practices (Baranzini, Faust, & Huberman, 2010; Börner, Schulz, Wunder, & Pfaff, 2020).

Studies on forests have mostly focused on Forest Schools (Cumming & Nash, 2015). In the secondary school biology curriculum in Türkiye, the concept of the forest is generally introduced to students as a component of ecosystems and is presented in relation to topics concerning environmental and natural sciences, such as photosynthesis, the carbon cycle, biodiversity, and natural resource management (MEB, 2018; 2024). Arıkan (2023), examining the concept of the forest in the 2018 secondary school biology curriculum, noted that although the forest concept and related issues - such as the definition of the forest, its ecological significance, its place within biodiversity, and its economic value - are addressed in a balanced manner within the program, the concept of the forest is not clearly defined, and the role of forests in biodiversity and their contribution to biological diversity are not sufficiently emphasized. Beyond the adequacy of the curriculum content itself, the way in which these concepts are taught is also decisive for the permanence of learning. In this context, how forest education can be effective in different learning environments is also discussed in international studies. For instance, Raab and Bogner (2020), in a study conducted in Germany, investigated whether teaching the forest ecosystem to 7th-grade students is more effective in the classroom or in nature. The results showed that while outdoor teaching produced similar performance compared to classroom teaching in some knowledge domains, the permanence of learning depended more on the quality of the program and students' familiarity with nature rather than the learning environment itself (Raab & Bogner, 2020). Schilhab (2021) demonstrated that nature-based outdoor activities (e.g., forest excursions) deepen students' understanding of fundamental concepts such as biodiversity, interspecies interactions, and ecological balance.

1.3. Aim of Study and Problem of the Study

The increasing conceptual intensity in biology education makes it difficult for students to understand fundamental concepts and relate them to everyday life (Miller & Yoon, 2023). This challenge has heightened the importance of active learning strategies that support meaningful learning (Behrendt & Franklin, 2014). Bruner's (1961) discovery learning approach stands out as a method that enables knowledge to be constructed through observation and exploration rather than direct transmission. In the secondary school curriculum in Türkiye, however, the concept of the forest is addressed only in a limited manner, with its definition and its relationship to biodiversity not sufficiently emphasized (Arıkan, 2023).

In this context, the main purpose of the study is to reveal the extent to which secondary school students, during nature observations conducted in a forest, can acquire knowledge related to the concept of the "forest" through guided discovery, which is a component of the discovery learning method. The study aims to determine the extent to which students reach scientific knowledge through nature-based exploration and observation, and to evaluate the contribution of this method to formal education in light of both quantitative and qualitative data.

In line with this general aim, the study seeks to achieve the following specific objectives:

1. To determine how nature observation activities conducted in a forested area influence students' cognitive structures regarding the concept of the forest.
2. To reveal how the discovery learning approach changes students' level of knowledge acquisition through guided discovery over time.

2. METHODOLOGY

2.1. Study Design

This study was structured by adopting a mixed-methods approach. During the research process, both qualitative and quantitative data collection and analysis techniques were employed; the students' written outputs based on their observations in the forest were evaluated through content analysis, and the findings obtained were analyzed both qualitatively and quantitatively. Within this framework, the study was conducted using an explanatory sequential mixed design (Creswell & Plano Clark, 2018; Tashakkori & Teddlie, 2010). This design allows for providing quantitative support to the meaningful patterns emerging from qualitative findings and offers an effective framework for explaining complex learning processes in educational research (Ivankova, Creswell, & Stick, 2006).

2.2. Participants and Study Timeline

The study group consisted of 25 10th-grade students enrolled in public schools in Ankara during the 2023–2024 academic year. The participants were selected through maximum variation sampling, one of the purposive sampling methods, and were included in the nature observation activities conducted in the forest of Hacettepe University's Beytepe Campus on a voluntary basis. After volunteering and one week prior to the nature observations, students were asked to write a descriptive text about the concept of the forest. The data obtained from this stage were defined as "Time 1 (T1)." Afterwards, the students participated in two guided nature observations, each lasting four hours, at two different time points (T2 and T3) as a part of guided discovery learning method. There was an interval of one month between the observation sessions. Following each nature observation, the students were again asked to write down their knowledge regarding the concept of the "forest."

The nature observation process was based on the guided discovery learning approach. This approach, developed by Bruner (1961), assumes that learners build knowledge through their own observations and experiences with guidance, rather than by receiving information directly. The implementation process was structured in such a way as to enable participants to construct their own cognitive structures within a natural learning environment (Dewey, 1938; Kolb, 1984). The aim was for students to construct conceptual knowledge through active observation. In this context, no prior information on the concept of the forest was presented to the students before the implementation; they were only instructed to carry out nature observation activities under the supervision of the guide, analyze environmental patterns, and record the knowledge they acquired in written form. During these activities, students were encouraged to independently observe the forest's relationships with plants, animals, and other ecological patterns. Guidance was provided only when students posed questions; in such cases, the guide offered brief explanations or asked prompting questions (e.g., "What differences do you notice between these trees and those in open areas?") to stimulate inquiry rather than transmit direct knowledge.

2.2. Data Collection Tools

The data were obtained from the students' written definitions related to the concept of the "forest." These outputs were used to determine the extent to which students constructed knowledge regarding the concept of the forest. Three separate written data entries were collected from each participant following the T1, T2, and T3. In addition, field notes, researcher observation forms, and implementation protocols related to the process were used as supporting documents in the study; however, they are not presented here as they are beyond the scope of this research.

2.3. Data Analysis

The data analysis process was conducted in two stages. In the first stage, the students' texts were analyzed through qualitative content analysis using the MAXQDA software. Following the principles of thematic content analysis proposed by Mayring (2000), Schreier (2012), and Kuckartz (2014), the data were coded and subsequently categorized under main themes. In accordance with Kuckartz's (2014) framework, the analysis procedure involved repeated reading of the data, generation of preliminary codes, identification of themes, revision of the coding system, and reclassification of the data according to the revised system. The coding procedure was carried out twice, and intercoder reliability was calculated using Cohen's kappa coefficient ($\kappa = 0.89$), which indicated a high level of agreement (Landis & Koch, 1977). In the second stage, the students' texts from three different time points (T1, T2, T3) were compared to examine the changes in coding over time. Non-parametric tests were employed to determine whether the differences among the quantitative values derived from the qualitative data were statistically significant. The significance level was set at $p = .05$, and all analyses were performed using IBM SPSS Statistics 25.0.

3. FINDINGS

According to the results of the Mann-Whitney test for the T1, T2, and T3 time points, no statistically significant differences were found between genders in terms of the number of codes, sentences, words, and characters (Table 1) ($p > .05$). At T3, however, the students' data on codes, sentences, words, and characters differed statistically from the data obtained at T1 and T2 ($p < .01$). In contrast, while there was no statistically significant difference in the number of sentences between T1 and T2 ($Z = -0.645$, $p = .519$), significant differences were found in terms of codes, words, and characters.

Table 1.
Descriptive Statistics of Time-Based Changes in Codes, Sentences, and Characters in Students' Definitions

	Code		Sentence		Word		Characters	
Time	$\bar{x}$±SE	Min.-Max.	$\bar{x}$±SE	Min.-Max.	$\bar{x}$±SE	Min.-Max.	$\bar{x}$±SE	Min.-Max.
T1	5.60±0.37	1-9	4.32±0.16	2-5	32.80±1.09	13-39	247.4±7.27	111-288
T2	7.60±1.70	5-11	4.280±0.79	3-6	38.32±4.02	28-43	310.6±34.2	202-357
T3	15.84±2.62	11-20	6.68±2.32	3-12	55.84±16.8	29-91	461.2±135.7	246-754

3.1. Student Evaluations Prior to the Nature Observation – T1

Analysis of the student texts at Time 1 (T1) revealed 7 main themes and 17 codes (Table 2). These expressions were mostly concentrated around the codes of *conservation* (N = 26), *tree* (N = 20), and the theme of *Emotional Expressions* (N = 23). The student texts consisted primarily of basic knowledge and emotional expressions. For example, Student-19, in a part of their text about forests, stated: *"When I think of a forest, only many trees and a little silence come to mind. I think protecting forests is important."* Similarly, Student-24 wrote: *"Forests seem to me like places only for resting. Maybe there are a few birds, but I used to think not many living creatures exist. I think protecting forests is important. Maybe forests are not just trees but contain a balance that needs to be preserved."* As can also be inferred from the frequency of codes presented in Table 2, the student statements showed similarities. When combined, the students' expressions formed a general pattern: *"Forests are places with trees, that are dark, quiet, and need to be protected."* Sixteen students expressed their ideas not in definitive terms but with qualifiers such as *"I think," "I thought,"* or *"maybe."* At T1, six students defined the forest as a *"recreational area, a place for walking or doing sports."* Only one student mentioned the presence of birds, and another mentioned animals living in the forest. The data show that students defined the forest in a simple manner based on their life experiences. Prior to the observations, students did not use expressions or terminology referring to the importance of forests or the biological processes within them. These findings indicate that at T1, students' perceptions of the forest concept were largely superficial, experience-based, and subjective, with scientific knowledge elements not yet reflected in their statements. This is further supported by the word cloud generated from the analysis of all student texts, shown in Figure 1.

3.2. Evaluations After the First Nature Observation – T2

The texts at T2 time differ significantly from those at T1 time. The number of words and characters used by the students in the T2 period increased considerably compared to T1 ss shown in Table 1. The distribution of themes and codes in the texts belonging to T2 is shown in Table 2. Here, the number of themes decreased to 3, while the number of codes increased to 19. The only common theme between T1 and T2 is the *Biological Concepts* theme. In addition, there is no specific phrase pattern used to define the forest at T2 unlike in T1. The most notable difference between T1 and T2 is the absence of the codes *calm, dark, quiet* (which were included in the *Emotional/Perceptual Expressions* theme) and the lack of expressions related to the *Conservation and Environmental Awareness* theme. The three most frequently occurring codes at T2 are *bird* (N = 24), *tree* (N = 23), and *mushroom* (N = 21). This change in the texts indicates that students made observations and drew original inferences based on their own experiences. One of the most prominent examples of observation-based expression is Student-12's statement: *"During the forest walk, the sounds of birds filled the entire area. Clusters of mushrooms around the tree roots caught my attention. Watching insects emerge from under stones and then hide again was surprising. I realized that the forest is not just greenery but a complex structure."* Some students took these texts even further, forming sentences based on observation and inquiry about life in the forest. For example, Student-7 wrote: *"While walking, I saw mushrooms on the trunks, insects on the ground, and birds flying among the trees. It seemed like every living being had a duty there. The sounds of the birds and the movements of the insects showed that the forest was full of life."* These observation-based texts demonstrate that students updated their prior knowledge of the forest within their cognitive processes. For instance, at T1 Student-2 stated: *"When I think of the forest, only dense trees come to mind. It looks like a place where one cannot enter, a quiet and dark place."* In contrast, at T2 Student-2 said: *"The forest is not only made up of trees; it also consists of birds, insects, mushrooms, mosses, and soil."* The expression "*not only made up of trees*" shows that Student-2 revised the knowledge from T1. Whereas in T1 trees were expressed directly as "*trees,*" at T2 additional expressions regarding the parts of the tree - *such as branches, leaves, greenery, trunk, and roots* - were included. For example, Student-18 stated: *"While walking, I heard the different sounds of birds; some of them were moving on the branches. I saw mushrooms clustering near the tree roots."* This expression directly conveys the living things on the trees based on observation. The detail of the tree parts and their relationship with other organisms highlights the dominance of observation-based data in the texts. Such direct observation-based expressions, like those of Student-18, also caused the students' perceptions of forest conservation to diminish at T2. This is because while the T1 texts were mostly based on what students had learned or on the feelings evoked by the concept of the forest, in T2 this shifted to expressions based solely on direct observations, lacking interpretation or association.

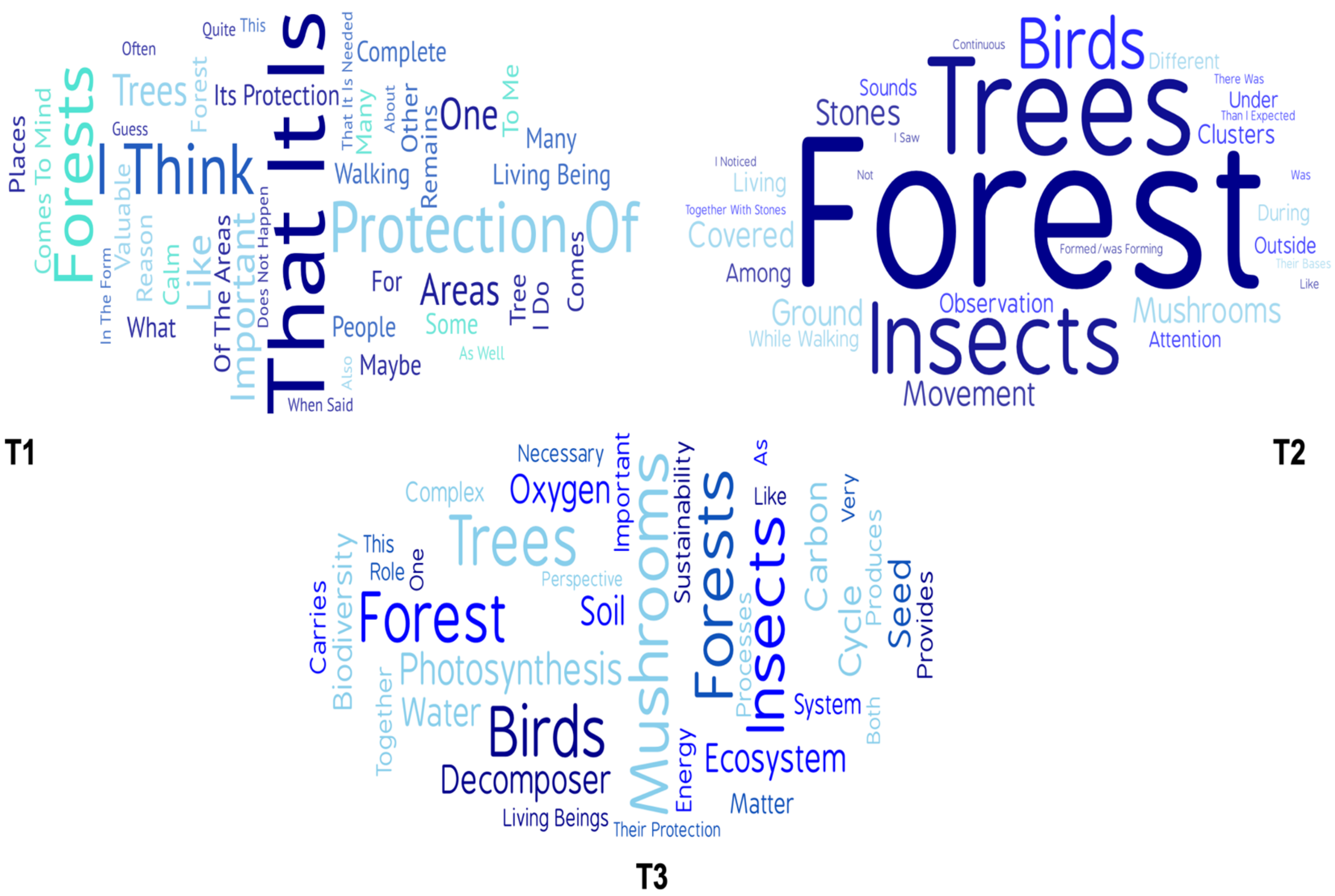

Figure 1. Word clouds generated from the analysis of student texts on the concept of forest at T1, T2, and T3

3.3. Evaluations after the Second Nature Observation – T3

After the T3 period, students' texts became more diverse, enriched, compared to T1 and T2. Students' statements about the forest during T3 contained statistically more words and characters as shown in Table 1. The variety of codes increased, reaching 37. In their descriptions, students referred 174 times to species in the forest and 55 times to the roles of these species or their relationships with other species. The *Conservation and Environmental Awareness* theme, which had faded in T2, reappeared in

T3 with greater diversity in codes as shown in Table 2. The *Biological Concepts* theme expanded in terms of codes, and an additional *Ecological Concepts* theme emerged to support it. Student descriptions in the T3 period indicate a shift from the simple observation-based expressions of T2 to more complex explanations that students could not perceive solely through observation but could infer by integrating their existing biological knowledge. In addition to concepts emphasizing biodiversity, such as *species* (21.97%) and *species' roles* (6.94%), process-based ecological concepts also became prominent and increased in frequency of use, including *photosynthesis* (2.90%), *ecosystem* (2.40%), and *water* and *the water cycle* (2.02%). Statements such as "*photosynthesis is carried out by trees*" and that "*trees and other organisms are responsible for cycles*" demonstrate that students combined their biological knowledge with their observations. For example, Student-12's statement; *"The forest is a complex structure where birds disperse seeds, fungi act as decomposers, insects work the soil, and trees regulate the water cycle and photosynthesis."* supports this finding.

3.4. Comparison All Nature Observation Results – T1, T2, and T3

In T1 and T2, one of the three most frequently mentioned concepts was *tree*, whereas in T3 it dropped to 11th place in terms of frequency. This indicates that students no longer perceive the forest as "*a structure consisting only of trees*." Student-9's statement; *"Forests are complex systems where many living beings such as plants, fungi, insects, and birds coexist."* along with the distribution of codes, supports this conclusion. The theme of *Conservation and Environmental Awareness*, which included frequent references to forest conservation at T1, diminished in T2 but developed and diversified in T3. The *conservation* code in T1 was relatively high at 9.29%, but the emphasis mostly remained abstract. Conservation-related expressions declined due to the dominance of observation-based concepts in T2. However, *conservation* (3.66%) was accompanied by more technical and holistic codes such as *sustainability* (1.01%), *environmental health* (0.76%), and *natural resources* (0.25) in T3. Students at T3 did not only emphasize that forests should be "*protected*" but also specified that they should be safeguarded against *fires, grazing, logging, and human use*, and even proposed educating people as a preventive measure. Student-14 combined many of these points in the following statement; *"Forests are vital in terms of ecosystem services and must be protected. Unnecessary grazing should be avoided. Measures should be taken against fire. Education can be provided."* This shows that students no longer treat the "*forest*" as a simple descriptive concept, but instead make comprehensive evaluations about forest. *Sustainability* was another important code supporting to this finding. Eight students referred to the necessity of ensuring forest sustainability. For example, Student-23 wrote; *"The sustainability of these structures is of vital importance for nature,"* while Student-16 stated; *"The sustainability of the forest is essential for the continuation of biodiversity."* The concept of sustainability was associated with biodiversity, living species, and trees. Similar to inferences about ecological cycles, the sustainability concept also represents a conclusion that students reached based on their observations. Another emerging concept in T3, expressed by two students, was the "*economic importance of forests*". Student-24 highlighted this perspective by stating; *"Forests are very valuable both ecologically and economically."* From the perspective of student perceptions, this demonstrates a developmental shift: in T1, the forest was expressed simply as "*a place*"; in T2, it was described through neutral, observation-based expressions without interpretation; and in T3, it was conceptualized as "*a structure where biological processes take place, species coexist, and which is under threat and in need of protection*."

Table 2.
Changes and Frequencies of Main Themes and Code Groups Emerging from Student Statements at T1, T2, and T3 Times

T1			T2			T3					
1. Biological Concepts			1. Biological Concepts			1. Biological Concepts					
Tree	20	7.14	Bird	24	32.00	Species	174	21.97	Tree	20	2.53
Living Being	15	5.36	Tree	23	30.67	Species Roles	55	6.94	Inter-species Relationship	8	1.01
Nature	6	2.14	Mushroom	21	28.00	Mushroom	27	3.41	Plant	6	0.76
Animal	1	0.36	Insect	20	26.67	Bird	27	3.41	Animal	5	0.63
Bird	1	0.36	Forest Floor	7	9.33	Insect	26	3.28	Living Being	8	1.01
2. Ecological Concepts			Tree Trunk	5	6.67	Biological Diversity	23	2.90	Human	2	0.25
Balance	4	1.43	Tree Branch	5	6.67	2. Ecological Concepts					
Ecological Cycle	1	0.36	Tree Root	4	5.33	Photosynthesis	23	2.90	Balance	6	0.76
3. Conservation and Environmental Awareness			Tree Debris	1	1.33	Ecosystem	19	2.40	Carbon	6	0.76
Conservation	26	9.29	Leaf	1	1.33	Ecological Cycle	18	2.27	Matter	2	0.25
4. Emotional/Perceptual Expressions			Ant	3	4.00	Water and Water Cycle	16	2.02	Food Chain	1	0.13
Emotional Expression	23	8.21	Flower	1	1.33	Environmental Balance	16	2.02	Air	1	0.13
Quiet	13	4.64	Moss	1	1.33	Oxygen	9	1.14	Nitrogen	1	0.13
Calm	5	1.79	2. Non-living Elements			Energy	9	1.14	Ecology	1	0.13
Dark	1	0.36	Stone	20	26.67	Soil	7	0.88	-	-	-
5. Cognitive Process			Soil	6	8.00	3. Conservation and Environmental Awareness			4. Human Impacts and Threats		
Think	16	5.71	-	-	-	Conservation	29	3.66	Fire	12	1.52
-	-	-	3. Observational Concepts			Sustainability	8	1.01	Grazing	1	0.13
6. Humans and Purposes of Use			Direct Observation	12	16.00	Environmental Health	6	0.76	Logging	3	0.38
Place	11	3.93	Diversity	12	16.00	Natural Resource	2	0.25	Human-Induced Threat	4	0.51
Recreational Area	6	2.14	Movement	8	10.67	5. Economic and Social Dimensions			-	-	-
Human	5	1.79	Role of Living Beings	8	10.67	Education	4	0.51	-	-	-
7. Visual Perception			-	-	-	Economic Importance	2	0.25	-	-	-
Green	5	1.79	-	-	-	-	-	-	-	-	-

4. RESULTS, DISCUSSION AND RECOMMENDATIONS

Findings of the study reveal that students demonstrated a gradual developmental process in their perceptions of the concept of forest. The expressions at T1, predominantly consisted of general natural elements such as "*tree*," "*animal*," and "*nature*," along with emotional and perceptual descriptions like "*quiet*," "*calm*," and "*dark*." Students began to focus more on observational details at T2, frequently using concrete components such as "*trunk*," "*branch*," "*root*," "*leaf*," "*mushroom*," and "*ant*," and making definitions centred around "*direct observation*." These observations had become integrated with conceptual and system-level ecological terms such as "*ecosystem*," "*biodiversity*," "*water cycle*," "*carbo*n," and "*environmental balance*" at T3. In addition, expressions reflecting human impacts and environmental ethics - such as "*human-induced threat*," "*logging*," "*fire*," and "*economic importance*" - became more prominent. This developmental trajectory indicates that initial emotional/perceptual engagement through nature observation strengthens students' observational skills over time and ultimately contributes to the internalization of abstract ecological concepts. Discovery learning, as developed by Bruner (1961), is a strategy that envisions students actively constructing knowledge through activities such as problem-solving, hypothesizing, and researching, rather than receiving information passively. Based on this, Mayer (2004) demonstrated that the guided discovery approach supports meaningful learning when appropriate scaffolding is provided. This finding helps explain why the design implemented in our study was effective: students were encouraged to observe and reflect on the concept of forest without being given direct information, while the structure and focus of the activities were intentionally designed to guide the learning process.

The students' use of emotionally and perceptually driven expressions such as "*quiet*," "*calm*," and "*dark*" indicates that their understanding of the forest concept involved not only cognitive but also affective dimensions. Emotional and perceptual responses play a critical role in shaping students' attitudes toward the environment (Kals, Schumacher, & Montada, 1999). In particular, emotional states such as peace, curiosity, or awe experienced in natural settings have been positively associated with environmental awareness and pro-environmental behaviors (Chawla, 1998; Beery & Wolf-Watz, 2014). In conclusion, research on nature education has shown that students' perceptual descriptions of natural environments provide powerful contextual cues that support knowledge construction during the learning process (Ballantyne & Packer, 2009). In this context, it can be argued that emotional and perceptual expressions not only reflect individual experiences but also serve as mediators in the internalization of ecological concepts.

In the study, it was observed that at T1, students' perceptions of the forest were largely limited to subjective and emotion-based descriptions. However, these expressions had been replaced by more scientifically enriched definitions that incorporated ecological components, including terms such as "*biodiversity*," "*ecological cycle*," and "*water cycle*" at T3. This shift demonstrates that nature observation experiences and guided discovery-based learning processes support students' transition from emotional perceptions to more structured ecological knowledge (Rickinson et al., 2004). Similarly, Palmberg, & Kuru (2000) reported that students participating in nature-based activities developed emotionally grounded approaches toward the environment, which significantly influenced both their cognitive knowledge levels and their conservation behaviors throughout the process. In this context, emotional and perceptual expressions serve not only as reflections of students' initial perceptions of nature but also as critical bridges in the internalization of scientific concepts. There is strong evidence that the guided discovery approach in science education has positive effects on students' conceptual understanding, problem-solving skills, and learning retention (Ünal & Ergin, 2006; Alfieri, Brooks, Aldrich, & Tenenbaum, 2011). In particular, the meta-analysis conducted by Alfieri et al. (2011), which reviewed 164 studies, demonstrated that guided discovery significantly improves student achievement compared to traditional instructional methods. Within this framework, the fact that students began to use concepts such as photosynthesis, matter cycle, and carbon cycle at the T3 stage of our study illustrates how effective the guided discovery approach can be in deepening students' prior knowledge. Another strength of guided discovery learning lies in its ability to allow students to construct meaning through their own experiences during the learning process.

Novak (2002) stated that meaningful learning can only occur when the relationships between concepts are integrated into the learner's cognitive structure. In this context, while students in the study initially described the forest at the T1 stage with simple expressions such as "*a quiet place with trees*," by T3 they had developed more relational and functional definitions such as "*a place where birds disperse seeds, mushrooms act as decomposers, and insects process the soil*." This transformation confirms the role of nature observation and inference in supporting conceptual understanding during the guided discovery-based learning process. Similarly, Schneiderhan-Opel and Bogner (2021), in their research on forest ecosystems, found that instruction conducted in natural environments had a greater impact on students' ecological knowledge levels and environmental attitudes compared to classroom-based instruction. The T3 findings in our study align with these results; students no longer defined the forest merely as a physical space, but rather as an ecosystem where processes such as energy flow, matter cycling, and biodiversity are integrated. Students' T3 responses increasingly reflected not only observation-based but also inference-driven and solution-oriented interpretations. This supports the findings of Harwood, Huang, and Somma (2022), who demonstrated that activities conducted in forest environments foster student's curiosity and creative problem-solving skills. The comprehensive review by Rickinson et al. (2004) on outdoor learning similarly found that such environments have lasting impacts on conceptual understanding, self-efficacy, and environmental attitudes. The process observed from T1 to T3 in our study directly reflects this transformation. Initially, students focused mainly on the physical attributes of the "*forest*," but by the end, they were defining it as an integrated ecosystem involving interrelationships among living beings, cycles of energy and matter, and human impact. This highlights that the combination of guided discovery-based learning and outdoor activities serves as a powerful tool for facilitating deep conceptual transformation.

This study demonstrates that when integrated with nature observation, the guided discovery-based learning approach significantly enhances students' understanding of the concept of "*forest*." Future research is recommended to compare the effectiveness of this method across different age groups and types of ecosystems. Additionally, longitudinal studies should be conducted to examine the retention of learning outcomes, employing both quantitative and qualitative data collection techniques. The integration of technology-supported observation tools and digital learning applications could also provide methodological diversity.

From a practical standpoint, nature observation activities should be systematically incorporated into the curricula of biology courses. In-service training programs are essential to equip teachers with the skills needed to effectively implement guided discovery methods. Utilizing local ecosystems can help students form stronger connections with their environment.

At the policy level, it is necessary to allocate financial and logistical support for schools to organize nature-based learning activities and include them in their educational programs. Interdisciplinary collaboration should be encouraged so that various subject areas contribute meaningfully to outdoor learning processes. Such holistic approaches will support both the cognitive and affective development of students.

Research and Publication Ethics Statement

The study was conducted with ethical approval obtained from the Social Sciences and Humanities Research Ethics Board of Hacettepe University (June 21, 2023 - E-35853172-600-00002911931). Informed consent was obtained from all participants. Participation in the study was entirely voluntary. Participants were fully informed about the procedures of participation, the purpose of the research, and how their responses would be used and stored. They were also informed that they could withdraw from the study at any time. Throughout the study, all participant data and information were anonymized.

Contribution Rates of Authors to the Article

This article was prepared by a sole author. The author was solely responsible for all stages of the research process, including topic selection, data collection, data analysis, interpretation, and manuscript writing.

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Statement of Interest

I declare that there is no conflict of interest.

5. REFERENCES

Alfieri, L., Brooks, P. J., Aldrich, N. J., & Tenenbaum, H. R. (2011). Does discovery-based instruction enhance learning? *Journal of Educational Psychology, 103*(1), 1–18. https://doi.org/10.1037/a0021017

Allen, J. C., & Barnes, D. F. (1985). The causes of deforestation in developing countries. *Annals of the Association of American Geographers, 75*(2), 163–184. https://doi.org/10.1111/j.1467-8306.1985.tb00079.x

Arıkan, K. (2023). Ortaöğretim biyoloji öğretim programında orman kavramı. *Düzce Üniversitesi Orman Fakültesi Ormancılık Dergisi, 19*(1), 269–282. https://doi.org/10.58816/duzceod.1244721

Arora, N. K., & Fatima, T. (2024). Environmental sustainability and biotechnology: Opportunities and challenges. *Environmental Sustainability, 7*(2), 115–119. https://doi.org/10.1007/s42398-024-00317-9

Ballantyne, R., & Packer, J. (2009). Introducing a fifth pedagogy: Experience-based strategies for facilitating learning in natural environments. *Environmental Education Research, 15*(2), 243–262. https://doi.org/10.1080/13504620802711282

Baranzini, A., Faust, A. K., & Huberman, D. (2010). Tropical forest conservation: Attitudes and preferences. *Forest Policy and Economics, 12*(5), 370–376. https://doi.org/10.1016/j.forpol.2010.02.008

Beery, T., & Wolf-Watz, D. (2014). Nature to place: Rethinking the environmental connectedness perspective. *Journal of Environmental Psychology, 40*, 198–205. https://doi.org/10.1016/j.jenvp.2014.06.006

Behrendt, M., & Franklin, T. (2014). A review of research on school field trips and their value in education. *International Journal of Environmental and Science Education, 9*(3), 235–245. https://doi.org/10.12973/ijese.2014.213a

Black, P. N. (2020). A revolution in biochemistry and molecular biology education informed by basic research to meet the demands of 21st century career paths. *Journal of Biological Chemistry, 295*(31), 10653–10661. https://doi.org/10.1074/jbc.aw120.011104

Börner, J., Schulz, D., Wunder, S., & Pfaff, A. (2020). The effectiveness of forest conservation policies and programs. *Annual Review of Resource Economics, 12*(1), 45–64. https://doi.org/10.1146/annurev-resource-110119-025703

Bouwman, A. F., & Leemans, R. (1995). The role of forest soils in the global carbon cycle. In *Carbon forms and functions in forest soils* (pp. 503–525). https://doi.org/10.2136/1995.carbonforms.c23

Bruner, J. S. (1961). The act of discovery. *Harvard Educational Review, 31*(1), 21–32.

Chawla, L. (1998). Significant life experiences revisited: A review of research on sources of environmental sensitivity. *The Journal of Environmental Education, 29*(3), 11–21. https://doi.org/10.1080/1350462980040402

Committee on a New Biology for the 21st Century (CNB). (2009). *A new biology for the 21st century: Ensuring the United States leads the coming biology revolution.* National Research Council. https://doi.org/10.17226/12764

Creswell, J. W., & Plano Clark, V. L. (2018). *Designing and conducting mixed methods research* (3rd ed.). Sage.

Cumming, F., & Nash, M. (2015). An Australian perspective of a forest school: Shaping a sense of place to support learning. *Journal of Adventure Education and Outdoor Learning, 15*(4), 296–309. https://doi.org/10.1080/14729679.2015.1010071

Das, S., Ray, M. K., Panday, D., & Mishra, P. K. (2023). Role of biotechnology in creating sustainable agriculture. *PLOS Sustainability and Transformation, 2*(7). https://doi.org/10.1371/journal.pstr.0000069

Dewey, J. (1938). *Experience and education.* Macmillan.

Fahey, T. J., Woodbury, P. B., Battles, J. J., Goodale, C. L., Hamburg, S. P., Ollinger, S. V., & Woodall, C. W. (2010). Forest carbon storage: Ecology, management, and policy. *Frontiers in Ecology and the Environment, 8*(5), 245–252. https://doi.org/10.1890/080169

Harwood, D., Huang, M., & Somma, M. (2022). "We're trying to find cool things in the forest" – Exploring children's curiosity and creativity in the outdoors. *International Electronic Journal of Elementary Education, 15*(1), 33–42.

Honomichl, R. D., & Chen, Z. (2012). The role of guidance in children's discovery learning. *Wiley Interdisciplinary Reviews: Cognitive Science, 3*(6), 615–622. https://doi.org/10.1002/wcs.1199

Ivankova, N. V., Creswell, J. W., & Stick, S. L. (2006). Using mixed-methods sequential explanatory design: From theory to practice. *Field Methods, 18*(1), 3–20. https://doi.org/10.1177/1525822X05282260

Kals, E., Schumacher, D., & Montada, L. (1999). Emotional affinity toward nature as a motivational basis to protect nature. *Environment and Behavior, 31*(2), 178–202. https://doi.org/10.1177/00139169921972056

Karan, E. (2023). Discovery-based approach combined with active learning to improve student learning experiences for STEM students. *International Journal of Education and Humanities, 3*(4), 288–299. https://doi.org/10.58557/(ijeh).v3i4.163

Kelley, T. R., & Knowles, J. G. (2016). A conceptual framework for integrated STEM education. *International Journal of STEM Education, 3*(1), 11. https://doi.org/10.1186/s40594-016-0046-z

Kolb, D. A. (1984). *Experiential learning: Experience as the source of learning and development.* Prentice Hall.

Kuckartz, U. (2014). *Qualitative text analysis: A guide to methods, practice and using software.* Sage.

Landis, J. R., & Koch, G. G. (1977). The measurement of observer agreement for categorical data. *Biometrics, 33*(1), 159–174.

Mayer, R. E. (2004). Should there be a three-strikes rule against pure discovery learning? The case for guided methods of instruction. *American Psychologist, 59*(1), 14–19. https://doi.org/10.1037/0003-066X.59.1.14

Mayr, E. (1997). *This is biology: The science of the living world.* Universities Press.

Mayring, P. (2000). Qualitative content analysis. *Forum: Qualitative Social Research, 1*(2). https://doi.org/10.17169/fqs-1.2.1089

McAteer, L., Roche, J., & Kelly, Á. M. (2023). Renewing an undergraduate science curriculum for the 21st century. *Frontiers in Education, 8*, 1270941. https://doi.org/10.3389/feduc.2023.1270941

Miller, K. M., & Yoon, S. A. (2023). Teaching complexity in biology through agent-based simulations: The relationship between students' knowledge of complex systems and metamodeling knowledge. *Frontiers in Education, 8*, 1198307. https://doi.org/10.3389/feduc.2023.1198307

Milli Eğitim Bakanlığı (MEB). (2018). *Biyoloji dersi öğretim programı (9, 10, 11 ve 12. sınıflar).* Talim ve Terbiye Kurulu Başkanlığı.

Milli Eğitim Bakanlığı (MEB). (2024). *Türkiye yüzyılı Maarif modeli; Biyoloji dersi öğretim programı (9, 10, 11 ve 12. sınıflar).* Talim ve Terbiye Kurulu Başkanlığı.

Myers, N. (2023). *Tropical deforestation: Rates and patterns.* Routledge. https://doi.org/10.4324/9781003428190-3

Novak, J. D. (2002). Meaningful learning: The essential factor for conceptual change in limited or inappropriate propositional hierarchies leading to empowerment of learners. *Science Education, 86*(4), 548–571. https://doi.org/10.1002/sce.10032

Noviyanti, E., Rusdi, R., & Ristanto, R. H. (2019). Guided discovery learning based on internet and self concept: Enhancing students' critical thinking in biology. *Indonesian Journal of Biology Education, 2*(1), 7–14. https://doi.org/10.31002/ijobe.v2i1.1196

Palmberg, I. E., & Kuru, J. (2000). Outdoor activities as a basis for environmental responsibility. *The Journal of Environmental Education, 31*(4), 32–36. https://doi.org/10.1080/00958960009598649

Raab, K., & Bogner, F. X. (2020). Learning about forest ecosystems: Comparing indoor and outdoor instruction. *Forests, 11*(9), 91265. https://doi.org/10.3390/f12091265

Rickinson, M., Dillon, J., Teamey, K., Morris, M., Choi, M. Y., Sanders, D., & Benefield, P. (2004). *A review of research on outdoor learning.* National Foundation for Educational Research and King's College London.

Rodríguez-Muñoz, C., & Huincahue, J. (2024). Interdisciplinary practices for teaching biology: A systematic review. *Journal of Biological Education*, 1–19. https://doi.org/10.1080/00219266.2024.2399516

Schilhab, T. (2021). Nature experiences in science education in school: Review featuring learning gains, investments, and costs in view of embodied cognition. *Frontiers in Education, 6*, 739408. https://doi.org/10.3389/feduc.2021.739408

Schneiderhan-Opel, J., & Bogner, F. X. (2021). Cannot see the forest for the trees? Comparing learning outcomes of a field trip vs. a classroom approach. *Forests, 12*(9), 1265. https://doi.org/10.3390/f12091265

Schreier, M. (2012). *Qualitative content analysis in practice.* Sage.

Tashakkori, A., & Teddlie, C. (2010). *Sage handbook of mixed methods in social & behavioral research* (2nd ed.). Sage.

Teker, S., Kurt, M., & Karamustafaoğlu, O. (2017). "Işığın ve sesin yayılması" ünitesini buluş yoluyla öğrenmenin öğrenci başarısı ve tutumuna etkisi. *Adıyaman Üniversitesi Sosyal Bilimler Enstitüsü Dergisi, (27)*, 835–863. http://dx.doi.org/10.14520/adyusbd.294931

Ünal, G., & Ergin, Ö. (2006). Buluş yoluyla fen öğretiminin öğrencilerin akademik başarılarına, öğrenme yaklaşımlarına ve tutumlarına etkisi. *Journal of Turkish Science Education, 3*(1), 36–52.

Wilke, R. R., & Straits, W. J. (2001). The effects of discovery learning in a lower-division biology course. *Advances in Physiology Education, 25*(2), 62–69. https://doi.org/10.1152/advances.2001.25.2.62

Wilson, E. O. (1998). *Consilience: The unity of knowledge.* Vintage.