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Perceptions of common Nordic ecosystems reveal knowledge differences among and within rural and urban area pupils in West Sweden

Abstract

Photographs as a direct representation of nature can serve as a means of probing pupils' perceptions of ecosystems and biodiversity. In this empirical study, 98 pupils aged 10–12 years in primary schools in rural and urban western Sweden were asked to describe what they saw in a photograph of a lake and a forest, as well as what could be present but not visible. An ecological approach to visual perception was used as the theoretical framework. Individual pupils within groups exhibited a broad range of species knowledge. Although no animals were visible in the photograph, animals were imagined much more readily than plants. Forest species outnumbered aquatic ones in the answers. Pupils in rural schools named more tree and mammal species, while urban pupils more often used generic terms, such as 'tree' and 'animal'. These findings raise implications for 'what' and 'how' in ecology instruction to reinforce plant awareness and species naming.

INTRODUCTION

There is widespread consensus that the world faces a global biodiversity crisis (Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, 2020). Simultaneously, the general population—and particularly schoolchildren—is exhibiting a decline in species knowledge (Gerl et al., 2021; Kaasinen, 2019; Nates et al., 2010; Robles-Moral et al., 2022; Skarstein & Skarstein, 2020; Yli-Panula et al., 2018). ‘Reading nature’ serves as an educational tool in biology education and highlights the importance of an individual’s perception of the environment in understanding how living and non-living components are interconnected: ‘Basically, it concerns discerning relevant and typical structures, such as plants and animals, within an ecosystem’ (Magntorn, 2007, p. 6). This statement conforms to the approach to visual perception in ecological psychology (Gibson, 2014). Within ecological psychology, perception is understood as an outcome of sensing the surrounding environment and precedes ‘knowing in the meaning of detecting’ (Gibson, 1986, p. 149). Consequently, ‘knowing is an extension of perceiving’ (Gibson, 1986, p. 258). To make knowledge explicit, Gibson stresses the role of language: ‘Knowledge that has been put into words can be said to be explicit instead of tacit’ (p. 260). Accordingly, in Swedish elementary education, instruction about organisms begins in preschool and continues through grades 1–6 (ages 6–12) (Skolverket, 2024). Pupils start by naming organisms and learning about their life cycle stages and traits, typically within the local environment. The didactic questions of ‘how’ and ‘what’ young pupils perceive in nature are therefore timely and important for understanding ecological relationships.

The state of species knowledge

A decline in knowledge of plant and animal species has been reported among both children and adults across various countries. In Germany, a 15% loss in species knowledge was observed among Grade 4 grammar school pupils between 2006 and 2016 (Gerl et al., 2021). In a study on the plant and animal knowledge of children aged four to ten in the US and England (Patrick & Tunnicliffe, 2011), children were asked to free-list plants and animals, along with the locations where they had seen them. In both countries, the primary source of learning about animals was within the children’s communities. US children demonstrated greater knowledge of endemic animals, while English children tended to mention exotic animals seen in places such as zoological gardens. The plants referenced were generally not wild species but rather those commonly encountered in family gardens and homes. In the Netherlands, primary school children and the public also exhibit low knowledge of native wild animals (Hooykaas et al., 2019). In Argentina, a notable decline in knowledge of birds, arthropods, and mammals was observed among students aged 9–17 years (Nates et al., 2010). Children in primary schools in Germany and the Netherlands knew less about reptiles and birds than about mammals (Gerl et al., 2021; Hooykaas et al., 2019). Preservice preschool teachers in Spain were less knowledgeable about native vertebrates than domesticated exotic animals (Robles-Moral et al., 2022). In Finland, lower and upper-secondary students, along with student teachers from preservice to upper-secondary education, demonstrated almost non-existent knowledge of invertebrates in coniferous forests (Yli-Panula & Matikainen, 2014).

The concept of Plant blindness, introduced by Wandersee and Schussler (1999), describes humans’ general disregard for plants in favour of animals. Knapp (2019) observed that animals resembling humans attract more than invertebrates and other organisms. Consequently, Parsley (2020) proposed renaming the concept as plant awareness disparity. Plants also receive less coverage in biology textbooks (Ferlin & Sundberg, 2015). Fewer experiences and limited plant knowledge are believed to contribute to a decrease in Plant awareness disparity among students and teachers (Stagg & Dillon, 2022). Additionally, specific taxonomic knowledge has lost educational prominence in favour of broader concepts, like ecosystem services. This curricular shift has decreased species identification skills, described as species diversity blindness (Christ & Dreesmann, 2022).

Residential background and species knowledge

It is often assumed that children living in rural settings, having better access to nature, are more knowledgeable about the natural world than their urban counterparts. However, several factors be-

yond geographical residence also play a role. According to Wold et al. (2023), time spent in nature contributes significantly to species learning. In Spain, students in rural areas aged 12–13 could list more wild native animals than students from urban regions. However, a German study found that hometown size or the number of excursions into nature had less impact on species knowledge among children aged 11–13 than did their academic expectations and the influence of their biology teacher. This was explained by similarities in how children and youth spend their leisure time (i.e. using electronic media), regardless of place of residence or access to nature. Differences in children's experiences of natural environments are rather related to cultural, ethnic, and socioeconomic backgrounds (Natural England, 2015; Sandberg, 2009). Children's contact with nature is not necessarily more prevalent among rural children than among children in urban settings (Lisberg Jensen, 2014). Additionally, rural children in Sweden reportedly spend more time online than contemporary urban children (Statistics Sweden, n.d.).

Instruction and species learning

Children learn about species through formal instruction (Gerl et al., 2021). However, Patrick and Tunnicliffe (2011) found that learning in informal settings—such as family visits to natural areas during children's leisure time—results in more learning of species than occurs in formal education. The emotionality and the utilities of plants have also been highlighted (Jose et al., 2019; Strgar, 2007). Even simple exposure to plants (Lindemann-Matthies, 2005) and hands-on interactions in an authentic field can promote species learning and stimulate interest in plants (Patrick & Tunnicliffe, 2011; Waller et al., 2017). Additionally, interacting with plants through language, memorising, and valuing plant knowledge can enhance learning (Balding & Williams, 2016). Identifying places in nature helps pupils perceive plants in the broader ecological context of reading nature (Nyberg et al., 2021). Yet, the quality of teaching materials matters. A Norwegian study investigating an educational digital application found that the forest was not depicted in sufficient detail to support students' understanding of it as a functioning ecosystem (Eidissen, 2018).

AIM

We aimed to investigate how pupils aged 10–12 years in West Sweden perceive common ecosystems and whether the proximity of the school to nature influences pupils' descriptions. To this end, we formulated the following research questions:

1. What words do rural and urban 10–12-year-old pupils use to describe two common ecosystems, 'lake' and 'forest'?
2. Do pupils' descriptions of the two ecosystems differ between rural and urban contexts?

THEORETICAL FRAMEWORK

This study's theoretical framework is based on the ecological approach to visual perception, as developed by James and Eleanor Gibson (Gibson, 2001). An environment with its objects or events offers 'affordances', allowing an individual to discover and act upon them (Gibson, 1977, 1979). Seeing and listening actively support understanding variations between objects in the environment (Emanuelsson, 2001). This situates ecological theory within the tradition of pragmatism (Linderoth, 2016). From an ontological viewpoint, an individual exists in a reciprocal relationship with the environment. Knowledge, in turn, is perceptual: 'the environment is what is perceived' (Lombardo, 1987, p. 274).

The theory of affordances has been further developed in social semiotics through a multimodal perspective, with definitions such as 'meaning potential' (Halliday et al., 2004, p. 14), 'potentials and limitations' of modes (Kress, 2010, p. 84), or simply as 'potentials' (Lindstrand et al., 2016, p. 7). Recent applications of this framework include its use in modelling relational properties in human-computer interactions (Flach et al., 2017), neuroscience (Cisek & Kalaska, 2010), and science education (for example teaching the atomic structure) (Danielsson, 2016). In its original sense, 'affordance' has also been used to investigate gaming affordances for educational purposes (Linderoth, 2012, 2013)

and children's use of space (Waters, 2017). Eleanor Gibson and Anne Pick studied the affordances of events for infants' perception of the seen and the heard (Gibson, 2000).

In this study, a photograph was used to enable pupils to connect their biological knowledge to familiar ecosystems. The digital screen served as a tool for zooming in and out of view. Gibson (1986) described tools as independent objects connected to the body, thereby possessing affordances for the user. A digital photograph displayed on a computer screen retains the affordance of the tool. It can be manipulated—enlarged with the fingers—thus affording closer engagement with the image's subject. By zooming in and out, viewers may feel as though they are entering the environment depicted in the photograph, thereby enhancing perceptual engagement.

An environment offers a knowledge affordance to a viewer through the senses by cultivating 'awareness of the environment' (Gibson, 1986, p. 253). This awareness is at work when the viewer constructs meaning from the visible and hidden surfaces of fixed elements (such as the ground and forest) and loose elements (such as trees or animals). Although hidden objects cannot be perceived directly, they can be recalled from memory (Gibson, 1986). Objects are distinguished and identified by their surfaces through naming and categorising. In this sense, these surfaces act as affordances shaped by memories, expectations, and prior knowledge to support identification and naming: 'It should now be clear that perceptual seeing is an 'awareness of' of persisting structure' and 'knowing is an extension of perceiving' (Gibson, 1986, p. 258). In this context, we investigated pupils' perceptions as they actively examined the photograph provided.

MATERIALS AND METHODS

The empirical data were collected from pupils aged 10–12 years (N = 98) in West Sweden. The rural sample included four mixed-age classes (n = 51) selected to represent agricultural and wooded areas with easy access to varied natural environments. The urban sample was drawn from five classes in two urban schools (n = 47) with access to park-like or recreational green spaces. The urban schools were selected through convenience sampling (Stratton, 2021) in cooperation with two biology teachers known to one of the authors. The data collection was carried out 'face-to-face' either by one of the authors or by the pupils' regular class teacher, who had received instructions from the researcher. The sampling was conducted across four semesters and completed in 2021.

The inspiration for the present study came from an investigation into student teachers' perceptions of the shell of a vineyard snail (*Helix pomatia*) through a photograph (Käpylä, 2014). In Käpylä's study, the students were asked to describe everything they could see in the picture. The answers were categorised according to human experience, combining factual knowledge, emotions, and personal and social meanings. The present study investigates how pupils perceive common ecosystems by describing factual knowledge based on what they see and what they imagine might be present in the photograph. Learning from photographs has been shown to prompt knowledge recall effectively (Walter et al., 2019) and support literacy instruction (Zenkov et al., 2012). A photo is useful because it allows the viewer to visualise what could exist in an environment (Gibson, 1986).

A 'researcher-generated' photograph guides the type of information gathered for a study (Delamont, 2012). For example, a picture of a frog may yield more than 50 relevant words or expressions (Sasi, 2018). As objects of study, photographs deviate from Gibson's (Gibson, 1986) concept of direct realism, as they are not first-hand experiences. Nevertheless, Gibson (1986) supports the use of photographs as objects of perception: 'in use of the photographer's head, mediating a view and keeping analogous with a firsthand perception' (p. 262), the photographer exercises intention through active engagement.

In addition, an authentic, coloured photograph rich in detail helps create a realistic orientation (Nygård Larsson, 2011). Familiarity with the natural elements shown in the photo was a selection criterion. Organisms featured in the scene occur in schoolbooks and wider societal contexts; there-

fore, it was assumed that pupils would recognise species from this habitat. In this study, a photograph (Figure 1) of two ecosystems, a lake and a forest, enabled pupils to connect with a typical Nordic environment. The pupils were asked to free-list as many answers as they could to the question ‘What do you see in the picture?’ (hereafter referred to as Q1) and ‘What else could be there, even though you cannot see it?’ (hereafter referred to as Q2).



Figure 1. The photo used in the questionnaire depicts a typical Swedish landscape. Photo: Minna Panas

Free listing is a method used to generate items in the order they come to mind within a defined domain (Quinlan, 2005). The first question prompted pupils to write down their observations about the visible content in the photograph. This activity called for ‘awareness of’ the environment and the ability to recognise or imagine the ‘virtual objects’ concealed behind its surface (Gibson, 1978). The second question complemented the first by asking pupils to name what might be present but not visible, drawing on their knowledge and experience of the environment. Pupils received both the questions and the photograph as printed handouts and digital files on their computers. The picture was also projected onto the classroom board. To answer Q1 and Q2, pupils were asked to recall their knowledge of organisms and ecosystems. They could respond either on paper or on their computers. The total response time was approximately 45 minutes.

DATA ANALYSIS

The inspiration for categorising the collected answers was drawn from the scientific identification key used by Patrick and Tunnicliffe (2011). These categories were tested against the taxonomic classification of the Swedish Species Information Centre (2022). The categorising scheme was discussed

among the authors and researchers teaching biology. Categories were organised independently by the authors to ensure intersubjectivity and transparency (Creswell, 2023). Given that classroom vocabulary does not always correspond to formal taxonomic classifications (Nygård Larsson & Jakobsson, 2020), we introduced a ‘Species’ category. This encompasses scientifically accurate Swedish species names and nonstandard, colloquial, or generic names, e.g., ‘grass’ and ‘spruce’. Throughout this paper, we used ‘Species’ to refer to this inclusive grouping.

After an initial review, we developed a categorisation scheme consisting of the main groups and subgroups for the responses. For plants, we started from the concept of primary producers and named the group ‘Plants and other primary producers’. Thus, ‘Lichens’ were included in this group rather than in Fungi. This scheme was tested on the dataset and adjusted before finalising the version presented in Table 1. Descriptive statistics—including mean, trimmed mean, and range of the category assignments—were applied across data categories and analysed using IBM SPSS Statistics 29.0.2.0. A nonparametric Mann–Whitney U test was used to investigate possible differences between rural and urban pupils.

Table 1. Categorisation scheme of pupils’ responses to Q1 and Q2.

1. Living organism words (e.g. ‘pine’ and ‘leaf’)	
I.	Plants and other primary producers
i.	Species
a.	Tree species
b.	Other vascular plant species
c.	Algae, lichen, moss, and fern species
ii.	Life cycle–related words and ecological traits
iii.	Other naming – plant
II.	Animals
i.	Species
a.	Mammal species
b.	Other vertebrate species
c.	Insect species
d.	Other invertebrate species
ii.	Life cycle–related words and ecological traits
a.	Related to vertebrates
b.	Related to invertebrates
iii.	Other naming – animals
III.	Fungi
i.	Species
ii.	Life cycle–related words and ecological traits
iii.	Other naming – fungi
IV.	Bacteria
i.	Species
ii.	Life cycle terms and ecological traits
iii.	Other naming – bacteria
2. Habitats and environments (e.g. ‘lake’ and ‘mixed forest’)	
I.	General
II.	Forest
III.	Water

ETHICS

The ethical requirements concerning information, consent, confidentiality, and secure data storage were explained in an information letter provided to the research participants—the pupils—and their legal guardians (SFS 2003:460, n.d.; Statens offentliga utredningar, 2017). Consent was also obtained from the headmaster of each participating school and the teachers involved. The pupils and their guardians were informed via an information letter and consent form about the anonymous and voluntary nature of their participation, including the option to withdraw at any time without providing a reason. Only pupils with consent from their legal guardians before the lesson were included in the study. Pupils without consent from legal guardians were assigned to work with pictorial material related to organisms or alternative tasks, as suggested by the class teacher. The answer sheets were collected without any identifying information, such as names or other personal data. The consent forms are stored in a locked cabinet, and the empirical data are stored on an encrypted hard drive and protected following the General Data Protection Requirements (SFS 2018:218).

RESULTS

A total of 98 pupils from grades four, five, and six in six different schools participated in the study by answering two questions about visible and invisible organisms in a photograph of a Nordic landscape (Figure 1). The primary dataset included 1038 words provided by the pupils, words which were sorted using the categorisation scheme described in Table 1.

Habitats and environments

The categories ‘general’, ‘forest’, and ‘water’ emerged from the pupils’ responses regarding habitats and environments. Words such as ‘wilderness’ and ‘nature’, as well as ecological terms, such as ‘vegetation’ and ‘soil’, were grouped under the category ‘general’. A total of 71% (n=70) of the pupils mentioned the lake using the terms ‘lake’, ‘water’, or other water-related words such as ‘pond’ or ‘river’; all were categorised under ‘Water’. The most frequently used word to describe the forest habitat was ‘forest’ (n=27), besides ‘birch forest’, ‘deciduous forest’, and ‘mixed forest’. Three pupils referred to the lake as ‘sea’.

Table 2. Habitat- and environment-related words in response to Q1 and Q2.

2. Habitats and environments (N=194)
I. General (n=27)
II. Forest (n=43)
III. Water (n=124)

Naming of organisms in the lake and forest

In total, 637 words referred to plants, 379 to animals, 18 to fungi, and four to bacteria (Figure 2). The plant- and animal-related answers (Table 3 and Table 4) were further analysed. The number of words describing organisms in the lake and forest was 43 and 124, respectively. However, references to forest organisms were four times more numerous (145 items with 734 mentions) than those for water-living organisms (35 items with 170 mentions). The term ‘tree’ accounted for 20% (n=64) of all plant-related words for the forest (n=317). A proportion of 52% of the pupils mentioned ‘shrubs’, ‘birches’, ‘trees’, and ‘leaves’, each of which appeared in 60% – 70% of the responses to Q1. In total, 59 pupils (60%) observed the presence of water lilies.

Although the word ‘fish’ made up 75% (n=81) of the animal-related words associated with the lake (n=61), only two pupils named three specific fish species. Birds were mentioned by 40% of the pupils (n=39), typically at the taxonomical level ‘birds’. Bird species made up 33% (n=13) of the words within the bird group. The word ‘bird’ comprised 12% (n=44) of the animal-related words. However,

only 15 pupils named 12 bird species altogether. Of the bird mentions, nine were associated with the lake, for example, ‘duck’ and ‘swan’, and four with the forest, such as ‘owl’ and ‘bluetit’. One mention of a ‘crab’ suggests a possibly incorrect perception of the environment.

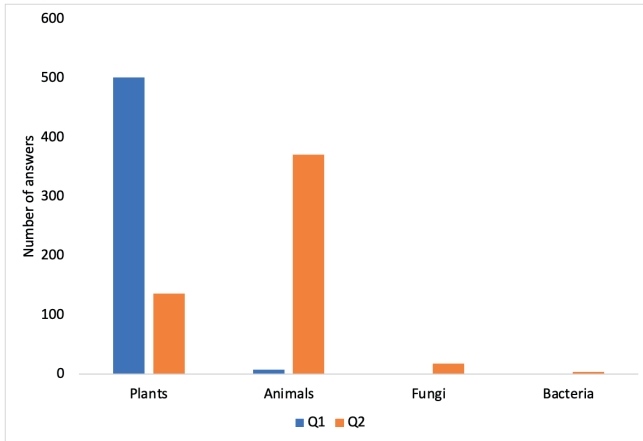


Figure 2. The number of answers to Q1 and Q2 related to plants and other primary producers, animals, fungi, and bacteria.

Animal species (n=182) were more than three times as numerous as plant species (n=58) in the Q2 responses (Figure 3). It should be noted that no animals are visible in the photograph. The category ‘Other naming’ accounted for approximately one-third of the terms for plants in both Q1 and Q2, but nearly half (n=176, 49%) of those for animals. Life cycle–related words and ecological traits represented less than one-tenth (n=25, 8%) of the animal-related terms. These included less frequently mentioned terms, such as ‘fry’, ‘nestling’, ‘tadpole’, and ‘birds’ nest’. Most pupils provided only a few answers, while a small number gave a broad range—this was consistent across all participating classes. This finding aligns with results from a study on learning during a holiday activity for children at a public aquarium (Ferlin et al., 2025). Only four responses included the life-stage form ‘tadpole’. In contrast, life cycle and ecological trait words made up 22% (n=110) of plant-related responses to Q1.

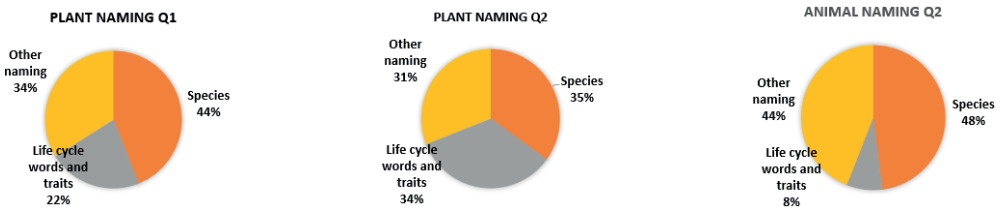


Figure 3. Distribution of plant and animal naming in response to the questions ‘What do you see in the picture?’ and ‘What else could be there, even though you cannot see it?’.

Naming of plants and other primary producers

Plant-related words accounted for 61% of all responses to Q1 and Q2 combined (Table 3), ranging from 0 to 28, with a median of 6.5.

Table 3. Plant-related words in response to Q1 and Q2.

1. Plants and other primary producers (N=637)
i. Species (n=271)
a. Tree species (n=113)
b. Other vascular plant species (n=137)
c. Algae, lichen, moss, and fern species (n=21)
ii. Life cycle-related words and ecological traits (n=155)
iii. Other naming – plants and other primary producers (n=211)

Tree-related words formed the largest subgroup of answers to both questions, with 331 mentions (52%). Tree species constituted 42% (n=113) of all named plant species. The most frequently mentioned tree was 'birch' (61%, n=60). Combined, 'spruce' and 'pine' accounted for 36% (n=35) of the tree species. A total of 17 pupils mentioned 12 distinct tree species. Deciduous trees (n=74) were mentioned more often than coniferous ones (n=38). Fourteen pupils (14%) mentioned common plants bearing edible berries.

Naming of animals

Animal-related words (N=379) make up 37% of all living organisms mentioned across both questions combined (Table 4). The number of animal-related words per pupil ranged from 0 to 32, with a median of 2. Four taxonomical terms – 'fish', 'bird', 'insect', and 'animal' – accounted for 34% (n=156) of the animal-group mentions. The words for vertebrates were nearly twice as numerous (n=220, 58%) as those for invertebrates (n=116, 31%). The remaining terms (n=43) were unspecified (e.g. 'animal', 'predator', and 'prey'). Words referring to mammals (n=71) and insects (n=75) each represented approximately 20% of the animal-related terms. Insect species accounted for 26% (n=47) of all species names. Thirteen pupils used the word 'ant'. Among the most frequently named mammals were large animals, such as 'moose' (n=11), 'fox' (n=9), and 'hare' (n=6). Species associated with the lake comprised 15% (n=31) of all named animal species. Large predators were rarely mentioned; only four references to bears, four to wolves, and one to a lynx were recorded. Mentions of amphibians and reptiles accounted for 13% (n=28) of all animal species.

Table 4. Animal-related words in response to Q1 and Q2.

II. Animals (N=379)
i. Species (n=176)
a. Mammal species (n=69)
b. Other vertebrate species (n=31)
c. Insect species (n=50)
d. Other invertebrate species (n=26)
ii. Life cycle-related words and ecological traits (n=26)
a. Related to vertebrates (n=6)
b. Related to invertebrates (n=20)
III. Other naming – animals (N=177)

Effects of proximity to nature

A statistically significant difference was found in the number of plant-related words used in the Q1 answers between rural and urban schools. Rural pupils generally mentioned more plant-related terms, with a trimmed mean of 5.6 per pupil, compared to 4.1 for urban pupils (Figure 4). This represents a

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35% higher mention rate among rural pupils. Median values showed that rural pupils reported more plant-related words ($Mdn=5$) than urban pupils ($Mdn=4$). A Mann–Whitney U test confirmed that the difference was statistically significant: $U(N=51, N=47)=702.5, z=-3.562, p=.001$.

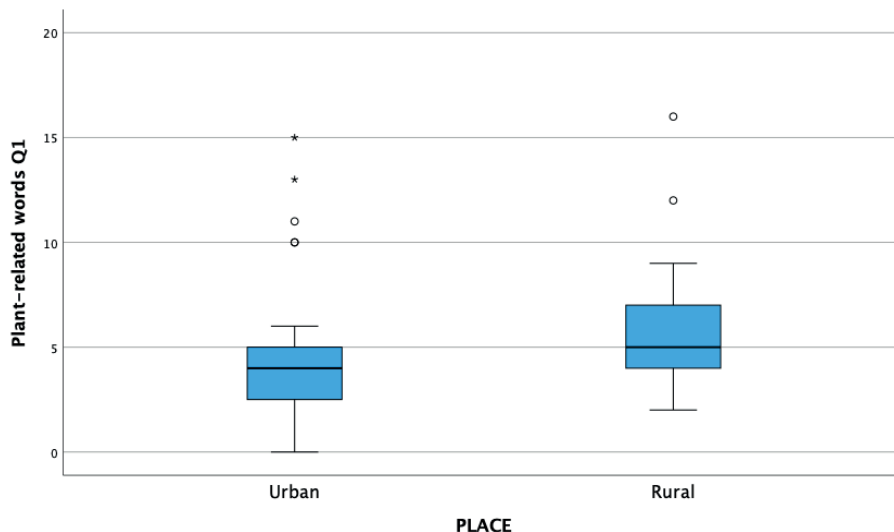


Figure 4. Plant-related words mentioned per pupil in Q1 in urban and rural groups.

Note: Boxes represent the 25%–75% quartiles, with the median indicated by a horizontal line; whiskers denote the minimum and maximum values.

Data on plant species in Q2 did not suggest a significant difference between rural and urban pupils. The trimmed means (excluding extreme values) were 0.44 for rural pupils and 0.24 for urban pupils ($U=48.81, p=.762$). Two urban pupils named seven species each, while one rural pupil listed six species. A notable difference between the groups concerned the naming of visible organisms in the photograph, particularly trees. Rural pupils mentioned ‘birch’ and ‘waterlily’ more frequently, while urban pupils more often used generic terms, such as ‘tree’ and ‘animal’ (Table 5). Rural pupils named significantly more specific tree species (69) than their urban counterparts (43) and demonstrated significantly greater knowledge of tree species overall ($U=.584, p=.001$) and of ‘deciduous tree species’ ($U=.707, p=.001$) compared to the urban pupils (Table 6). On average, rural pupils named one more tree species per pupil than urban pupils.

Table 5. Most frequently mentioned words by rural and urban pupil groups.

Word	% by rural school pupils (N=51)	% by urban school pupils (N=47).
‘birch’, ‘birch leaf’, ‘birch forest’	73	51
‘waterlily’, ‘waterlily leaf’	71	49
‘a tree’, ‘trees’, ‘different trees’	59	68
‘animal’	24	45

Table 6. Mentions of tree species in rural and urban pupil groups.

Count	Rural	Urban	Total
0	8	27	35
1	19	14	33
2	13	3	16
3	7	3	10
4	2	0	2
5	2	0	2
Total	51	47	98

DISCUSSION

In this study, we investigated the words used by pupils aged 10–12 years in West Sweden to describe two common ecosystems: the lake and the forest and the potential differences in pupils’ descriptions based on their proximity to nature, as reflected by their place of residence. The discussion section reflects on the material collected using photographs and a free listing of words, based on pupils’ perceptions of common ecosystems and implications for practice.

Photographs as a data collection method

In our study, pupils adopted the photographer’s perspective and examined the flat photo surface as if it depicted a scene beyond it (Gibson, 1986). While photographs represent real-world depth, they exist as two-dimensional representations (Erkelens, 2018). As such, a digital screen conveys both ‘real’ and ‘perceived’ (learned) affordances. For an affordance to be real, it must be visible to the viewer (Norman, 1999). A computer screen carries physical affordances for manipulative actions, whether through direct touch or via a trackpad (Bub et al., 2018). The very existence of a digital screen renders the image real and encourages users to manipulate it using their fingers as an experience-based action. High-quality photographs provide sufficient detail to induce post-Gibson affordances, such as ‘motor affordances’, which are involved in reach-and-grasp actions directed at objects with defined structures and surfaces (Pappas, 2014). In this study, pupils scanned the image visually and mentally zoomed in and out, drawing on associations with the ‘world outside the picture’ (Holšánová, 2001, p.52).

Despite the common occurrence of these habitats in Sweden, the chosen motif may have posed a limitation for pupils with prior knowledge of other Swedish landscapes, for example, those dominated by agriculture, as in Scania. The inclusion of close-up photographs and a broader variety of lake and forest habitats might have reduced potential bias and provided a more accurate measure of pupils’ ecological literacy. Rural and urban pupils’ perceptions of common ecosystems and implications for practice are discussed.

A free listing of words as a sampling method

Free listing is a valid sampling method (Weller & Kimball Romney, 1988). For example, it was employed to assess pupils’ knowledge of animal species at ages 6, 10, and 15 across six countries, revealing a general awareness of mammals as examples of animals (Patrick et al., 2013). In our study, the first question prompted pupils to list words describing what they could see in the photograph’s environment. The second question encouraged them to recall and list items based on prior knowledge

of the lake and forest ecosystems, thereby increasing reliability. The inclusion of two questions introduced a complication in the analysis due to the duplication of some words. However, the duplicates were too few to affect the statistical validity.

The grammatically factual answers (for example, 'fox', 'root', etc.) are easily categorised by frequency and could be reproduced across various contexts, irrespective of language or topic (Worley, 2015). We noticed that the diversity of responses offers potential as an instructional assessment method. The open-ended format offers a broader recall of knowledge compared with a fixed, preselected set of photographic stimuli.

Pupils' perceptions of common ecosystems

Pupils in both rural and urban groups used more words to describe the forest than the lake, and recalled more animal species than plant or other primary producers or fungal ones. Animal species associated with the forest accounted for 85% ($n=171$) of the responses to the question about what might be present but not visible. Plant-related words dominated largely due to frequent mentions of 'leaf' and 'branch' (Figure 3). Organisms associated with the lake comprised 15% ($n=31$) of all species mentioned. The difference in naming organisms between the forest and lake environments aligns with findings from a Norwegian study on preschool children's species knowledge (Wold et al., 2023).

Several noteworthy patterns emerge both within and between the rural and urban groups. First, each question elicited a range of responses, from none to many, regardless of residence. However, pupils who mentioned only one word outnumbered those who listed several. Similar findings have been reported in studies conducted in Israel and Finland (Bashan et al., 2021; Kaasinen, 2009). Second, the pupils frequently mentioned animals, even though none were visible in the photograph. This effect may be due to a memory advantage for animals or a general preference for them over plants, which could explain why three times as many animal species were named (Balas & Momsen, 2014). Familiar mammals, such as 'squirrel', 'moose' and 'fox', were relatively scarce in the data, although rural pupils mentioned mammal species more often than their urban peers. Third, pupils often used generic subgroup or life-form terms, such as 'plant', 'grass', 'tree' or 'shrub'. This is consistent with the use of nonspecific plant terms by pupils aged 8–16 in Switzerland (Lindemann-Matthies, 2002) and supports existing research on the widespread disinterest and unawareness in plants (Vujaković, 2019; Parsley, 2020; Wandersee & Schussler, 1999). Similar results were found in a Finnish study on students' species knowledge. The fourth key finding is a low level of knowledge concerning invertebrates and life-stage forms in both the lake and forest ecosystems, echoing previous findings from Finland (Yli-Panula & Matikainen, 2014). This effect is despite the frequent appearance of organisms—for example, tadpoles—in biology textbooks aimed at this age group. Similarly, limited use of life cycle-related vocabulary in pupils' ecological responses has been observed at the elementary level in the United States (Shepardson, 2002). Ecologically significant groups, such as bacteria, fungi, and mosses, were also rarely mentioned in the present study.

The results suggested that the rural pupils perceived the greenness of the forest in a more nuanced way than their urban counterparts did. The pupils' use of a greater number of plant-related words and identification of more tree species than pupils from urban areas suggests plant awareness. Also, they recalled 14% more forest-dwelling vertebrates than pupils in urban schools. This result aligns with those of a study on vertebrate knowledge (Gerl et al., 2021) and with observations of pupils from smaller towns who demonstrated deep knowing of wild species (Barrutia et al., 2022). Overall, pupils in both groups mentioned a few plant, animal, and fungal species. Animals were preferred over plants and other primary producers, and a substantial variation was found in individual knowledge levels. We anticipate that the growing alignment between rural and urban lifestyles—particularly concerning digital leisure activities—may eventually diminish the ecological knowledge of rural pupils as well.

Implications for didactic practice

Varied use of the senses improves individuals' experiencing of the world (Marton, 2015). Mobile applications can enhance species knowledge (Coskunserce, 2024; Iskrenovic-Momcilovic, 2023). Hands-on investigations and the observation of living animals improve student attitudes (Sammet & Dreesmann, 2017; Wilde et al., 2012) and motivation for self-directed learning (Hummel & Randler, 2012). However, the dominant interest in animals should not dictate instructional content, and educators should resist pupils' one-sided focus to ensure that broader curriculum goals are met (Sanders, 2007). We argue for increased outdoor instruction focusing on species in the forest, aquatic environments, and particularly those found in the soil but not visible to the naked eye.

Broad ecological literacy supports pupils in transferring knowledge across ecosystems (Magntorn, 2007). The low number of references to life-cycle stages in the lake and forest environments does not support the development of such transfer. This insight could inform instruction before and after specific lessons to enhance pupils' ability to 'read nature'. Words such as 'prey' and 'predator' or 'water plant' and 'water animal' point to ecological functions and can serve as starting points for learning transferable concepts in the early school years. The question 'What do you see in the picture?' prompted pupils to mention producer-level organisms. However, responses to the question 'What else could be there, even though you cannot see it?' included only a few mentions of such organisms, suggesting an area for instructional emphasis.

Pupils were not asked to provide examples of food chains. However, the results indicate that fewer than half (44%) of the pupils would have been able to construct a realistic three-level food chain. Nevertheless, the broad variation in pupils' knowledge supports the need for a joint ecological literacy resource (Blatchford et al., 2006). As such, mapping knowledge through open-ended questions linked to a photograph can serve as an effective teaching method.

CONCLUSION

The words used by middle school pupils to describe nature reveal multiple aspects of their ecological perceptions. Animals are often 'seen' and imagined, even when not visible. Furthermore, they tend to be perceived at the species level, whereas plants are more often identified through life-cycle traits or organs. Many groups of organisms that occupy ecologically important roles were rarely mentioned. Pupils' ecological literacy—encompassing knowledge of species, life cycles, and traits—is fundamental to understanding biodiversity and sustainability. The use of open-ended questions in combination with a photograph uncovered a wide range of 'reading nature' abilities among pupils, independent of residential background. Proximity to nature may enhance a pupil's capacity to discern and identify species. The results of this study can support educators in developing more effective teaching strategies. Therefore, we propose that future research investigate the affordances that enable pupils to perceive ecosystems by actively observing and searching for organisms beneath, upon, and beyond visible surfaces.

USE OF ARTIFICIAL INTELLIGENCE

No AI-based tools were used to edit this text except the built-in proofreading functions in Microsoft Word and the free version of Grammarly (www.grammarly.com).

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