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ORIGINAL ARTICLE

Biodiversity Conceptualization and Plant Blindness in Portuguese Student Teachers

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ABSTRACT

Biodiversity is a multidimensional concept, and its integration into school curricula is essential for promoting sustainable development. Plants are central to the biodiversity of ecosystems; however, student teachers often fail to recognize them and understand their importance. This phenomenon, known as "plant blindness," was first introduced in the late 20th century. This study is focused on a Portuguese pre-service teacher education degree in Basic Education and addresses the following problem: To what extent educational strategies that value interaction with plants contribute to the promotion of biodiversity and to prevent plant blindness in student teachers? Twenty-seven undergraduate students enrolled in two elective subjects completed a questionnaire before and after the implementation of educational strategies, which included field trips and research activities. Data from a selection of questions are presented, regarding some dimensions of the concepts of biodiversity and plant blindness, namely, students' interest in nature and biodiversity, the complexity of their conceptualization of biodiversity, and their awareness and knowledge of plants. Key findings reveal a significant improvement in reducing plant blindness and enhancing understanding of biodiversity but not in students' interest. The overall results highlight the importance of exploring plant rich environments and introducing students to plant biodiversity in their immediate surroundings, but also the resistance of concept change.

KEY WORDS: Biodiversity; plant blindness; pre-service teacher education

INTRODUCTION

The concept of biological diversity, introduced in 1992 by the Convention on Biological Diversity at the Earth Summit in Rio de Janeiro, encompasses three different levels of diversity: genetic diversity, species diversity, and ecosystem diversity. Today, the concept of biodiversity is understood more broadly, including other components such as functional groups, species interactions, and population sizes (Bermudez and Lindermann-Matthies, 2020). Nevertheless, biodiversity is often narrowly perceived as merely the variety of species in a given place, presenting challenges to the teaching and learning process of this subject, at different levels of education. The study of biodiversity should be one of the essential subjects in science education in the pre-service teacher education since teachers can play a crucial role in increasing pupils' plant knowledge.

Students often display a lack of awareness regarding biodiversity, particularly plant biodiversity (Borsos et al., 2023; Çil and Yanmaz, 2017; Pedrera et al., 2021). For instance, many students are unable to identify the most common trees and wild plants that surround them in their daily lives (Kaasinen, 2019; Lindemann-Matthies, 2005; Pedrera et al., 2021). This phenomenon, known as plant blindness, encompasses not only the inability to see or notice plants in the environment but also the lack of understanding about their importance and unique characteristics (Wandersee and Schussler, 1999).

In the 1990s, American botanists and biology educators James H. Wandersee and Elisabeth E. Schussler launched a campaign to enhance public understanding of plants, called "Prevent Plant Blindness" (Wandersee and Schussler, 1999). These botanists introduced the term "plant blindness" to highlight the widespread tendency of society to overlook plants. This term was broader in scope than earlier concepts such as zoocentrism or zoochauvinism, which had been used in the 1980s (Parsley, 2020; Wandersee and Schussler, 1999). Plant blindness is defined according to four dimensions: (a) The inability to see or notice the plants in one's environment; (b) the inability to recognize the importance of plants in the biosphere and in human affairs; (c) the inability to appreciate the esthetic and unique biological features of the life forms that belong to the Plant Kingdom; and (d) the misguided anthropocentric ranking of plants as inferior to animals and thus, as unworthy of consideration (Wandersee and Schussler, 1999, p.1).

Some symptoms of plant blindness include the inability to see or notice plants in daily life, and the lack of hands-on experiences in growing, observing, and identifying plants in their own geographic region (Wandersee and Schussler, 1999; 2001). In addition, plants are often mistakenly classified as non-living organisms (Amprazis and Papadopoulou, 2020). More recently, Parsley (2020) introduced the term "plant awareness disparity" to address the ableist implications of the term "plant blindness." Pany et al. (2022) further streamlined

this by adopting the term "plant awareness." However, in this study, the authors chose to use the original term proposed and conceptualized by Wandersee and Schussler, as it defined dimensions facilitate the operationalization of the concept.

Different studies researched the implementation of educational strategies designed to prevent plant blindness and to increase undergraduate students' interest in plants (e.g., Colon et al., 2020; Hiatt et al., 2021; Wells et al., 2021). In a study involving 474 students who participated in an immersive botanical experience as part of a general biology course at an U.S. university (Colon et al., 2020), results showed a significant improvement in students' positive perceptions of botany in general. Another project involved a hands-on experience in which students planted a native pollinator garden on a US university campus. This project assessed students' appreciation and knowledge of native pollinator habitats in their everyday lives (Wells et al., 2021) and the results highlighted the importance of such activities in reducing plant blindness. Similarly, Hiatt et al. (2021) reported comparable outcomes in a study where 437 students of four US universities engaged in authentic research opportunities focused on dual themes of plant biology and global change. Even higher education biology students exhibit plant blindness (e.g., Batke et al., 2020). A study conducted in UK surveyed 88 undergraduate biology students and identified a positive correlation between the amount of content students perceived to have covered on plant biology in school and their current awareness of plants (Batke et al., 2020). In addition, when asked how educators could make plants more attractive, the most frequent response category was "contact with plants." Students would like more plant related activities outside the classroom.

Plant blindness is present among pre-service teachers (e.g., Bob-Pinilla et al., 2023); however, fewer studies have focused on research into educational experiences within initial teacher training courses. Nyberg et al. (2019) investigated the observations of 94 Sweden elementary student teachers at a science center, where animals were the main focus, and in a greenhouse at a botanical garden, where plants were the central feature. The results point out a predominance of animal references in the student teachers' responses at the science center and a predominance of plant references at the botanical garden. The authors concluded that plants in these indoor environments must be presented in ways that make them more noticeable. In another study by Borsos et al. (2023), conducted in three higher education institutions in Serbia, Croatia, and Hungary, 151 student teachers were divided into intervention and control groups. The intervention group participated in outdoor classes at their respective institutions and demonstrated better plant identification knowledge compared to the control group. The study is an exploratory study focused on a Portuguese pre-service teacher education, specifically a three-year undergraduate degree in Basic Education. It addresses the following problem: To what extent educational strategies that value interaction with plants contribute to the promotion of biodiversity and to prevent plant blindness in student teachers? The study is part of a broader project centered on the study of biodiversity on the campus of the of the Polytechnic Institute of Setúbal, Portugal, aligning with Sustainable Development Goal 15, which focuses on life on land. Ignoring plants can prevent environmental balance and hinder the achievement of Sustainable Development Goals (Amprazis and Papadopoulou, 2020)

METHODOLOGY

Context and Participants

Our sample consisted of 27 undergraduate students, aged between 19 and 42 years. Those students attended the subjects "Environmental Studies" (n = 11) or "Experimental Research Workshop" (n = 16), semestral options of the second year of undergraduate degree in Basic Education (elementary school), in 2021/22, at the School of Education of the of the Polytechnic Institute of Setúbal. Those students completed a questionnaire about biodiversity and aspects related to the phenomenon of plant blindness, administered both before and after the implementation of the educational strategies in each subject. This instrument was applied at two moments: first, at the beginning of the semester, and again at the end of the semester.

Questionnaire

The questionnaire was adapted from Pedrera et al. (2021) to account for the unique biodiversity of the Polytechnic Institute of Setúbal campus, located in a former cork oak forest, with about 10 ha of green area, mostly with native Mediterranean forest species. The research instrument was also enhanced to better identify pre-service teachers' conceptions related to plant blindness. The following question, adapted from Jose et al. (2019), was included: what do you observe in the image (Figure 1)?

The questionnaire consists of 19 questions, divided into five groups: the first gathering information about the students (questions 1–3); the second focusing on contact with and interest in nature and biodiversity (questions 4–8); the third centered on knowledge of biodiversity and its importance

Figure 1: Photograph of question 11 from the questionnaire (Source: https://www.inaturalist.org/observations/59691280). (©naturpel, CC BY-NC)

(questions 9 and 10); the fourth centered on identifying plants and animals (questions 11–14); and the fifth addressing knowledge of plant physiology and the role of plants in ecosystems (questions 15–19).

The paper specifically explores the questions most related to biodiversity and plant blindness, namely question 4 (contact with nature), question 5 (self-perception of biodiversity knowledge), question 7 (interest in biodiversity), question 8 (interest in plants and animals), question 9 (knowledge about biodiversity), question 10 (importance of biodiversity), question 11 (identification of a squirrel and an oak), question 12 (free listing of living beings), and question 13 (campus plant species identification). The analysis of these questions was mainly quantitative, however for the open-ended questions, the analysis involved content analysis, with the definition of categories and the calculation of the Cohen's Kappa reliability coefficient. IBM SPSS software, version 28, was used for this analysis.

This research instrument was previously reviewed by a third researcher, familiar with the theoretical framework of the study. It was also tested through a pilot implementation with 15 undergraduate students in Basic Education, enrolled in a different second-year option. As a result, some questions were clarified. For example, question 12, which asked students to list the names of 10 living beings of their choice, was simplified. In question 13, two photographs of species found on the campus were replaced with more detailed photographs: strawberry tree (*Arbutus unedo*) and purple milk thistle (*Galactites tomentosus*) (Figures 2 and 3, respectively).

Educational Strategies

The educational strategies implemented, in an articulated way, in the two subjects, "Environmental Studies" and "Experimental Research Workshop," were designed to explore the plant biodiversity on Polytechnic Institute of Setúbal campus, namely, herbaceous plants, shrubs, and trees. This exploration was carried out from a phenomenological perspective (Symeonidis and Schwarz, 2017), based on real-life phenomena and tasks that were both challenging and designed to promote students' autonomy, collaborative work, and experiential learning, all while fostering the mobilization and construction of knowledge. The activities carried out mainly involved field trips and research activities. Student teachers also developed competences in using the free app Seek by iNaturalist. A total of 20 plant species were identified, characterized and, whenever possible, shared on the citizen science platform iNaturalist/Biodiversity4all. This platform allows users to publish their findings and contribute to other projects (Echeverria et al., 2021; Lüsse et al., 2022). Collecting information regarding the name of a given species can serve as a starting point for a learning path about the species identified and their ecosystems as well its conservation importance.

In Environmental Studies, students analyzed different species of trees and shrubs native to the Mediterranean Forest. The guidelines for observation and gathering information about these trees and shrubs are presented in Appendix 1. Three field trips were organized to allow students to closely observe the plants under study. A supplementary lesson involved laboratory work, where students used compound microscopes and binocular magnifying glasses to observe, for example, the constituent parts of a flower. The information collected was organized into identification sheets for each of the species. Figure 2 shows the fruit of the strawberry tree (*Arbutus unedo*), a shrub found on the campus.

In the Experimental Research Workshop, students, organized into groups, studied some herbaceous plants. Each group marked out a 0.5 m × 0.5 m square (Nuffield foundation, 2008) in a specific area of the campus. For approximately 8 weeks, the groups visited their designated square weekly, recorded their observations, and were able to appreciate the changes in biodiversity at the site (Figure 4). Each group selected at least one herbaceous plant within the square and proceeded to characterize it in greater detail. Figure 3 shows a close-up of the inflorescence of one of the herbaceous plants studied,

Figure 2: Photograph of strawberry tree (*Arbutus unedo*) from the questionnaire (source: https://www.inaturalist.org/observations/141654178)

Figure 3: Photograph of purple milk thistle (*Galactites tomentosus*) from the questionnaire (source: https://www.inaturalist.org/observations/78374946)

the purple milk thistle (*Galactites tomentosus*). Appendix 2 presents the guidelines of the work carried out by the student groups.

At the end of the semester a joint field trip was organized, during which students explored the campus together and shared their findings.

FINDINGS

Contact and Interest in Nature and Biodiversity

Figure 5 presents the results of three questions from this exploratory study involving Portuguese pre-service teachers: question 4, How often are you in contact with nature?; question 5, What would you say is your knowledge about the concept "biodiversity"?; and question 7, How do you define your interest in subjects related to nature and biodiversity?. The findings indicate more frequent contact with nature (question 4) and an improved self-perception of the concept of biodiversity (question 5) following the implementation of the educational strategies. When asked about their interest in topics related to nature and biodiversity (question 7) and their preferences between plants and animals (question 8), pre-service teachers expressed moderate to high interest in nature and biodiversity, showing a stronger preference for animals over plants. Only 3.7% of the respondents exclusively chose plants (Figure 6). The results suggest that the implemented strategies did not significantly increase interest in these topics.

Figure 4: Students recording their observations in the square and using the Seek by iNaturalist app

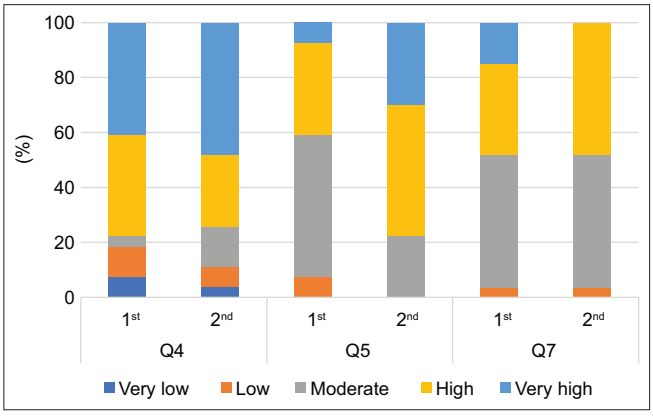

Figure 5: Portuguese student teachers' responses (%) to question 4 about contact with nature, to question 5 about knowledge of the concept of biodiversity, and to question 7 about interest in topics related to nature and biodiversity, in the initial (1st) and final (2nd) questionnaire applications

Conceptualization of Biodiversity and its Importance

With regard to the student teachers' conceptions of the term biodiversity (question 9), five hierarchical categories of increasing complexity were identified in their definitions. The reliability of this categorization was verified with Cohen's Kappa reliability coefficients of 1 and 0.80 for the initial and final questionnaire applications, respectively. The results, presented in Figure 7, suggest an enhanced conceptual understanding by the end of the semester. In the initial application of the questionnaire, most students (70.3%) defined biodiversity only as the diversity of living beings or species. By the final application, this simplified definition was maintained by 48.1% of the students, while more complex definitions emerged. These included references to the three levels of diversity (genetic, species, and ecosystems diversity) and the interactions among living organisms. Similarly, the results of the study by Pedrera et al. (2021) showed that most secondary school students initially held a simple and partial understanding

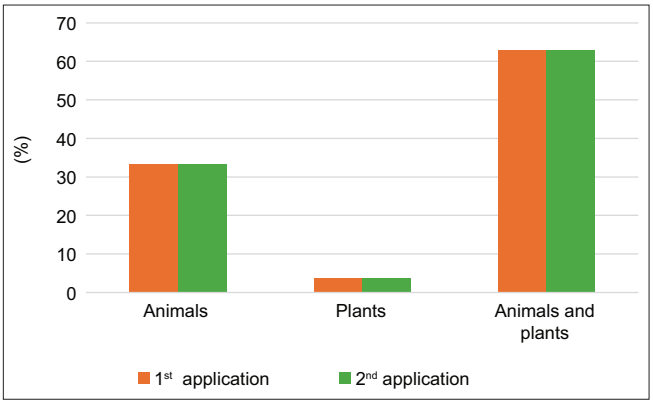

Figure 6: Portuguese student teachers' responses (%) to question 8 about interest in plants and animals, in the initial (1st) and final (2nd) questionnaire applications

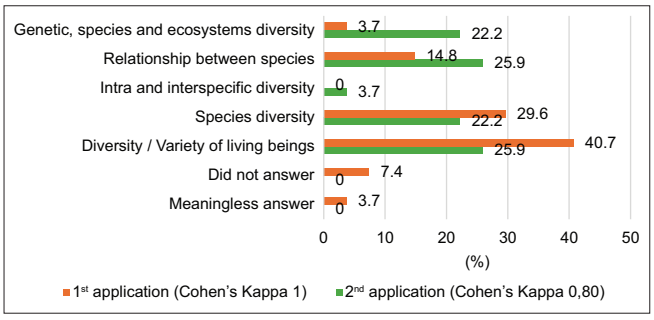

Figure 7: Portuguese student teachers' responses (%) to question 9 related the definition of biodiversity, in the initial (1st) and final (2nd) questionnaire applications

of biodiversity, focusing primarily on the diversity of living beings. Table 1 shows examples of student responses to this question and their corresponding categorization.

Regarding student teachers' conceptions of the importance of biodiversity (question 10), four hierarchical categories were used to classify their responses. The reliability of these categories was supported by Cohen's Kappa reliability coefficients of 0.78 and 0.77 for the initial and final questionnaire applications, respectively. The results, shown in Figure 8, indicate a slight improvement in recognizing the intrinsic value of biodiversity, with responses increasing from 11.1% in the initial application to 14.8% in the final one. In addition, there was a reducing in the anthropocentric utilitarian perspective, which decreased from 22.2% to 18.5%.

Listing of Living beings and Identification of Species

Figure 9 presents the results of question 11: what do you observe in the image? (Figure 1) based on responses from the 27 student teachers who participated in the study. The findings suggest a reduction in the students' plant blindness.

In the initial questionnaire application, most students (70%) identified the presence of a squirrel and a tree, with a high inter-rater reliability (Cohen's Kappa reliability coefficient 0.92). By the final application, nearly half of the students (44%) were able to identify the oak tree (Cohen's Kappa = 0.84). This increased scientific accuracy aligns with the campus exploration, where *Quercus sp.* is the most abundant species. Notably, only in the final application, students referred to the tree with its specific term, "oak," instead of using more general terms such as "tree," "stem," or "branches."

The results of the free listing of living beings (question 12) and species identification (question 13) indicated a considerable improvement in plant awareness and knowledge among the students. In the initial application, as shown in Figure 10, most students listed animals. However, in the final application, there was a noticeable increase in the number of students who included plants in their responses. Mentions of other groups were not represented in the graph; these included bacteria (2 mentions), fungi (1 mention), and phytoplankton (1 mention).

Table 2 shows the results of question 13, which assessed the identification of ten plant species found on campus. In the initial questionnaire application, most students were able to identify only a few species, such as the olive tree (63.0%), stone pine (48.1%), cork oak (29.6%), and strawberry tree

Table 1: Examples of Portuguese student teachers' answers to question 9 on the term biodiversity, in the initial application and in the final questionnaire applications.

Application	Excerpt	Category
Initial	"Biodiversity is the variety of living beings that (plants, animals, etc.)" (student A14)	Diversity of living beings
Initial	"Biodiversity is the variability of species, whether they are plants or animals" (student A2)	Species diversity
Final	"Biodiversity is the totality of the diversity of plant and animal species present in different ecosystems" (student B6)	Relationship between species
Final	"Biodiversity means the biological diversity existing in a certain place, it is related to species, ecosystems and genes" (student B23)	Genetic diversity, between species and ecosystems

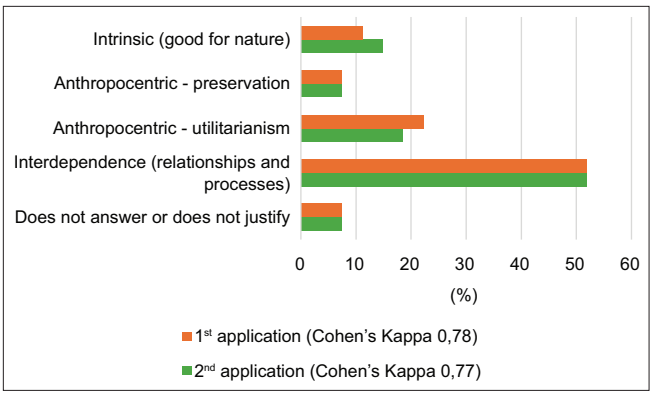

Figure 8: Portuguese student teachers' responses (%) to question 10 related the importance of biodiversity, in the initial (1st) and final (2nd) questionnaire applications

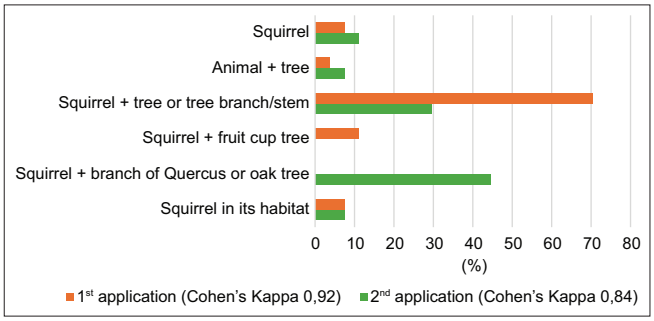

Figure 9: Portuguese student teachers' responses (%) to question 11 about identification of squirrel and oak, in the initial (1st) and final (2nd) questionnaire applications

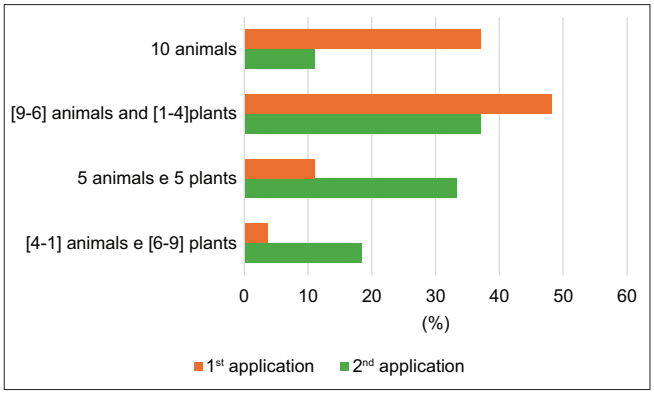

Figure 10: Portuguese student teachers' responses (%) to question 12 related the lists of living beings, in the initial (1st) and final (2nd) questionnaire applications

Table 2: Portuguese student teachers' responses (%) to question 13 on identifying ten species of flora on the [authors' institution] campus present in photographs (1–10), in the initial application and final questionnaire applications.

Categories	Initial application (%)	Final application (%)
1. Hawthorn (*Crataegus monogyna*)	0.0	51.9
2. Olive tree (*Olea europaea*)	63.0	88.9
3. Purple milk thistle (*Galactites tomentosa*)	0.0	7.4
4. Cork oak (*Quercus suber*)	29.6	70.4
5. White clover (*Trifolium repens*)	11.1	48.1
6. Stone-pine (*Pinus pinea*)	48.1	55.6
7. Myrtle (*Myrtus communis*)	0.0	74.1
8. Curled leaf rock rose (*Cistus crispus*)	3.7	11.1
9. Strawberry tree (*Arbutus unedo*)	22.2	74.1
10. Oleander (*Nerium oleander*)	3.7	3.7

(22.2%). However, the final questionnaire responses revealed improvements not only in the identification of these species but also in recognizing other species, including myrtle, white clover, and hawthorn. Knowing the names of plants will not eliminate plant blindness, but it reduces it, since learning and sharing plant names make plants more visible, and tangible (Borsos et al., 2023). Nonetheless, similar to findings in the study by Pedrera et al. (2021), no student was able to correctly identify all ten species.

DISCUSSION AND CONCLUSION

Plant blindness is a significant barrier to understanding the crucial role plants play in sustaining life on Earth, as well as to developing a comprehensive perspective on biodiversity and nature (Kletecki et al., 2021; Nyberg et al., 2019; Wandersee and Schussler, 2001). Addressing this phenomenon is essential in pre-service teacher education, where future educators influence how biodiversity and environmental issues are perceived and taught.

In this exploratory study, we investigated student teachers' conceptions of biodiversity and plant blindness before and after the implementation of educational strategies that value interaction with plants. Our findings suggest that these educational strategies contributed to a change in the student teachers' conceptions of biodiversity and a reduction in plant blindness. However, the results also show the resistance of conceptions change, which highlights the importance of a continuous and articulated work and contact with nature, particularly local environments, as a teaching and learning context.

The results reveal a more frequent contact with nature and an improved understanding of biodiversity, after the implementation of the educational strategies. By the end of the semester, student teachers demonstrated a more complex conceptualization of biodiversity, progressing beyond simplistic definitions to include genetic, species, and ecosystem diversity. Free listing of living beings and species identification also showed considerable improvement in plant awareness and knowledge. These findings align with the study conducted in Serbia, Hungary, and Croatia, where outdoor educational strategies were found to enhance student teachers' plant identification knowledge (Borsos et al., 2023).

Therefore, our study highlights the critical role of outdoor education in higher education. Although several studies have emphasized the importance of outdoor activities in primary and secondary education (Fančovičová and Prokop, 2011; Hellinger et al., 2022; Lindemann-Matthies, 2005), more research is needed into educational experiences in initial teacher training courses. Outdoor classes, particularly those using school grounds and local environments, provide accessible and authentic contexts for fostering deeper engagement with biodiversity. Similarly, as Bobo-Pinilla et al. (2023), suggest, promoting hands-on experiences with plants from nearby environments can strengthen the connection between students and plants, and contribute to overcoming plant blindness.

In line with the GreenComp European Sustainability Competence Framework (Bianchi et al., 2022), bringing nature back to our lives implies enhancing contact and connection with natural environments. By exploring schools' surroundings, student teachers were able to notice and identify plants and to recognize their vital contribution to biodiversity. This connection is pivotal, as teachers play a fundamental role in promoting plant education and preventing plant blindness (Kletecki et al., 2021; Strgar, 2007).

While this study provides valuable insights, its conclusions cannot be generalized due to its exploratory nature and limited scope. Nonetheless, the findings offer important implications for pre-service science teacher education. The analysis underscores the value of utilizing school grounds and nearby natural environments as dynamic teaching contexts. These spaces provide tangible opportunities to engage with biodiversity, emphasizing the importance of plants within ecosystems and placing local biodiversity in a global context.

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APPENDIX 1

Group Work Guidelines: What do we want to know?

Data to collect:

1. Common names
2. Scientific name
   2. 1. Variety
   2. 2. Family
3. Conservation status
4. Native species; non-native (indicating if invasive)
5. Origin (text and map with location)
6. Distribution in Portugal (text and map)
7. Habitat
8. Dimensions (average values)
   8.1. Trunk perimeter
   8.2. Height
   8.3. Canopy area
9. Longevity (average value)
10. Morphology
    10.1. Stem (trunk for trees) – Shape, color, bark
    10.2. Leaf – deciduous/evergreen; color; leaf type (simple/compound); length; image; if simple: shape, margin, venation
    10.3. Reproductive structures
        10.3.1. Monoecious/dioecious/hermaphroditic species
        10.3.2. Inflorescence - Unisexual (female or male), hermaphroditic flowers; color; (image)
        10.3.3. Inflorescence - Cones ("pine cones") – female/male; color (image)
        10.3.4. Fruit – name; type of fruit; dry/fleshy; image
    10.4. Calendar – flowering and fruiting periods
11. Similar species
12. Life in the trees – observed living beings – name; relationships between species (feeding; protection;…); image (photo)
13. Observations/Curiosities – name origin; growth rate; environmental adaptations; pests and diseases; toxicity; special care; water needs; others.
14. Presence in our culture – handicrafts; literature; painting; popular music; gastronomy;… (text and images); economic value; utility (e.g., ornamental, medicinal, food) (text and images)

APPENDIX 2

Group Work Guidelines: Getting to know and promoting campus biodiversity

The group project will be developed throughout the semester and should be organized around three fundamental components:

1. Selection of the location and weekly observations
   1.1. Each group marks a square of 0.5 m × 0.5 m on the IPS campus, near the School of Education.
   1.2. Record the GPS coordinates of the location.
   1.3. Take photographs of the site regularly.
   1.4. Create a graphical representation of the square, marking different specimens and respective counts.
   1.5. Recording of meteorological conditions.
2. Identification of species present in the square
   2.1. Install the Seek by iNaturalist app on your mobile phone.
   2.2. With the help of the app, whenever possible, identify the species present in the square, indicating their specific and common names whenever possible.
   2.3. Confirm species identification using additional digital tools (e.g., Flora-on https://flora-on.pt/index.php#; Encyclopedia of Life https://eol.org/)
3. Final presentation: Understanding and preserving campus biodiversity
   3.1. Introduction, explaining the concept of biodiversity and its importance.
   3.2. Location and description of the square.
   3.3. Weekly records of the square (quantitative and qualitative), observations, predictions, classification of observed species, and interpretation of observations.
   3.4. Characterization of one herbaceous species found within the campus square.
   3.5. Final reflection, focusing on key learnings and challenges encountered during the project.
   3.6. Bibliographical references used throughout the project should be included at the end of the work following APA 7th edition guidelines.