European Journal of Science and Mathematics Education, 2023, **11**(2), 234-248
ISSN: 2301-251X (Online)

OPEN ACCESS

Research Article

Plant awareness disparity among students of different educational levels in Spain

Javier Marcos-Walias [1*]
0000-0002-3111-4348

Javier Bobo-Pinilla [2,3]
0000-0001-9600-2657

Jaime Delgado Iglesias [3]
0000-0001-8726-6976

Roberto Reinoso Tapia [3]
0000-0003-0476-4975

[1] Department of Botany, University of Salamanca, Salamanca, SPAIN
[2] Department of Didactics of Experimental Sciences and Mathematics, University of Salamanca, Salamanca, SPAIN
[3] Department of Didactics of Experimental, Social, and Mathematical Sciences, University of Valladolid, Valladolid, SPAIN
[*] Corresponding author: javimarcosw@usal.es

Citation: Marcos-Walias, J., Bobo-Pinilla, J., Delgado Iglesias, J., & Reinoso Tapia, R. (2023). Plant awareness disparity among students of different educational levels in Spain. *European Journal of Science and Mathematics Education, 11*(2), 234-248. https://doi.org/10.30935/scimath/12570

ARTICLE INFO

Received: 30 Aug 2022

Accepted: 15 Oct 2022

ABSTRACT

Plant awareness disparity (PAD), formerly known as plant blindness, refers to the fact of overlooking or failing to perceive plants, perhaps due to poor 'species literacy'. Despite numerous efforts made by scientists and educators over the years, PAD is still present in students at all educational levels. An assessment was carried out on 259 students from primary school to university in the Spanish education system to evaluate their species literacy, especially regarding local flora and fauna, its possible improvement across educational levels, and to assess whether PAD was a reality among students. A biased perception towards animals was confirmed with strong statistical support. Animals were recognized and identified more than plants at all educational levels. Even if a positive correlation for animal-plant literacy was found, the values were weak. Although the curricula set out content and learning outcomes related to local environment and flora, their teaching has been proven to be unsatisfactory. The recently implemented curricula have the mission to reverse this trend, which can be done by improving students' interest in plants through specific educational programs and activities, as well as comprehensive training in the field of botany and the effective implementation of activities for current and future educators.

Keywords: plant awareness disparity, plant blindness, environmental education, university students

INTRODUCTION

Biodiversity loss is one of the main environmental problems facing biologists and the planet Earth itself nowadays (Cardinale et al., 2012). The current reduction in the number of species leads to a deregulation in ecosystem dynamics, with harmful consequences for its structure and components, including human beings (Cardinale et al., 2012). Biodiversity conservation is a task for society as a whole, as emphasized by the Convention of Biological Diversity (United Nations Organization, 1992). Thus, the Convention establishes the need to promote educational programs aimed at awareness-raising, identification, and sustainable exploitation of biodiversity, as well as at including in educational curricula necessary measures to preserve it.

Science education for young people, specifically in environmental education (EE), is one of the current challenges for society and education systems (Hudson, 2001). EE is defined as a 'continuous process in which individuals and communities become aware of their environments and acquire knowledge and skills that allow them to act, both individually and collectively, in order to solve present and future environmental problems (Monroe & Krasny, 2016; UNESCO, 1978); moreover, at least three of the sustainable development goals (13, 14, and 15) focus on biodiversity, as well as on quality education (goal 4). Therefore, EE is supposed to make students aware of the need to preserve the environment. EE-related contents are well represented in all educational stages of the Spanish education system, regulated from 2013 to 2020 by the Organic Law 8/2020, of 29 December (Ministry of Education, 2013). The curricula at all levels reflect an adequate and proportional representation of contents related to both botany and zoology (Ministry of Education of the Community of Castilla and León, 2015a, 2015b, 2016). Nevertheless, the integration of EE in the classroom has been complicated despite the fact that environmental contents are present in the curricula (Suárez-López & Eugenio-Gozalbo, 2021; Sureda-Negre et al., 2014). In general, specific long-term extracurricular programs have tried to ensure that students acquire the necessary skills in EE, which can also be conceived as competences in environmental health (Fernández et al., 2016; Sánchez-Llorens et al., 2019). This task becomes even more important in a context of climate change and biological crisis.

As an essential part of the EE, botany has permeated the daily life of many societies, such as the British (Sanders, 2007). However, interest in botany has now diminished, especially among young people (Bebbington, 2005; Kubiatko et al., 2021). This fact has generated, and continues to do so, concern among botany researchers and teachers, as it not only implies a loss of technical and scientific knowledge of new generations, but also the ignorance of both the native flora and its traditional uses (Hooykaas et al., 2019; Signorini et al., 2009). This is even more worrying considering that plants constitute around 80% of the total biomass of the planet and play a fundamental role in such important aspects as ecological security, food, climatic and environmental sustainability, medicine, nutrient cycles, and the water cycle (Jose et al., 2019). Furthermore, research has shown that teaching with and about plants represents a pedagogical handicap even for biology teachers (Wandersee, 1986).

Related to the above, more than two decades ago a unique phenomenon occurring in society was detected and defined as 'plant blindness' (Wandersee & Schussler, 1999). This term could be transcribed as 'blindness' towards plants and was defined by the authors as the 'inability to see or notice the plants in the environment, to recognize their importance in the biosphere and for humans, to appreciate their differential and unique physical and biological characteristics, in addition to the perception that plants occupy a lower status than animals and human beings' (Wandersee & Schussler, 1999). In this sense, it has been shown that many students have a limited view of what plants are (Bianchi, 2000; Jose et al., 2019). There are many studies on how students perceive or identify plants (Pedrera et al., 2021; Sanders, 2007), especially in relation to animals. Despite the supposedly equal representation of botany and zoology contents in curricula (Amprazis et al., 2021; Schussler & Olzak, 2008), research to date confirms the inequality between the degree of students' knowledge on plants versus animals (even when they have to visually recognize specific organisms), biased towards the latter. There has also been a loss of interest in fieldwork, which is considered endangered (Barker et al., 2002), even though it has been proven to be of paramount importance for learning and being interested in biodiversity (Scott et al., 2012). This is a concerning fact, especially as students' interest in plants and botanical learning can be enhanced through an appropriate addressing of the differences between animals and plants and direct activities with plants that appeal to children (Kubiatko et al., 2021; Wandersee, 1986). The concept of 'plant blindness' has recently been renamed (Parsley, 2020) as 'plant awareness disparity' (PAD), trying to avoid ableist language, since 'blindness' towards plants implies equating a visual disability to a deficient perception of plants, which can obviously be through other senses other than sight (McDonough MacKenzie et al., 2019). This concept suggests that although plants may go unnoticed, this would be a partial fact, so education can change this by increasing 'species literacy' (Hooykaas et al., 2019), defined as the knowledge, interest, and attitude about some species. Interest in nature has been shown to be an important variable for species identification skills (Palmberg et al., 2019), which could be used as a measure of how (dis)connected people and nature are (Hooykaas et al., 2019).

Thus, the main objective of this study was to evaluate the species literacy of students at different educational levels in the autonomous Community of Castile and Leon (Spain), through their ability to name endangered species and to identify several species native to the Iberian Peninsula and the Canary Islands; specifically, it intended to answer the following questions:

1. Are students able to mention both threatened animal and plant species? If so, is there any meaningful difference between their answers?
2. Is there an improvement in students' degree of species knowledge about animals and plants across different educational levels?
3. Despite the plant-related content and learning outcomes set out in the curricula, is PAD a reality among students at different educational levels?

MATERIAL & METHODS

Study Design

A knowledge assessment test was designed, similar to previous research (Hooykaas et al., 2019; Kaasinen, 2019; Skarstein & Skarstein, 2020; Wolff & Skarstein, 2020). The test consisted of two blocks with two sets of questions in each, for which the students had to write the answers down. In block 1, to objectively determine the ability to name endangered animals and plants, students were asked to list all the endangered animals (animals 1) and plants (plants 1) they knew, according to the definition they were previously explained based on IUCN (2012); positive results were considered with respect to the IUCN (2012) lists. In block 2, students were shown a high-quality slideshow with 15 photographs of animals (animals 2) and 15 of plants (plants 2), all of them previously randomized and were asked to write down as specific names as they could (for example, 'lynx' would be considered as correct as 'iberian lynx', as well as answering 'fern' instead of 'bracken'). To standardize the test, two conservation biologists supervised the species shown, so that animals and plants with a similar level of difficulty were selected. Prior to the study, a pilot test was carried out with a small sample (n=40) at the same selected levels (10 participants of each level), in order to validate the questionnaire. Results showed significant differences. All selected species were characterized by being important and emblematic of the students' closest environments (Mediterranean and temperate Iberian forests) in the Iberian Peninsula and the Canary Islands; species subject to conservation measures, flagship species, and charismatic species were included. All species followed the criteria specified in education curricula (**Table 1**).

Giving this, regarding animals, and considering the wide spectrum regarding age and area, only vertebrates were included in the study. Moreover, the images to be shown reflected the main characteristics of the species so they could be easily recognizable (whole organisms were shown, and when needed, specific details were also shown). The species chosen were the following: Iberian lynx (*Lynx pardinus*), raven (*Corvus corax*), white stork (*Ciconia ciconia*), Iberian wolf (*Canis lupus signatus*), seal (*Monachus monachus*), barn owl (*Tyto alba*), western capercaillie (*Tetrao urogallus*), lizard (*Podarcis hispanicus*), red deer (*Cervus elaphus*), salamander (*Salamandra Salamandra*), brown bear (*Ursus arctos*), bearded vulture (*Gypaetus barbatus*), mink (*Mustela lutreola*), bat (*Pipistrellus pipistrellus*) and sperm whale (*Physeter macrocephalus*) as animals, and stone pine (*Pinus pinea*), holly (*Ilex aquifolium*), oak (*Quercus pyrenaica*), dog rose (*Rosa canina*), holm oak (*Quercus ilex* subsp. *ballota*), canary dragon tree (*Dracaena draco*), orchid (*Ophrys tenthredinifera*), moss (*Sphagnum* sp.), cade juniper (*Juniperus oxycedrus*), blackberry (*Rubus ulmifolius*), milk thistle (*Silybum marianum*), poplar (*Populus alba*), bracken (*Pteridium aquilinum*), yew (*Taxus baccata*) and fir (*Abies alba*) as plants.

The test was the same for all participants, regardless of their educational level, since they were all students from the same region and therefore had the same common content and learning outcomes (**Table 1**). This design allowed us to assess whether or not there has been an improvement in the ability to recognize or recall animals and plants among educational levels. This assumption has been made in other similar studies (Pedrera et al., 2021).

Table 1. Curricula's specific contents and learning outcomes according to Ministry of Education of the Community of Castilla and León (2015a, 2015b, 2016) for each educational level

Educational level	Specific contents	Learning outcomes
Primary education	The biosphere. Living beings' different habitats.	Recognizes and explains biodiversity and identifies and gives examples of the causes underlaying species extinction. Recognizes and explains some ecosystems; fields, pond, forest, and littoral, as well as the living beings that inhabit them.
Secondary education	Kingdoms of living things. Monera, Protoctista, Fungi, Plantae, and Animalia. Biodiversity and threatened species. Ecosystems: Temperate forest (beech and oak groves), evergreen forest (pine, holm oak and juniper groves), gallery forests, and wetlands.	Identifies and recognizes characteristic examples of each one of these groups, highlighting their biological importance. Identifies examples of plants and animals typical of some ecosystems or of special interest for being endangered or endemic species.
Baccalaureate	Classification and nomenclature of the main groups of living beings. Biodiversity conservation and possible actions to avoid its loss. Experiences for the study of biodiversity.	Values the Plantae kingdom as a trigger for biodiversity. Lists the main ecosystems of the Iberian Peninsula and its most representative species. Lists the main plant and animal endemic species of Spain. Knows and explains the main threats for species and their extinction.
University	Not applicable	Not applicable

Participants

The study was conducted in two secondary schools of Salamanca and Valladolid, as well as in the Faculty of Early Childhood and Primary Education (PE) of the University of Salamanca (autonomous Community of Castile and Leon, Spain). To ensure that all students had received the same contents, they all belonged to the same region, since in Spain each autonomous community develops its own curriculum based on the minimum contents stated by the National Education Law.

The sample (n=259; **Table 2**) consisted of students from four different educational levels. To assess the PE level, students in the first year of secondary education (SE) were surveyed (n=55). Regarding SE, the test was applied to students in the last year (4th year of compulsory SE) belonging to the science pathway (n=65). The baccalaureate level (upper SE) was assessed through students in the 2nd (and last) year (n=85), belonging to the science pathway (49 students) and to the social sciences & humanities pathway (36 students). It was assumed that students in the latter pathway did not have the science-related learning outcomes of their peers in the science pathway (**Table 1**). This allowed to assess if there were any differences between itineraries within the baccalaureate level. For the university level, students in the 2nd year of the bachelor's degree in early childhood education and in the 2nd year of the bachelor's degree in PE were assessed (n=54). Participants at this level are taught some science subjects; however, these are didactic subjects, whose objective is to give them tools to teach science, not to acquire new knowledge. It is then assumed that they have a background, learned in previous educational stages (i.e., SE and baccalaureate) even though most of them come from the humanities and social sciences pathways. The educational levels were chosen to evaluate the progress of students from PE to university.

Table 2. Sample characteristics (age, sample size, and sex ratio are specified)

Educational level	Age	Sample size (n)	Sex ratio (male/female)
Primary education	12-13	55	0.77
Secondary education	15-16	65	1.24
Baccalaureate	17-18	85	0.88
University	19-20	54	0.5

Data collection was agreed with the teachers and head teachers at the different secondary schools participating in the study. Parents and legal guardians were informed of the anonymous nature of the survey, its objectives, its content, and gave their approval, being aware that they could refuse their children's participation at any time. University students were also duly informed and gave their consent for their answers to be included in the study.

Data Analysis

Data were analyzed using the SPSS v.26 software (IBM Corp., 2019). First, the following descriptive values were obtained for both blocks: mean number of species named or identified, standard error, standard deviation, minimum and maximum. Values were calculated considering the data as a set and by educational levels. Regarding block 2, values were expressed as a percentage of correctly identified images to facilitate the interpretation of the results. The normality of the data was checked using the one-sample Kolmogorov-Smirnov test, applied to both blocks and to the different levels. Due to the non-normality of the data, the Mann-Whitney U test for independent samples was applied to detect significant differences (p-value<0.05) between pairs of questions (animals vs. plants). In our case, the null hypothesis indicated a low probability that the distribution of the results of the questions related to animals and plants were different. Analyses were applied for the whole sample group, for the different educational levels separately (PE, SE, baccalaureate, and university), and also for the different groups, where necessary (science and social sciences & humanities pathways), within levels.

In addition, Spearman's correlation coefficient was calculated to determine whether, despite possible differences, there was correlation between results. Specifically, the analysis performed compared the results for animals and plants within each block (animals 1/plants 1 and animals 2/plants 2) and the relationship between the results for animals of both blocks and plants of both blocks (animals 1/animals 2 and plants 1/plants 2). This was done for the full dataset and for the different educational levels. Finally, given the non-normality of the data, the Kruskal-Wallis test for independent samples was carried out to assess possible differences between educational levels within each set of questions within each block, as well as for the two baccalaureate pathways.

Ethics Statement

This study did not require formal ethics approval. The data was completely anonymous, with no personal information collected (apart from age, sex, and a record of informed consent), and was not considered to be sensitive or confidential in nature. It was used for a purpose which falls within the remit of the original consent provided by subjects. The issues being researched were unlikely to upset or disturb participants. Vulnerable or dependent groups were not included. There was no risk of possible disclosures or reporting obligations.

RESULTS

Regarding block 1, the mean number of animals that the full set of students were able to cite was 3.53 (±2.05), while the mean number of plants cited was 0.33 (±0.62; **Table 3**).

The maximum number of endangered animals and plants cited was 12 and three, respectively, both in SE. By levels, the maximum number of correct assignments for threatened animals was, respectively, 10 (PE), 12 (SE), seven (baccalaureate), and 11 (university) (**Table 3**, block 1). For plants, the maximum numbers were two (PE), three (SE), two (baccalaureate), and two (university). At all levels, the minimum number was zero plants or animals assigned, except for PE, where all students assigned at least one animal.

Regarding block 2, the mean recognition value for animals 2 was 75.78% (±13.97%), while for plants 2 it was 22.60% (±14.47%; **Table 3**); the minimum percentage of correctly identified images was 40% for animals and 0% for plants (except PE, 10%). The maximum identification values were 100% for animals and 73% for plants (**Table 3**).

By levels, the mean scores of species recognition were low for plants (26%, PE; 17.63%, SE; 20.82%, baccalaureate; 27.91%, university). The mean recognition results for animals (88.18%, PE; 72.83%, SE; 73.47%, baccalaureate; 70.35%, university) were similar to the maximum plant recognition percentages (60%, PE; 67%, SE; 73%, baccalaureate; 73%, university), whilst the maximum percentage of animals correctly recognized was 100% for all levels, except university (93%).

Table 3. Descriptive values of the dataset

			Full set	PE	SED	Baccalaureate	University
Block-1	Animals	Mean	3.53	4.02	3.82	3.05	3.46
		SE	0.13	0.29	0.26	0.17	0.33
		SD	2.05	2.16	2.07	1.6	2.39
		Minimum	0	1	0	0	0
		Maximum	12	10	12	7	11
	Plants	Mean	0.33	0.29	0.34	0.16	0.61
		SE	0.04	0.08	0.09	0.04	0.1
		SD	0.62	0.6	0.71	0.4	0.71
		Minimum	0	0	0	0	0
		Maximum	3	2	3	2	2
Block-2	Animals	Mean	75.78	88.18	72.83	73.47	70.35
		SE	0.87	1.27	1.46	1.5	1.83
		SD	13.97	9.45	11.79	13.79	13.48
		Minimum	40	50	40	40	40
		Maximum	100	100	100	100	93
	Plants	Mean	22.6	26	17.63	20.82	27.91
		SE	0.9	1.63	1.64	1.56	2.18
		SD	14.47	12.11	13.23	14.35	16.02
		Minimum	0	10	0	0	0
		Maximum	73	60	67	73	73

Note. Block-1 refers to the level of knowledge of animals and plants in danger of extinction; Block-2 refers to the percentage of recognition of the animals and plants shown; SE: Standard error; SD: Standard deviation; PE: Primary education; & SED: Secondary education

The Mann-Whitney U test for independent samples showed significant differences between the responses given for animals and plants in both blocks (**Figure 1**). This result was also obtained with respect to the analysis carried out at the different educational levels.

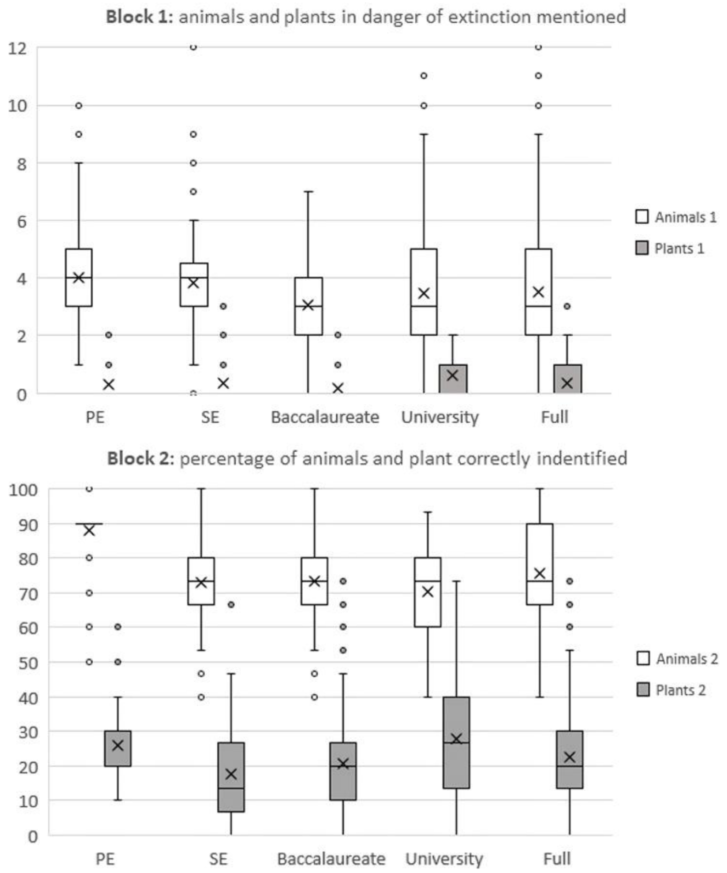

Figure 1. Box-plot of values obtained for block 1 (endangered animals & plants mentioned) & block 2 (percentage of animals & plants correctly identified) (PE: Primary education & SE: Secondary education) (Source: Authors' own elaboration)

As for the correlation analysis, the results showed significant values (p-value<0.05) for the full set in all the tests performed (animals 1/animals 2 and plants 1/plants 2, and animals/plants within both block 1 and block 2, **Table 4**). Despite this, Spearman's coefficient values showed weak correlations (**Table 4**). Note that analyses were performed over the full dataset and over the educational levels (PE, SE, baccalaureate, and university). Sciences and social & humanities itineraries were also compared separately.

Table 4. Values of Spearman's correlation analysis comparing results for animals in both blocks, plants in both blocks, and plants and animals within the blocks

		n	Correlation coefficient	Sig. (bilateral)
Animals 1/animals 2	Full set	259	.232**	0.00
Plants 1/plants 2		259	.217**	0.00
Animals 2/plants 2		259	.333**	0.00
Animals 1/plants 1		259	.121*	0.04
Animals 1/animals 2	Primary education	55	-.041	0.76
	Secondary education	65	.112	0.37
	Baccalaureate	85	.257*	0.10
	Baccalaureate science	49	.110	0.45
	Baccalaureate SS&H	36	.464**	0.00
	University	54	.463**	0.00
Plants 1/plants 2	Primary education	55	.030	0.82
	Secondary education	65	.086	0.49
	Baccalaureate	85	.263*	0.01
	Baccalaureate science	49	.347*	0.01
	Baccalaureate SS&H	36	.083	0.62
	University	54	.290*	0.03
Animals 1/plants 1	Primary education	55	.080	0.56
	Secondary education	65	.228	0.06
	Baccalaureate	85	.150	0.16
	Baccalaureate science	49	.14	0.32
	Baccalaureate SS&H	36	.26	0.11
	University	54	.094	0.49
Animals 2/plants 2	Primary education	55	.312*	0.00
	Secondary education	65	.377**	0.00
	Baccalaureate	85	.301**	0.00
	Baccalaureate science	49	.24	0.08
	Baccalaureate SS&H	36	.21	0.21
	University	54	.337*	0.01

Note. *Significant correlation at 0.05 level (bilateral); **Significant correlation at 0.01 level (bilateral); & SS&H: Social sciences & humanities

Considering the different educational levels, only the correlation between plants and animals of block 2 (animals 2/plants 2) was significant at all levels, obtaining weak correlation values (**Table 4**); however, within baccalaureate, considering the two pathways separately, the correlation was not significant for any of them. Only the correlation between animals and plants in block 1 (animals 1/plants 1) was not significant for any level. Looking at the baccalaureate pathways separately, results were only significant for the social sciences and humanities baccalaureate pathway (animals 1/animals 2) with a moderate correlation (0.464) and the science pathway (plants 1/plants 2) with a weak correlation (0.347).

The correlation in university was only non-significant for animals 1/plants 1, with weak values except for animals 1/animals 2 (0.463). PE and SE values were not significant except for animals 2/plants 2 (weak values, mentioned above).

The Kruskal-Wallis test for independent samples showed significant differences (p-value<0.05) for all sets of questions within the blocks (**Table 5**). Within the sets, significant differences were found between some pairs of educational levels: within animals 1, PE-SE, and SE-baccalaureate; within plants 1, differences were found between university and the rest of educational levels (PE and SE, and baccalaureate); within animals 2, differences were found between PE and the rest of educational levels; finally, within plants 2, differences were found between all pairs of educational levels except PE-university and SE-baccalaureate. Within the last set of questions (plants 2), significant differences were also found between the science and the social sciences & humanities itineraries (**Table 5**).

Table 5. Kruskal-Wallis test for independent samples (the test was made for animals and plants within each block [1 & 2] for all the answers and by pairs of educational level)

		Statistical	SD	Sig.
Animals 1	Total	11.52		0.01
	Primary education-secondary education	3.15	0.23	0.82
	Primary education-baccalaureate	35.70	2.80	0.01
	Primary education-university	26.30	1.86	0.06
	Secondary education-baccalaureate	32.55	2.68	0.01
	Secondary education-university	23.14	1.71	0.09
	Baccalaureate-university	-9.41	-0.73	0.46
	Baccalaureate science/social sciences & humanities	-7.98	-0.49	0.62
Plants 1	Total	20.00		0.00
	Primary education-secondary education	-1.92	-0.18	0.85
	Primary education-baccalaureate	9.84	1.00	0.32
	Primary education-university	-33.68	-3.08	0.00
	Secondary education-baccalaureate	11.76	1.25	0.21
	Secondary education-university	-31.76	-3.03	0.00
	Baccalaureate-university	-43.53	-4.39	0.00
	Baccalaureate science/social sciences & humanities	13.72	1.09	0.27
Animals 2	Total	63.04		0.00
	Primary education-secondary education	89.24	6.56	0.00
	Primary education-baccalaureate	82.12	6.39	0.00
	Primary education-university	97.75	6.87	0.00
	Secondary education-baccalaureate	-7.12	-0.58	0.56
	Secondary education-university	8.50	0.62	0.53
	Baccalaureate-university	15.62	1.21	0.23
	Baccalaureate science/social sciences & humanities	22.49	1.38	0.16
Plants 2	Total	24.22		0.00
	Primary education-secondary education	52.01	3.83	0.00
	Primary education-baccalaureate	35.81	2.79	0.01
	Primary education-university	-2.73	-0.19	0.85
	Secondary education-baccalaureate	-16.19	-1.33	0.18
	Secondary education-university	-54.73	-4.01	0.00
	Baccalaureate-university	-38.54	-2.99	0.00
	Baccalaureate science/social sciences & humanities	48.07	2.95	0.00

Note. SD: Standard deviation

DISCUSSION

Species Literacy, Species Identification Skills, & Plant Awareness Disparity

In terms of recall of endangered animal and plant species (**Table 3**), the number of endangered plant species which students mentioned versus the number of endangered animal species was very low, being biased to the latter (**Table 3** & **Figure 1**). Students named significantly fewer endangered plants than animals but were also unable to recognize as many plants as animals when photographs were shown (**Table 3** & **Figure 1**). Those results are consistent with others that have been observed under similar conditions, with plants being significantly less mentioned (Patrick & Tunnicliffe, 2011) or identified (Díez et al., 2018; Pedrera et al., 2021; Skarstein & Skarstein, 2020). It has been found that students tend to name animal species either because they are close to them in the environment or because they are 'lovable' (Nates et al., 2010); as for plants, they tend to name significant species (flag or charismatic species) rather than rare or endangered ones (Kaasinen, 2019).

Given the correlation results at all education levels (**Table 4**), the more animals, the more plants students were able to mention. Taking the two baccalaureate pathways separately (sciences and social sciences & humanities), the correlation was not significant for test animals 2/plants 2, suggesting that, unlike plant recognition (plants 2, **Table 4**), correlation between plant and animal literacy would not depend on pathways, but on educational levels. The results could be related not just to students overseeing plants, but to the fact that, for example in PE, pupils might not even consider plants as living beings (Jiménez-Tejada et al., 2013; Martínez-Losada et al., 2014), thus transferring this handicap to SE. Their characteristics (lack of movement, absence of a face, uniform colors, etc.) could lead students to overlook them (Schussler & Olzak, 2008).

Apart from the fact that students do not have problems recognizing animals from an early age, it is striking that they recognize only a few animals considered important from the point of view of conservation. This is concerning since students tend to recognize more easily exotic (Ballouard et al., 2011) or 'loveable' animals (Lindemann-Matthies, 2005) over native ones, and without any doubt over 'lifeless plants' (Lindemann-Matthies, 2005). It is worth mentioning that as it happens with plants, some authors have also detected this phenomenon associated with some animal groups, mainly invertebrates (Snaddon et al., 2008; Titley et al., 2017; Yli-Panula & Matikainen, 2014), which implies that it is not only the plant blindness effect but a greater affinity for certain animal species, mainly mammals. This is essential as it has been shown that the more people are interested on biodiversity, the more they know about it, especially about plants (Kubiatko et al., 2021; Otto & Pensini, 2017).

It has been observed that the percentage of recognition increases proportionally with age (Yli-Panula & Matikainen, 2014), with both Primary and Secondary teachers being able to identify most of the species shown (Kaasinen, 2019); despite this, and similar to other studies (Buck et al., 2019), our results show that, with respect to age, there were no increases in species recognition for either plants or animals (**Table 3**). Nevertheless, significant differences were found between certain educational levels for the answers given to each set of questions. As for plant identification (plants 2, **Table 5**), species recognition showed significant differences from one educational level to the next, except in the case of SE-baccalaureate. It is remarkable that belonging to either the science or the social sciences & humanities pathway matters for the recall of plant species, as significant differences were found between the two itineraries (plants 2, **Table 5**).

PAD could be, somehow, a consequence of the long exposure, in today's society, to media and the entertaining industry. Most of the wildlife species present in video games, cartoons, films, or even fables are animals, most of them either exotic or flagship species (Ballouard et al., 2011). It has been shown that media can influence children and teenagers and may have a positive impact on students' perception of both plants and animals, and therefore on species literacy (Holbert et al., 2003). In any case, children are quite capable of recalling and recognizing a large amount of information in a similar way they would do with biodiversity, since they identify and remember more Pokémon 'species' than local fauna and flora (Balmford et al., 2002). It is therefore the responsibility of content creators to try to make biodiversity as a whole more visible, while focusing on local biodiversity and paying special attention to plants (Almeida et al., 2020). A first step might be what has been found to help animal conservation: an appropriate anthropomorphizing of plants (Tam, 2013). This would be a good starting point to contribute to creating a strong footprint in the collective consciousness of students to counteract PAD. Otherwise, the achievement of the Sustainable Development Goals could be at risk, since biodiversity knowledge, including plants as an intrinsic part of it is the first step to protect it (Amprazis & Papadopoulou, 2018, 2020).

Curricula and Educational Disparity Between Levels

In the autonomous region where our research was carried out (Castile and Leon, Spain), natural sciences in early childhood and PE have an important weight in the curriculum, with thematic blocks dedicated to them. In early childhood education, the teaching of natural sciences is conceived from a dynamic point of view, in which pupils must 'know some animals and plants, their characteristics, habitat, and life cycle, and value the benefits they bring to health, human well-being and environment' (Ministry of Education of the Community of Castilla and León, 2008). In PE, the block dedicated to living beings has an important weight in the curriculum of each of the courses, establishing the need for students to be able to recognize and classify the main taxonomic groups of organisms, especially animals and plants, as well as identifying and explaining the causes of their extinction (Ministry of Education of the Community of Castilla and León, 2016). However, some authors have criticized the lack of dynamic procedures, resulting in a low or null curiosity among children for plants (Urones et al., 2013). It is during SE and baccalaureate when contents related to environment and biodiversity decrease (**Table 2**). Even though the subject of biology and geology is taught in five out of the six years of SE and baccalaureate together, only in three of them specific content referring to biodiversity, ecology and taxonomy are studied (**Table 2**). In addition, the fundamental principles of botany and zoology are taught during the 1st year (**Table 2**). This might be the reason underlying the apparent absence of differences between the two baccalaureate itineraries (science and social sciences & humanities), except for plant identification (**Table 5**), which is surprising given the absence of significant correlation levels for plant literacy and recognition for both itineraries (**Table 4**). These differences between itineraries could be a result of the plant-related content studied during the 1st year of baccalaureate (**Table 2**), in which students might have an improvement in their species literacy, also with regard to plants.

Environmental Education (EE) was first introduced into Spanish curricula in the Law of General Ordination of the Educational System (LOGSE), in 1990 (Ministry of Education, 1990). Since then, its integration in the classroom has been complicated, and the Spanish Education Law for the Improvement of Educational Quality (Ministry of Education, 2013) does not include the concept of 'EE'. In contrast, the legislation of the autonomous community of Castile and Leon does, but only for the SE curriculum (Ministry of Education of the Community of Castilla and León, 2015a). Thus, the environment has been considered as a human resource within the current Law, which also confuses 'sustainability' and 'sustainable development' and applies them by equating both to nature preservation (Suárez-López & Eugenio-Gozalbo, 2021). This way, it addresses the need for incoming curricula to include the Sustainable Developments Goals and innovative methods and tools that enable incoming generations to receive a comprehensive EE degree of knowledge (Amahmid et al., 2019; Suárez-López & Eugenio-Gozalbo, 2021).

In this sense, the Spanish Government has recently developed the new SE curriculum (Ministry of Education and Vocational Training, 2022) within the framework of the current Education Act (Ministry of Education and Vocational Training, 2020), which will be implemented in the academic year 2022/2023. It stablishes, for example, the need to identify, observe and classify species in the immediate environment, the importance of caring for ecosystems, biodiversity and environmentally sustainable habits, and the relationship between environmental, human, and other living beings' health as in the concept of 'one health' (Mackenzie & Jeggo, 2019). The act also seeks the reinforcement of scientific literacy to, among other actions, respect other living beings or care for the environment; moreover, it emphasizes the need for a more active, dynamic, and experimental approach to natural sciences to achieve an adequate scientific, environmental, and species literacy, also in relation to plants. However, a deeper and future analysis of it will be necessary, as well as further studies to assess the results of its implementation.

Educational Implications: Proposals to Counteract Plant Awareness Disparity

As we have already discussed, PAD still remains present in the Spanish Education System, also among those studying the degrees of teacher in early childhood and in PE. Although identification values seem to improve at university level (**Table 3**) and there is a weak positive correlation between animal and plant recognition (**Table 4**), values are still low. The lack of strategies focused on comprehensive and sound botany teaching in schools, high schools, and universities is one of the main causes of PAD (Kaasinen, 2019; Parsley, 2020). It is a reality that plants are under-represented in textbooks, and if they are, they are exotic rather than native (Celis-Diez et al., 2016): moreover, transversal information is usually presented with animal-based examples (Brownlee et al., 2021). The specific content and how it is taught at school determines the 'degree' of PAD (Batke et al., 2020).

In the case of students of the bachelor's degree in early childhood and PE, this is even more important, as they will be in charge of children's future learning. Thus, the objectives set out in the curriculum will only be achieved if the teachers of the future are adequately trained. Here we propose three main ways to counteract PAD:

1. Incorporate into the curriculum at all educational levels specific content aimed at raising awareness of local flora and increasing students' species literacy and knowledge, as discussed above (Suárez-López & Eugenio-Gozalbo, 2021).
2. Studies have found that students' species (including plants) literacy, attitudes, and identification skills improved after specific activities aimed at increasing their interest in local flora (Nyberg & Sanders, 2014; Kaasinen, 2019); workshops (Nates et al. , 2012), outdoor educational programs (Fančovičová & Prokop, 2011; Wyner & Doherty, 2021), use of living organisms in the classroom (Krosnick et al., 2018; Krell & Schmidt, 2020) , visits to botanical gardens (Kissi & Dreesmann, 2017), or board games (Friedersdorff et al., 2019) and mobile applications (Hartman et al., 2019), were some of the proposals investigated.

3. Finally, future educators, both early childhood, PE, and biology teachers, should receive a comprehensive training in the field of botany and in the effective implementation of activities aimed at transferring plant knowledge to students and therefore reduce their PAD degree in order to avoid a 'zoo-chauvinistic' point of view (Darley, 1990). Outdoor experiences for future teachers improve their ability to identify local flora (Borsos et al., 2021; Magntorn & Helldén, 2005), make them aware of their need to learn about local species, and make them feel more confident to transfer their knowledge to students (Wolff & Skarstein, 2020). However, the study plans for the training of PE teachers should include, like those for SE and Baccalaureate, more competences related to EE, since in Spain there are no minimum guaranteed standards in the training of future teachers (Sureda-Negre et al., 2014).

CONCLUSIONS, LIMITATIONS OF THE STUDY, & FUTURE RESEARCH

Plant blindness is still present among students at all educational levels, from PE to university. It has been observed that knowledge about plants and animals (mainly about vertebrates) is biased towards the latter. New pedagogical methods, techniques and tools should be employed to motivate students. Plant blindness might also represent a threat for achieving the sustainable development goals. Future research is needed to further evaluate whether those measures, programs, and activities can improve the plant literacy of students and teachers to counteract PAD. Special interest should also be focused in evaluating the implementation of the new Spanish curricula, to assess whether it improves the level of the next generation of students with respect to PAD and EE.

Author contributions: JM-W & JB-P: conceived and designed the analysis, performed the analysis, and wrote the paper; **JDI & RRP:** reviewed and edited the paper; & **JM-W, JB-P, JDI, & RRP:** collected the data. All authors approve final version of the article.

Funding: The authors received no financial support for the research and/or authorship of this article.

Acknowledgements: The authors would like to thank the participating students, their parents/guardians, teachers, and schools for their collaboration.

Ethics declaration: Authors declared that the study did not require formal ethics approval since the data was completely anonymous, with no personal information collected (apart from age and sex). Informed consents were obtained from the research participants. Vulnerable or dependent groups were not included in the study.

Declaration of interest: Authors declare no competing interest.

Data availability: Data generated or analyzed during this study are available from the authors on request.

REFERENCES

Almeida, A., García Fernández, B., & Strecht-Ribeiro, O. (2020). Children's knowledge and contact with native fauna: A comparative study between Portugal and Spain. *Journal of Biological Education, 54*(1), 17-32. https://doi.org/10.1080/00219266.2018.1538017

Amahmid, O., el Guamri, Y., Yazidi, M., Razoki, B., Kaid Rassou, K., Rakibi, Y., Knini, G., & el Ouardi, T. (2019). Water education in school curricula: Impact on children knowledge, attitudes, and behaviors towards water use. *International Research in Geographical and Environmental Education, 28*(3), 178-193. https://doi.org/10.1080/10382046.2018.1513446

Amprazis, A., & Papadopoulou, P. (2018). Primary school curriculum contributing to plant blindness: Assessment through the biodiversity perspective. *Advances in Ecological and Environmental Research, 3(11),* 238-256.

Amprazis, A., & Papadopoulou, P. (2020). Plant blindness: A faddish research interest or a substantive impediment to achieve sustainable development goals? *Environmental Education Research, 26*(8), 1065-1087. https://doi.org/10.1080/13504622.2020.1768225

Amprazis, A., Papadopoulou, P., & Malandrakis, G. (2021). Plant blindness and children's recognition of plants as living things: A research in the primary schools context. *Journal of Biological Education, 55*(2), 139-154. https://doi.org/10.1080/00219266.2019.1667406

Ballouard, J.-M., Brischoux, F., & Bonnet, X. (2011). Children prioritize virtual exotic biodiversity over local biodiversity. *PLoS ONE, 6*(8), e23152. https://doi.org/10.1371/journal.pone.0023152

Balmford, A., Clegg, L., Coulson, T., & Taylor, J. (2002). Why conservationists should heed Pokémon. *Science, 295*(5564), 2367-2367. https://doi.org/10.1126/science.295.5564.2367b

Barker, S., Slingsby, D., & Tilling, S. (2002). *Teaching biology outside the classroom: Is it heading for extinction? A report on biology fieldwork in the 14-19 curriculum*. Field Studies Council.

Batke, S. P., Dallimore, T., & Bostock, J. (2020). Understanding plant blindness–Students' inherent interest of plants in higher education. *Journal of Plant Sciences, 8*(4), 98. https://doi.org/10.11648/j.jps.20200804.14

Bebbington, A. (2005). The ability of A-level student to name plants. *Journal of Biological Education, 39*(2), 62-67. https://doi.org/10.1080/00219266.2005.9655963

Bianchi, L. (2000). So, you think you know what a plant is? *Primary Science Review, 61*, 15-17.

Borsos, É., Borić, E., & Patocskai, M. (2021). What can be done to increase future teachers' plant knowledge? *Journal of Biological Education*. https://doi.org/10.1080/00219266.2021.1909632

Brownlee, K., Parsley, K. M., & Sabel, J. L. (2021). An analysis of plant awareness disparity within introductory biology textbook images. *Journal of Biological Education*.https://doi.org/10.1080/00219266.2021.1920301

Buck, T., Bruchmann, I., Zumstein, P., & Drees, C. (2019). Just a small bunch of flowers: The botanical knowledge of students and the positive effects of courses in plant identification at German universities. *PeerJ, 7*(3), e6581. https://doi.org/10.7717/peerj.6581

Cardinale, B. J., Duffy, J. E., Gonzalez, A., Hooper, D. U., Perrings, C., Venail, P., Narwani, A., Mace, G. M., Tilman, D., Wardle, D. A., Kinzig, A. P., Daily, G. C., Loreau, M., Grace, J. B., Larigauderie, A., Srivastava, D. S., & Naeem, S. (2012). Biodiversity loss and its impact on humanity. *Nature, 486*(7401), 59-67. https://doi.org/10.1038/nature11148

Celis-Diez, J. L., Díaz-Forestier, J., Márquez-García, M., Lazzarino, S., Rozzi, R., & Armesto, J. J. (2016). Biodiversity knowledge loss in children's books and textbooks. *Frontiers in Ecology and the Environment, 14*(8), 408-410. https://doi.org/10.1002/fee.1324

Darley, W. M. (1990). The essence of "plantness." *The American Biology Teacher, 52*(6), 354-357. https://doi.org/10.2307/4449132

Díez, J., Meñika, A., Sanz-Azkue, I., & Ortuzar, A. (2018). Urban and rural children's knowledge on biodiversity in Bizkaia: Tree identification skills and animal and plant listing. *International Journal of Humanities and Social Sciences, 12*(3), 427-431. https://doi.org/10.5281/zenodo.1316197

Fančovičová, J., & Prokop, P. (2011). Plants have a chance: Outdoor educational programs alter students' knowledge and attitudes towards plants. *Environmental Education Research, 17*(4), 537-551. https://doi.org/10.1080/13504622.2010.545874

Fernández, B., Álvaro, N., Mayoral, O., & Gavidia, V. (2016). Las competencias en salud ambiental en el currículo de la educación obligatoria [Competences in environmental health within the compulsory education curricula]. In V. Gavidia (Ed.), *Los ocho ámbitos de la educación para la salud en la escuela* [*The eight domains of health education at school*] (pp. 425-444). Tirant Humanidades.

Friedersdorff, J. C. A., Thomas, B. J., Hay, H. R., Freeth-Thomas, B. A., & Creevey, C. J. (2019). From treetops to tabletops: A preliminary investigation of how plants are represented in popular modern board games. *Plants, People, Planet, 1*(3), 290-300. https://doi.org/10.1002/ppp3.10057

Hartman, T., Lydon, S. J., & Rasmussen, A. (2019). Hunting for answers: Linking lectures with the real world using a mobile treasure hunt app. *Plants, People, Planet, 1*(3), 233-247. https://doi.org/10.1002/ppp3.33

Holbert, R. L., Kwak, N., & Shah, D. V. (2003). Environmental concern, patterns of television viewing, and pro-environmental behaviors: Integrating models of media consumption and effects. *Journal of Broadcasting & Electronic Media, 47*(2), 177-196. https://doi.org/10.1207/s15506878jobem4702_2

Hooykaas, M. J. D., Schilthuizen, M., Aten, C., Hemelaar, E. M., Albers, C. J., & Smeets, I. (2019). Identification skills in biodiversity professionals and laypeople: A gap in species literacy. *Biological Conservation, 238*, 108202. https://doi.org/10.1016/j.biocon.2019.108202

Hudson, S. J. (2001). Challenges for environmental education: Issues and ideas for the 21st century: Environmental education, a vital component of efforts to solve environmental problems, must stay relevant to the needs and interests of the community and yet constantly adapt to the rapidly changing social and technological landscape. *BioScience, 51*(4), 2283-2288. https://doi.org/10.1641/0006-3568(2001)051[0283:CFEEIA]2.0.CO;2

IBM Corp. (2019). *IBM SPSS statistics for Windows* (26.0). IBM Corp.

Jiménez-Tejada, M.-P., Sánchez-Monsalve, C., & González-García, F. (2013). How Spanish primary school students interpret the concepts of population and species. *Journal of Biological Education, 47*(4), 232-239. https://doi.org/10.1080/00219266.2013.799081

Jose, S. B., Wu, C. H., & Kamoun, S. (2019). Overcoming plant blindness in science, education, and society. *Plants, People, Planet, 1*(3), 169-172. https://doi.org/10.1002/ppp3.51

Kaasinen, A. (2019). Plant species recognition skills in Finnish students and teachers. *Education Sciences, 9*(2), 85. https://doi.org/10.3390/educsci9020085

Kissi, L., & Dreesmann, D. (2017). Plant visibility through mobile learning? Implementation and evaluation of an interactive flower hunt in a botanic garden. *Journal of Biological Education, 52*(4), 1-20. https://doi.org/10.1080/00219266.2017.1385506

Krell, M., & Schmidt, J. (2020). Biology teachers' views towards using living organisms in biology education. *Journal of Biological Education, 56*(3), 353-364. https://doi.org/10.1080/00219266.2020.1812694

Krosnick, S. E., Baker, J. C., & Moore, K. R. (2018). The pet plant project: Treating plant blindness by making plants personal. *The American Biology Teacher, 80*(5), 339-345. https://doi.org/10.1525/abt.2018.80.5.339

Kubiatko, M., Fančovičová, J., & Prokop, P. (2021). Factual knowledge of students about plants is associated with attitudes and interest in botany. *International Journal of Science Education, 43*(9), 1426-1440. https://doi.org/10.1080/09500693.2021.1917790

Lindemann-Matthies, P. (2005). 'Loveable' mammals and 'lifeless' plants: How children's interest in common local organisms can be enhanced through observation of nature. *International Journal of Science Education, 27*(6), 655-677. https://doi.org/10.1080/09500690500038116

Mackenzie, J. S., & Jeggo, M. (2019). The one health approach—Why is it so important? *Tropical Medicine and Infectious Disease, 4*(2), 88. https://doi.org/10.3390/tropicalmed4020088

Magntorn, O., & Helldén, G. (2005). Student-teachers' ability to read nature: Reflections on their own learning in ecology. *International Journal of Science Education, 27*(10), 1229-1254. https://doi.org/10.1080/09500690500102706

Martínez-Losada, C., García-Barros, S., & Garrido, M. (2014). How children characterize living beings and the activities in which they engage. *Journal of Biological Education, 48*(4), 201-210. https://doi.org/10.1080/00219266.2013.849281

McDonough MacKenzie, C., Kuebbing, S., Barak, R. S., Bletz, M., Dudney, J., McGill, B. M., Nocco, M. A., Young, T., & Tonietto, R. K. (2019). We do not want to "cure plant blindness" we want to grow plant love. *Plants, People, Planet, 1*(3), 139-141. https://doi.org/10.1002/ppp3.10062

Ministry of Education and Vocational Training. (2020). Ley Orgánica 3/2020, de 29 de Diciembre, por la que se modifica la Ley Orgánica 2/2006, de 3 de Mayo, de educación [Organic Law 3/2020, 29th December, which modifies the Organic Law 2/2006, 3rd May, of education]. *Boletín Oficial del Estado* [*State Official Newsletter*]*, 340*, 122868-122953.

Ministry of Education and Vocational Training. (2022). Real Decreto 217/2022, de 29 de Marzo, por el que se establece la ordenación y las enseñanzas mínimas de la educación secundaria obligatoria [Royal Decree 217/2022, 29th March, which establishes the ordination and minimum teachings of secondary education]. *Boletín Oficial del Estado* [*State Official Newsletter*]*, 76*, 41571-41789.

Ministry of Education of the Community of Castilla and León. (2008). Decreto 122/2007, de 27 de diciembre, por el que se establece el currículo del segundo ciclo de la educación infantil en la Comunidad de Castilla y León [Decree 122/2007, 27th December, establishing the second cycle curricula of early childhood education in the autonomous Community of Castile and Leon]. *Boletín Oficial de Castilla y León* [*Official Gazette of Castilla and León*]*, 1*, 6-16.

Ministry of Education of the Community of Castilla and León. (2015a). Orden EDU 362/2015, de 4 de mayo, por las que se establece el currículo y se regula la implantación, evaluación y desarrollo de la educación secundaria obligatoria en la Comunidad de Castilla y León [Order EDU 362/2015, 4th May, establishing the curricula and regulating the implementation, evaluation, and development of secondary education in the autonomous Community of Castile and Leon]. *Boletín Oficial de Castilla y León* [*Official Gazette of Castilla and León*]*, 86*.

Ministry of Education of the Community of Castilla and León. (2015b). Orden EDU/363/2015 del 4 de mayo, por las que se establece el currículo y se regula la implantación, evaluación y desarrollo de bachillerato en la Comunidad de Castilla y León [Order EDU 363/2015, 4th May, establishing the curricula and regulating the implementation, evaluation, and development of baccalaureate in the autonomous Community of Castile and Leon]. *Boletín Oficial de Castilla y León* [*Official Gazette of Castilla and León*]*, 86*.

Ministry of Education of the Community of Castilla and León. (2016). Decreto 26/2016, de 21 de julio, por el que se establece el currículo y se regula la implantación, evaluación y desarrollo de la educación primaria en la Comunidad de Castilla y León [Decree 26/2016, 21st July, establishing the curricula and regulating the implementation, evaluation, and development of primary education in the autonomous Community of Castile and Leon]. *Boletín Oficial de Castilla y León* [*Official Gazette of Castilla and León*], *142*, 34184-34746.

Ministry of Education. (1990). Ley Orgánica 1/1990, de 3 de Octubre, de Ordenación General del Sistema Educativo [Organic Law 1/1990, 3rd October, of General Ordination of the Educational System]. *Boletín Oficial del Estado* [*State Official Newsletter*], *238*, 28927-28942.

Ministry of Education. (2013). Ley Orgánica 8/2013, de 9 de Diciembre, para la mejora de la calidad educativa [Organic Law 8/2013, 9th December, for the improvement of educational quality]. *Boletín Oficial Del Estado* [*State Official Newsletter*], *295*, 1-64.

Monroe, M. C., & Krasny, M. E. (2016). *Across the spectrum: Resources for environmental education*. North American Association for Environmental Education.

Nates, J., Campos, C., & Lindemann-Matthies, P. (2010). Students' perception of plant and animal species: A case study from rural Argentina. *Applied Environmental Education & Communication, 9*(2), 131-141. https://doi.org/10.1080/1533015X.2010.482495

Nates, J., Campos, C., & Lindemann-Matthies, P. (2012). The impact of a short conservation education workshop on Argentinean students' knowledge about and attitudes towards species. *EURASIA Journal of Mathematics, Science and Technology Education, 8*(4), 257-267.https://doi.org/10.12973/eurasia.2012.844a

Nyberg, E., & Sanders, D. (2014). Drawing attention to the 'green side of life.' *Journal of Biological Education, 48*(3), 142-153. https://doi.org/10.1080/00219266.2013.849282

Otto, S., & Pensini, P. (2017). Nature-based environmental education of children: Environmental knowledge and connectedness to nature, together, are related to ecological behavior. *Global Environmental Change, 47*, 88-94. https://doi.org/10.1016/j.gloenvcha.2017.09.009

Palmberg, I., Kärkkäinen, S., Jeronen, E., Yli-Panula, E., & Persson, C. (2019). Nordic student teachers' views on the most efficient teaching and learning methods for species and species identification. *Sustainability, 11*(19), 5231. https://doi.org/10.3390/su11195231

Parsley, K. M. (2020). Plant awareness disparity: A case for renaming plant blindness. *Plants, People, Planet, 2*(6), 598-601. https://doi.org/10.1002/ppp3.10153

Patrick, P., & Tunnicliffe, S. D. (2011). What plants and animals do early childhood and primary students' name? Where do they see them? *Journal of Science Education and Technology, 20*(5), 630-642. https://doi.org/10.1007/s10956-011-9290-7

Pedrera, O., Ortega, U., Ruiz-González, A., Díez, J. R., & Barrutia, O. (2021). Branches of plant blindness and their relationship with biodiversity conceptualization among secondary students. *Journal of Biological Education*. https://doi.org/10.1080/00219266.2021.1933133

Sánchez-Llorens, S., Agulló-Torres, A., del Campo-Gomis, F. J., & Martinez-Poveda, A. (2019). Environmental consciousness differences between primary and secondary school students. *Journal of Cleaner Production, 227*, 712-723. https://doi.org/10.1016/j.jclepro.2019.04.251

Sanders, D. L. (2007). Making public the private life of plants: The contribution of informal learning environments. *International Journal of Science Education, 29*(10), 1209-1228. https://doi.org/10.1080/09500690600951549

Schussler, E. E., & Olzak, L. A. (2008). It's not easy being green: Student recall of plant and animal images. *Journal of Biological Education, 42*(3), 112-119. https://doi.org/10.1080/00219266.2008.9656123

Scott, G. W., Goulder, R., Wheeler, P., Scott, L. J., Tobin, M. L., & Marsham, S. (2012). The value of fieldwork in life and environmental sciences in the context of higher education: A case study in learning about biodiversity. *Journal of Science Education and Technology, 21*(1), 11-21. https://doi.org/10.1007/s10956-010-9276-x

Signorini, M. A., Piredda, M., & Bruschi, P. (2009). Plants and traditional knowledge: An ethnobotanical investigation on Monte Orbene (Nuoro, Sardinia). *Journal of Ethnobiology and Ethnomedicine, 5*(1), 6. https://doi.org/10.1186/1746-4269-5-6

Skarstein, T. H., & Skarstein, F. (2020). Curious children and knowledgeable adults–early childhood student-teachers' species identification skills and their views on the importance of species knowledge. *International Journal of Science Education, 42*(2), 310-328. https://doi.org/10.1080/09500693.2019.1710782

Snaddon, J. L., Turner, E. C., & Foster, W. A. (2008). Children's perceptions of rainforest biodiversity: Which animals have the lion's share of environmental awareness? *PLoS ONE, 3*(7), e2579. https://doi.org/10.1371/journal.pone.0002579

Suárez-López, R., & Eugenio-Gozalbo, M. (2021). How is sustainability addressed in primary and secondary education curricula? Assessing the cases of Spain and Portugal. *International Research in Geographical and Environmental Education, 31*(3), 1-17. https://doi.org/10.1080/10382046.2021.1924498

Sureda-Negre, J., Oliver-Trobat, M., Catalan-Fernández, A., & Comas-Forgas, R. (2014). Environmental education for sustainability in the curriculum of primary teacher training in Spain. *International Research in Geographical and Environmental Education, 23*(4), 281-293. https://doi.org/10.1080/10382046.2014.946322

Tam, K.-P. (2013). Concepts and measures related to connection to nature: Similarities and differences. *Journal of Environmental Psychology, 34*, 64-78. https://doi.org/10.1016/j.jenvp.2013.01.004

Titley, M. A., Snaddon, J. L., & Turner, E. C. (2017). Scientific research on animal biodiversity is systematically biased towards vertebrates and temperate regions. *PLoS ONE, 12*(12), e0189577. https://doi.org/10.1371/journal.pone.0189577

UNESCO. (1978). *The Tbilisi Declaration: Final report: Intergovernmental Conference on Environmental Education*. https://unesdoc.unesco.org/ark:/48223/pf0000032763

United Nations Organization. (1992). *Convention on Biological Diversity*. https://treaties.un.org/pages/ViewDetails.aspx?src=IND&mtdsg_no=XXVII-8&chapter=27&clang=_en

Urones, C., Escobar, B., & Vacas, J. M. (2013). Las plantas en los libros de conocimiento del medio de 2º ciclo de primaria [The plants approach in textbooks of science in elementary education]. *Revista Eureka Sobre Enseñanza y Divulgación de Las Ciencias* [*Eureka Magazine on Teaching and Dissemination of Sciences*], *10*(3), 328-352. https://doi.org/10.25267/Rev_Eureka_ensen_divulg_cienc.2013.v10.i3.03

Wandersee, J. H. (1986). Plants or animals—which do junior high school students prefer to study? *Journal of Research in Science Teaching, 23*(5), 415-426. https://doi.org/10.1002/tea.3660230504

Wandersee, J. H., & Schussler, E. E. (1999). Preventing plant blindness. *The American Biology Teacher, 61*(2), 84-86. https://doi.org/10.2307/4450624

Wolff, L.-A., & Skarstein, T. H. (2020). Species learning and biodiversity in early childhood teacher education. *Sustainability, 12*(9), 3698. https://doi.org/10.3390/su12093698

Wyner, Y., & Doherty, J. H. (2021). Caring to know a name: An examination of New York City student attitudes towards knowing a tree's name. *Plants, People, Planet, 4*(3), 283-302. https://doi.org/10.1002/ppp3.10249

Yli-Panula, E., & Matikainen, E. (2014). Students and student teachers' ability to name animals in ecosystems: A perspective of animal knowledge and biodiversity. *Journal of Baltic Science Education, 13*(4), 559-572. https://doi.org/10.33225/jbse/14.13.559