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Attitudes towards plants – exploring the role of plants' ecosystem services

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ABSTRACT
With biodiversity loss as one of today's most pressing global problems, it is crucial to raise public recognition of this crisis and promote acceptance of conservation efforts. Plants, which typically struggle with low awareness ('plant blindness') and less emotional connection than animals with humans, are facing a special challenge. Promoting positive attitudes towards, and interest in, plants might provide the key to resolve this discrepancy. This study aims to differentiate attitudes and interest within the plant awareness framework while at the same time identify criteria for developing positive attitudes and interest towards plants in students. In a mixed-method approach, a questionnaire with closed and open items on attitudes and interest was developed and administered online to 179 students aged 9–19. Quantitative as well as qualitative results show that 'attitudes towards plants' can be differentiated from 'interest in plants'. Attitudes towards plants were positive, whereas interest in plants was rather low, with cultural and regulating ecosystem services acting as primary reasons for students' positive attitudes. These two components can be easily incorporated in botany teaching in order to promote plant awareness and increase knowledge about their crucial role in ecosystems and global climate, thus raising acceptance for conservation.

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Plant blindness; plant awareness; attitudes; questionnaire; interest

Introduction

Biodiversity loss is currently one of the world's most pressing issues and should also find more attention in our everyday lives (Cardinale et al. 2012; Settele et al. 2019; Jaureguiberry et al. 2022; Johnson et al. 2017). Much of the blame for the declining diversity of organisms falls on human activities such as loss of habitats through deforestation, urbanisation and agricultural intensification with large monocultures and the massive use of pesticides, such as herbicides, insecticides and fungicides (Settele et al. 2019; Gerardo, Ehrlich, and Dirzo 2017). Next to that, climate change has an increasing impact on the survival of species; for example, by disrupting the delicate co-dependencies between pollinators and plants. This also impacts global food production to a large

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extent, since one-third of our global crop production is dependent on animal pollination (Gérard et al. 2020; Klein et al. 2006). In their study, Smith et al. (2015) discuss that if pollination services were completely lost, malnutrition as a consequence of crop losses could result in 1.42 million additional deaths per year worldwide. But a loss of pollinators does not only have a vast impact on mankind: In addition to crops, up to 80% of all wild plants in Europe depend on pollination for their reproduction (Kwak, Velterop, and van Andel 1998).

Although the prognosis for plant diversity is negative (Mark et al. 2017; Vellend et al. 2013), conservation attempts for plants are not sufficient (Mung and Williams 2016). Studies show that an important basis for the public acceptance of conservation efforts is an emotional connection to the protected group of organisms (ibid, Knight et al. 2008). Since it is easier for people to connect emotionally to organisms more closely related to humans, such as mammals, obtaining funds for the protection of plants is more challenging (Mammola et al. 2020; Margulies et al. 2019; Mung and Williams 2016).

In order to raise conservation efforts for plants, different researchers suggested the implementation of ecosystem services in the debate (Chan et al. 2011). The UN defines ecosystem services as benefits people derive from ecosystems (Alcamo, Vuuren, and Cramer 2006) and differentiate four different services (e.g., regulating and cultural services). The importance of plant biodiversity is often misunderstood (Laura and Dreesmann 2022), which is a problematic trend as a multitude of plant species are necessary to keep up ecosystem services (Isbell et al. 2011). Additionally, a broad understanding of different ecosystem services of plants is urgently needed, e.g., to assess how trees contribute to climate mitigation (Bofferding and Kloser 2015) or the role trees play in the water cycle and their impact on cooling the environment due to evapotranspiration (Ryplova, Pokorny, and Ryplova 2020).

Conservation attempts for plants face additional hurdles. Adamo et al. (2022) found a bias of plant conservation towards the perceived aesthetics of plants. Such a bias towards aesthetically pleasing groups of organisms can also be seen in plant research in general (Adamo et al. 2021; Lindemann-Matthies 2005; Mammola et al. 2020; Nyberg, Brkovic, and Sanders 2021; Small 2011) and conversation efforts of invertebrate groups (e.g., butterflies) (Kellert 1993).

On the other hand, an aesthetic experience can encourage students to actively use a scientific concept that consequently expands their perception, values and emotions (Pugh and Girod 2007). Moreover, aesthetic considerations are strongly linked to cognitive understanding (Johnson 2007; Johnson et al. 2017). Introducing aesthetic experiences to people may serve as an initial step towards altering their emotional perception and cognitive understanding of plants. Comparable approaches were advocated by McDonough MacKenzie et al. (2019) and Sanders et al. (2022).

Research has shown that social norms have led to a trend in maintaining 'tidy gardens' that offer little benefits to wildlife, as noted by Goddard, Dougill, and Benton (2013). Interestingly, Lindemann-Matthies and Marty (2013) found out that people's aesthetic understanding of a garden is correlated to higher diversity and species richness, which is increased in gardens managed with ecological gardening practices. Although ambiance and aesthetic values might be an important factor why people bring plants into their homes in the first place, several additional positive effects of plants have been explored. Apaolaza et al. (2020) demonstrated that plants enhanced the aesthetic value of a location and positively impact social interaction among humans. Plants also raise wellbeing and influence stress relief, with Tyrväinen et al. (2014) going so far as proposing that they positively influence recovery after medical treatments (S.-H. Park and Mattson 2009).

Many of the obstacles for plant conservation mentioned above relate to the construct of 'plant awareness', initially referred to as 'plant blindness' by Wandersee and Schussler (2001). Although focusing mainly on the visual perception of plants and its physiological as well as psychological aspects, Wandersee and Schussler (2001) predicted different symptoms that also indicate aesthetic considerations. Subsequently, additions to the 'plant blindness' construct have been focusing on many aspects, expanding the construct (Parsley 2021) and leading to a vaguely defined term. This led to current efforts to rework its framing.

The main points in such reworking are the distance from ableism (Parsley 2020), creating a framework focused on people's resources instead of deficits (awareness instead of blindness) and a clear differentiation between the domains that contribute to a person's plant awareness. For this purpose, a plant awareness framework based on four different domains was proposed: visual perception (attention), categorisation of plants as living organisms, knowledge about plant biology and attitudes towards plants (Pany et al. 2022).

Although attitudes towards plants have often been explored as an aspect of plant blindness (Fančovičová and Prokop 2010, 2011; Kubiatko, Fančovičová, and Prokop 2021; Lohr and Pearson-Mims 2005; Strgar 2008), the sources of attitudes towards plants have never been explored until now. One possible explanation could be that in recent research the concept of 'attitudes' has often been mixed up with different constructs like interest and knowledge. For example, the 'Plant Attitude Scale' (Fančovičová and Prokop 2010) subsumes 'interest' as a subscale of 'attitudes'. Thus, it is important to use a coherent definition of 'attitudes towards plants' in the plant awareness construct and to sharpen differences with other constructs (e.g., 'interest').

Eagly and Chaiken (1993) define an 'attitude' as "[. . .] a psychological tendency that is expressed by evaluating a particular entity with some degree of 'favour or disfavour'. The concept of 'attitude' is generally understood to be an evaluated response to an entity (Gawronski 2007), whereas an entity can be everything from an object to an abstract idea (Alarracin and Shavitt 2018). In contrast to 'attitudes', 'interest' is conceptualised as a psychological state.

'Interest' in the realm of educational psychology is a multifaceted concept, often categorised into two distinct forms: individual interest and situational interest. *Individual interest* is a characteristic inherent in a person, representing a stable and enduring disposition towards a particular object or activity. On the other hand, *situational interest* arises from engaging stimuli and is conceptualised as a transient, specific state of motivation or psychological engagement within an individual (Krapp 2007). These interests are not mutually exclusive; they can influence and even evolve from one another (Hidi and Ann Renninger 2006). Short-term situational interest may evolve into a more enduring individual interest, while pre-existing individual interests can spark situational interest in novel contexts (Rotgans and Schmidt 2017). Notably, individual interest undergoes development throughout adolescence, growing in complexity and differentiation over time. During puberty, individual interest often undergoes a reconstruction influenced by peer interactions, leading to narrower and more specialised areas of focus (Krapp 2005). This intricate interplay between individual and situational interest significantly shapes the learning and motivational experiences of individuals (Hammann, Jördens, and Büschgens 2020). It is considered the motivational aspect leading people to engage (or re-engage) with certain entities (e.g., Krapp and Prenzel 2011). Consequently, the evaluation process described above distinguishes attitudes from interest and lies at the core of the 'attitude' concept.

Since people's attitudes towards organisms (e.g., invertebrates) correlate positively with their knowledge about these organisms (Schlegel et al. 2015), it is highly relevant for educators to take both learners' knowledge about plants and their attitudes towards plants into account. Concerning attitudes, educators need information on learners' attitudes, as well as an understanding of how learners develop these (positive) attitudes. Knowing learners' evaluation criteria based on their own attitudes provides educators with the chance to promote positive attitudes and create more engaging learning approaches. Next to that, research shows that attitudes (e.g., attitudes towards climate change or insects) can be developed (or changed) by presenting new information to students (Möller 2021).

Although attitudes play such an important role in conservation attempts, the development of attitudes towards plants has not yet been explored in detail. Despite the fact that previous studies suggest that interest in plants is rather low (e.g., Elster 2007) and students' attitudes towards plants are rather negative (e.g., Fančovičová and Prokop 2010), this matter stays rather diffuse because interest and attitudes towards plants have not yet been precisely separated. Thus, this paper examines 1) whether attitude and interest items can be differentiated within the plant awareness framework and 2) which evaluation criteria lead to students' attitudes towards plants.

Material & methods

The presented attitude scale is part of a larger project to assess plant awareness (Pany et al. 2022). Based on existing questionnaires (e.g., the plant attitude scale by Fančovičová and Prokop 2010), a five-item questionnaire was constructed in German. In response to the theoretical background (Eagly and Chaiken 1993), items were phrased to uniquely test only one theoretical construct ('attitude', 'interest'). This allowed us to test whether differences between interest in plants and attitudes towards plants exist.

Three items were constructed to form the 'attitude' subscale (reliability analysis using Cronbach's alpha), focusing on the evaluation of plant-related inputs that have a positive influence on humans (see Table 1). For example, recent research shows that plants enhance students' attention in school (Berto 2005; Laumann, Gärling, and Morten Stormark 2003; Taylor, Kuo, and Sullivan 2001). Moreover, plants in urban environments show positive emotional, restorative and vitalising effects on people (e.g. Kuo 2001; Maller et al. 2009; Takayama et al. 2014; Taylor, Kuo, and Sullivan 2001). Therefore, we developed two items that allowed students to evaluate whether they wanted fewer or more plants 1) in their direct environment in school and 2) in a city of their choice. Based on studies showing that plants have a calming effect on people (e.g., reduce blood pressure, heart rate and parasympathetic nervous activity) (Gladwell et al. 2012; Karjalainen, Sarjala, and Raitio 2010; B.-J. Park et al. 2011; Tsunetsugu et al. 2013) participants had to indicate how comfortable they felt when surrounded by plants.

Two single items were constructed as interest items focusing on active engagement with plants during students' spare time, one focusing on a more scientific activity, one on a manual activity with plants (see Table 1). All items were constructed as value-scales ranging from 1 to 100 (1 = low agreement, 100 = high agreement). After each item, the participants had the chance to explain their choice in an open question. These answers were used to explore qualitatively which criteria students used for creating their values.

Table 1. Items and subscales (the endpoints of the given scales and the corresponding values are written in parentheses).

	Item label	Item text
Subscale attitudes	Plants in school	*I want [less (1 . . . 100) more] plants in school*
	Comfortable around plants	*I feel [uncomfortable (1 . . . 100) comfortable] surrounded by plants*
	Plants in the city	*I want [less (1 . . . 100) more] plants (e.g. trees) in the city*
Subscale interest	Observation	*I like to observe and study plants in my spare time. [disagree (1 . . . 100) agree]*
	Gardening	*I want to plant and care for plants [disagree (1 . . . 100) agree]*

The questionnaire was administered as an online survey, using SoSci Survey, to a total of 179 students between 9- and 19-years of age (M_{age} = 15.3; SD = 2.9; 65.4% females) from three different urban schools, leading to 162 valid data sets. The research team was guided by the 'Guidelines for Good Scientific Practice' (Austrian Agency for Research Integrity 2016). Prior to participation, students were informed about the aims of the research, duration, procedure and anonymity of the data. Participation was always voluntary, and only those students who (or whose parents) gave consent to participate in the study were included in the data analysis. Data were collected and analysed anonymously. Under Austrian law, approval by an ethics committee was not necessary as this study did not involve patients, was non-invasive, and participation was voluntary and anonymous.

Quantitative data were analysed using *R*-4.2.2 and RStudio-2022.12.0–353. In order to test whether attitude and interest items can be separated, data were analysed using different methods. As variables were ordinal and samples with missing values were eliminated leaving only paired samples, Spearman correlation was used. Spearman correlations (rs) and the accompanying P-values were computed with the sjPlot package (Lüdecke 2023) and the tab_corr() codeline. In order to examine whether the means of the five items were different from each other, an ANOVA was computed with an aov() input (R Core Team 2022). Results were then used to compute Fisher's least significant difference in order to find significant differences between the items with the agricolae package (de Mendiburu and Yaseen 2020) and the code LSD.test().

After each item, the participants had the chance to explain their choice in an open-ended question. The resulting qualitative dataset complemented students' quantitative responses and provides insights into the evaluation criteria students used for answering the items. This qualitative dataset was subsequently analysed by open coding, with codes created with an inductive content analysis (Mayring, 2010). Segments that were either relevant to understand a possible differentiation between 'attitudes' and 'interest', or explained the chosen value, were marked. In a next step, the segments were paraphrased to understand the fundamental idea behind them. These paraphrased sentences were then used as codes. If segments could not be coded with already existing codes, new codes were constructed accordingly. After all relevant segments had been used, codes were revised and subcodes were introduced where additional levels of abstraction could be observed. Although 'Aesthetic considerations' and 'Ambiance' sometimes overlap with 'Emotions', the term 'Emotions' received its own code, because of many comments regarding emotions that had no connection to the ambiance of a room or the aesthetic value of plants, or were lacking additional explanations.

In total, seven codes (see in Table 2) and additional subcodes were constructed. The same codes were applied to all five items, which led to over 740 coded segments. However, some codes almost exclusively occurred in one subscale (e.g., general interest was specific for the interest subscale). To ensure validation of the analysis, two people coded the qualitative data with the same coding system (Cohen's Kappa 0.762, $p < 0.001$) and subsequently found consensus about all coded segments. Key statements have been translated from German into English and were used as examples for their correlating subjects in this paper.

Table 2. Used codes with corresponding number of coded segments in alphabetical order.

Code	Coded Segments
Cultural ecosystem services – aesthetic considerations	186
Cultural ecosystem services – ambiance	198
Regulating ecosystem service	115
Emotions	26
Interest	73
Negative aspects	62
Social interactions	11

Results

Quantitative analysis

Means

The attitude items (*Plants in the city*, *Comfortable around plants* and *Plants in school*) all show high mean values, indicating positive attitudes towards plants. Only five students used values under 50 to describe how comfortable they feel around plants. Quite on the contrary, interest items (*Observation* and *Gardening*) show significantly lower values (Figure 1). ANOVA ($F_{4,\ 777} = 129.2$, $p < .001$) with a post-hoc LSD test showed highly significant differences between attitude and interest items (see Figure 1; Table 5).

Reliability and correlations

Cronbach's α shows adequate item reliabilities for the subscale 'attitudes towards plants' (0.691). All three attitude items (*Plants in the city*, *Comfortable around plants* and *Plants in school*) significantly correlated with each other. The item *Comfortable around plants* correlated with all other items with highest significance and highest correlation coefficients. All correlations except the one between *Observation* and *Plants in school* are highly significant (see Table 4). The item *Gardening* correlates with attitude as well as the item *Observation*. The item *Observation* shows low coefficients on a lower level of significance

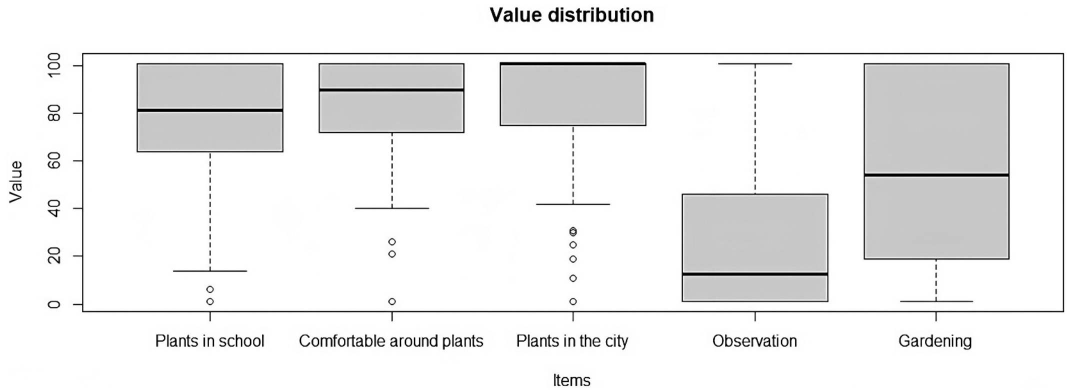

Figure 1. Boxplot of means of all items (n = 162 students). Plants in school: value 1 represents participants want less, value 100 more plants in school; Comfortable around plants: value 1 represents participants felt uncomfortable, value 100 comfortable around plants; Plants in the city: value 1 relates to participants want less, value 100 more plants in their city; Observation: value 1 means "I don't like to observe and study plants", value 100 "I like to observe and study plants"; Gardening: value 1 represents "I don't like to crop and care for plants", value 100 "I like to crop and care for plants".

($p < 0.05$) (except with *Comfortable around plants*). The results of the quantitative analysis help to answer primarily research objective 1 (students' differentiation between attitude and interest items).

Qualitative analysis

Applying qualitative content analysis (Mayring 1994) for students' open text answers, several codes were found to be applicable to all items. In the following paragraphs, we first provide an overview of the codes that were assigned to students' explanations for their choices. In particular, we then focus on differences in their explanations for the interest items and the attitude items. After this overview, we will provide more in-depth insights into students' reasoning. The results from the qualitative analysis help to answer both research objectives, but primarily research objective 2 (evaluation criteria used to choose answering options).

Three codes (including their subcodes) were most prominent and appeared more frequently than the rest: 'Cultural ecosystem services (aesthetic considerations) – further referred to as *Aesthetics*', 'Cultural ecosystem services (ambiance) – further referred to as *Ambiance*' and 'Regulating ecosystem services'. The code labelled as 'General interest' and 'Time investment' was found only in the qualitative analyses of the interest items.

Comparing the most used codes for both item groups shows how different attitudes and interest items were perceived. The only shared parent code in these most used codes between interest and attitude items is the 'Aesthetics' code.

Since we were particularly interested in the evaluation criteria for attitudes, we compared the codes also on the item level. By comparing the most used codes for the attitude items, it is obvious that two of the three items are quite similar, while the third item tested different characteristics (see Table 4). The main two codes used to analyse segments for the items *Plants in school* and *Comfortable around plants* were similar. For *Plants in school* 'Ambiance' and its subcodes cumulated to 41.8%, 'Aesthetic considerations' and its subcodes cumulated to 25.1%. For the item *Comfortable around plants* similar values have been found: 'Ambiance' 40.8% and 'Aesthetic considerations' 27.4%. This is in strong contrast to the item *plants in the city*. Over 45.3% of this item's segments were coded with the code 'Regulating ecosystem service' and its subcodes, while 26.5% of the segments were coded as 'Aesthetic'.

In order to explore in detail which reasons students indicated for their attitudes, we now focus on the different codes and provide insight into concrete answers.

Aesthetic considerations

The most often observed reason for positive scores in the attitude items was basic aesthetic considerations. A clear differentiation within those statements could be seen between the inherent aesthetic values of plants and their contribution to a comfortable ambiance. The vast majority of all segments coded with 'Aesthetic considerations' were basic aesthetic considerations that relate to plants' inherent aesthetic values and are connected to positive attitudes.

The subcode 'beauty' was created as students mentioned beauty or a synonym over 110 times in their written answers. However, for the most part, participants did not give detailed explanations of their understanding of beauty in plants.

> (I feel comfortable around plants because) it´s just beautiful.
>
> Comfortable around plants, Statement 102

Colours of plants were mentioned in 11 cases. All aspects used similarly to the aesthetic explanations included only basic colour descriptions like 'green' (*Plants in school, Statement 320*) or 'colourful' (*Plants in school, Statement 89*). Olfactory qualities like their '(. . .)scent' (*Plants in school, Statement 331*) were also mentioned a total of 11 times and equally basic.

Ambiance

Many participants associated the presence of plants with an improvement of the aesthetic quality and the ambiance of a room. The associated impact on ambiance has been plentiful, e.g., 'Plants give rooms a friendlier look' (*Plants in school, Statement 113*). Two aspects were mentioned more often and thus were used as distinct subcodes. On the one hand, participants wanted more plants around them because of their ability to reduce stress and calm them ($n = 56$). This was sometimes connected to a certain place (e.g., '(. . .) the wood is soothing me' [*Comfortable around plants, Statement 135*]) but mostly related to plants themselves '(. . .) because plants radiate a certain calmness and have a calming effect' (*Comfortable around plants, Statement 207*).

Moreover, participants mentioned how plants impacted their wellbeing in a place ($n = 44$). Many students talked about feeling 'comfortable' (*Comfortable around plants, statement 308*) surrounded by plants. This was emphasised by students talking about plants' ability to make a place 'feel like home' (e.g., *Comfortable around plants, statement 305*.).

In one case, all the codes mentioned above could be observed at the same time.

> Above all, I feel comfortable in nature surrounded by trees, bushes and flowers because they calm me down in a certain way and I feel at home.
>
> (Comfortable around plants, Statement 130)

Emotions

One often used example of an emotion that was not connected to the ambiance or aesthetic but was generally attributed to plants is 'happiness'.

> (. . . .) Plants make me happy.
>
> Comfortable around plants, Statement 335

Feeling happy was also related to watching plants grow (*Gardening, Statement 356 & 130*) and tending them (*Gardening, Statement 130*). Additionally, different aspects were associated with the presence of plants. Students explained that plants made them feel empowered (*Comfortable around plants, Statement 92 & 146*) or free (*Comfortable around plants, Statement 257*).

Regulating ecosystem services

Data showed that students differentiated three regulating ecosystem services. First, they express rather vague ideas of 'plants and their environmental impact', second 'shadows and cooling' and, finally, 'fresh air'. The first group of answers could not be further categorised due to their vagueness. Statements like '(More plants) are better for the Environment(.)' (*Plants in the City, Statement 142*) or 'Plants are essential for humans and animals' (*Plants in the city, Statement 92*) showed a rudimental awareness of plants and their impact on environment. However, none of them allows more detailed conclusions about students' awareness of the role plants play in an ecosystem.

The ability to shade and cool the environment was especially mentioned in the answers to the item 'plants in the city' (85% of this subcode) and only once in the answers to the item *comfortable around plants* as a specific ecosystemic service (see Table 3).

Table 3. Item means and standard deviations with post-hoc LSD.

Item	Mean ± Standard Deviation
Plants in school	77.1 ± 26.0
Comfortable around plants	83.5 ± 21.4
Plants in the city	85.6 ± 22.9
Observation	25.5 ± 29.7
Gardening	56.5 ± 36.7

> Trees are reducing the temperatures in the city.
>
> Plant in the city, Statement 117

Interestingly, data showed a lack of understanding of the cooling effect of plants. When cooling is mentioned, students tend to reduce plants' cooling effect to the shadow they cast. Transpiration is not mentioned once. This simplified connection could be seen in several answers like this one: 'more shadow = less heat' (*Plants in the city, Statement 268*).

The quality of air was the most distinguished subgroup ($n = 69$). Most of the students used vague terms like 'fresh air' (*Plants in the city, Statement 306*) or 'filtered air' (*Plants in the city, Statement 241*), whereas the term 'oxygen' was used less ($n = 14$). Furthermore, in most of these cases, students used sentences like '(Plants are) important for animals and us humans – (producing) oxygen' (*Plants in the city, Statement 163)*, showing an anthropomorphic idea of plants' oxygen production. At the same time, two students even used carbon dioxide (CO_2) as a reason why they wanted more plants in cities, pointing towards a misunderstanding of photosynthesis and the needs of plants. One single student correctly mentioned plants' CO_2 intake and its role in climate mitigation. The ability to filter air or reduce pollutants was also mentioned by several students.

General interest & time investment

The interest item *Observation* introduced a new code to the analysis. Participants who had chosen high values in the attitude items often chose a low value for this item. The analysis of the reasoning showed that most of these students understood the importance of plants or liked them because of aesthetic considerations but did not deem them interesting enough to actively observe them.

> I'm not really interested in plants, but I find them beautiful, and they also have an important influence, e.g., for the production of O_2. In my spare time, however, I don't deal with it intensively.
>
> Observation, Statement 309

Again, the biggest motivator for students to actively engage in observation of plants was their aesthetic value as several students mentioned that they chose to observe plants more closely if they had interesting aesthetic features and/or colours ($n = 21$).

> (I´ll closely observe plants) (. . .) if the plant has an interesting colour[,] then I consider if the plant is good for an Insta(gram) picture.
>
> Observation, Statement 352

The interest item *Gardening* was the second item where students showed rather low values by indicating that they did not want to grow or care for plants because '(. . .) (caring and cropping) was not interesting (..)' (*Gardening, Statement 79*) or 'the work is too much for something (they) do not care too much for' (*Gardening, Statement 237*). While the term interest was used less often for *Gardening* ($n = 11$) than in the *Observation*, students explained that they wanted to invest their time differently or have 'better use for their time' (*Gardening, Statement 360*) ($n = 14$), hinting at active engagement and, thus, indirectly at interest. One segment again showed a clear differentiation between attitudes ('I think plants are very beautiful (. . .)' and interest by indicating that the active engagement with the subject is a different concept '(. . .) but the work is too much for me' (*Gardening, Statement 297*).

Social interaction

Especially in the answers to the item *Gardening*, the social aspect of gardening ($n = 11$) was important, while such considerations were almost completely absent in the *Observation* item. Cropping plants and watching them grow was described as 'fun' (*Gardening, Statement 329*) and a 'positive feeling' (*Gardening, Statement 288)*. Finally, gardening seems to be an activity that is connected to social interactions with family members. Time was spent with parents (*Gardening, Statement 134*) or grand-parents (*Gardening, Statement 252*) while helping in the garden (e.g., *Gardening, Statement 134, 147*).

Negative attitudes

Negative attitudes towards plants were very scarce. Ten students explicitly indicated that they wanted fewer plants in school. All negative attitudes can be categorised using three different aspects. First, students feared that an increased number of plants would lead to an increased number of insects (*Plants in school, Statement 162*), even if plants were perceived as comfortable (*Comfortable around plants, Statement 142*). Second, they voiced the concern that having more plants in school implied that they would have to actively care for these plants and thus would have a related 'responsibility for the plants' (*Plants in school, Statement 325*). Caring and cropping were associated with the certain death of plants, often due to the lack of a 'green thumb' (*Gardening, Statement 315*). This was partly paired with a social dilemma as some students voiced the concern that their fellows would simply 'forget to water them (. . .)' (*Plants in school, 314*). Finally, students expressed that the given locations (cities as well as school) were unsuitable for plants due to different reasons (*Plants in school, Statement 123; Plants in the city, Statement 340*), one participant going as far as calling it 'cruelty against trees' (*Plants in the city, statement 361*).

Discussion

Quantitative data show that the means of the subscale 'attitudes' and the items measuring 'interest' were different. The means of the attitude items were high (see Figure 1 and Table 3) indicating positive attitudes. This contrasts with previous studies, for example, Fančovičová and Prokop (2010). A possible explanation is that their plant attitude scale tested mainly active engagement with plants.

The correlations between the items seem to imply that the *Observation* item as an interest item stands on its own, while the *Gardening* item (originally constructed as an interest item) correlates rather with the attitude items (see Table 4). A convincing explanation for this rather surprising result can be found in the accompanying qualitative data. When explaining their decision for the low values in the *Observation* item, students mostly argue that observing a plant takes too much time and is embarrassing. However, these aspects do not play a role in the *Gardening* item.

Table 4. Computed correlations used Spearman-method with listwise-deletion.

	Plants in school	Comfortable around plants	Plants in the city	Observation
Comfortable around plants	**.639*** **			
Plants in the city	**.343*** **	**.440** **		
Observation	.202*	.264**	-	
Gardening	**.410*** **	**.459*** **	**.329*** **	.254**

***$p < .001$, **$p < .01$, *$p < .05$.

In order to explain their decision for the *Gardening* item, social aspects were much more prominent. When thinking about gardening, students do not think of (allegedly boring) active engagement with plants but of spending time with family members and their friends. Such affective reasons are in the same category as criteria used to reason their positive attitudes towards plants like '*plants make me calm*' etc. (Karjalainen, Sarjala, and Raitio 2010). Additionally, gardening may offer an opportunity to interact with a plant using more senses than just the visual, whereas observing a plant is limited to one sense.

Simultaneously, the qualitative analysis made it possible to distinguish different evaluation criteria used to develop attitudes towards plants. The four most prominent criteria found are 'Aesthetic considerations', 'Ambiance', 'Regulating ecosystem services' and 'Emotions' (see Tables 2 and 5). Based on these characteristics, the three attitude items examined in this paper can be differentiated (Table 6).

Table 5. Codes and their usage in the 'attitude' subscale and interest items.

Main code	Subcode	Coded segments in attitude subscale [coded segments total = 594] (percentage of total answers for all attitude items)	Coded segments in interest items [coded segments total = 148] (percentage of total answers for all interest items)	Total coded segments [742]
Cultural ecosystem services – aesthetic considerations	Active engagement	0	21 (14.19)	21
	Beauty	108 (18.2)	5 (3.4)	113
	Other aesthetics	23 (3.9)	4 (2.7)	27
Cultural ecosystem services – ambiance	General	115 (19.4)	2 (1.4)	117
	Calmness	35 (5.9)	-	35
	Comfort	40 (6.7)	-	40
	Concentration	4 (0.7)	2 (1.4)	6
Regulating ecosystem service	General	30 (5.1)	3 (2.0)	33
	Temperature	18 (3.0)	-	18
	Air	64 (10.8)	-	64
Emotion	-	16 (2.7)	8 (5.4)	24
Interest	General	1 (0.2)	55 (37.2)	56
	Time investment	-	17 (11.5)	17
Negative aspects	General	24 (5.2)	12 (9.11)	36
	Responsibility	9 (1.5)	6 (4.1)	15
	Fear of insects	7 (1.2)	-	7
Social interaction		-	11 (7.3)	11

Table 6. Items of the 'attitude' subscale (with total number of coded segments and percentage per parent code).

Main code	Item *Plants in school* [coded segments total = 201]	Item *Comfortable around plants* [coded segments total = 189]	Item *Plants in the city* [coded segments total = 185]
Cultural ecosystem services – aesthetic considerations	25.1	27.4	26.5
Cultural ecosystem services – ambiance	41.8	40.8	13.5
Regulating ecosystem service	6	7.9	45.3
Emotion	3.6	5.3	0
Negative attitudes	12.7	5.8	2.6

Generally, students used very basic perception of plants' diversity to explain their evaluation processes. This was true for all codes. When talking about aesthetic values of plants, most answers were simply 'plants are beautiful'. Neither specific colours nor tactile nor olfactory values were mentioned or explained in detail. Similar patterns have been found with the code 'Regulating ecosystem services'. Students have only vague ideas of plants 'improving the air' or 'providing shade'. Nonetheless, students considered plants important. This was even the case if they misunderstood their role in the ecosystem; for example, when falsely stating that plants provide carbon dioxide.

However, aesthetic considerations, which are very prominent within the analysed data, are known to influence attitudes in a positive way (e.g., Nyberg, Brkovic, and Sanders 2021). Therefore, we suggest that using attractive plant study objects for teaching and learning botany may be an easy way to raise the willingness of students to actively engage with plants and simultaneously raise their awareness of plant species (Sanders et al. 2022) as well as create an emotional connection to plants. However, teachers must be careful not to enhance a bias towards colourful plants that currently can be observed in different areas (Adamo et al. 2021, 2022).

For a deeper insight into how aesthetic considerations can be used in teaching and learning, it is important to understand students' definition of 'beauty'. A possible follow-up question would be whether only 'beautiful' plants can influence attitudes towards plants or whether aesthetically unpleasant plants can also be used to change attitudes if they are outstanding in another way (e.g., carnivorous plants) and if the ability to understand and explain why they deem an object aesthetically pleasing raises attitude.

Although the items *Plants in the city* and *Plants in school* seemed very similar, qualitative data showed different reasons behind the accompanying development of attitudes. While students used mostly aesthetic reasons for the items *Comfortable around plants* and *Plants in school*, regulating ecosystem services were the dominant reasons for high values in *Plants in the city*. With an additional focus on regulating ecosystem services, the basic conceptions most of the students showed could be used as an introduction to a more detailed and scientifically correct understanding, or to expand to different services provided by plants (e.g., by introducing ecosystem services that are at first glance not in students' minds, such as pollination of plants), while simultaneously raising attitudes towards plants.

Further research is needed in order to understand whether detailed and correct content knowledge of the biological concepts behind effects such as the cooling impact of evapotranspiration correlates with students' attitudes differently than with basic knowledge about such effects (Rabbey & Clark 2016). If this were true, focusing on plants' ecosystem services could be and should be even more beneficial in raising attitudes towards plants. Additionally, there is a need to examine potential areas of interest not covered by the tool we used and their relations to attitudes towards plants.

Fortunately, in botany education, we have an enormous arsenal of beautiful, colourful plants that can be used as examples for illustrating almost every biological concept and the ecosystem services of plants are manifold and can easily be integrated into, and focused on within, biology lessons, backed with research on implementation (Ryplova, Pokorny, and Ryplova 2020).

In a first step, including aesthetic considerations into the botany class seems to be an appropriate gateway into improving students' positive attitudes towards plants. This can be easily accomplished by biology educators with only limited adaptation of their lesson plans; for example, by using attractive plants as study objects. Furthermore, introducing and teaching about plants' ecosystem services gives students not only an additional evaluation criterion to reason their attitudes but might simultaneously improve acceptance for conservation attempts (Chan et al. 2011). By improving and understanding students' attitudes towards this important group of organisms, we can hopefully look forward to a higher acceptance and attention towards conservation activities regarding plants in these critical times of global biodiversity loss.

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