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# Factual knowledge of students about plants is associated with attitudes and interest in botany

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## ABSTRACT

Plants are crucial parts of ecosystems but are traditionally considered boring and difficult by students. It is therefore not clear whether factual knowledge about plants contributes to building positive attitudes and interest in botany. We investigated whether factual knowledge about monocotyledonous plants is associated with secondary students' attitudes toward and interest in plants. Furthermore, we examined whether self-reported plant cultivation experiences and gender differences exist in attitudes toward plants. Factual knowledge about monocotyledonous plants significantly correlated with attitudes toward plants and these attitudes were greatly influenced by interest in botany, ecology, evolution, and zoology, but not with other, more distant biological disciplines (e.g. microbiology, or health and nutrition). Females received better scores in knowledge and attitudes toward plants, but interest in plants was similar between males and females. We suggest that (1) factual knowledge in botany is essential in building positive attitudes toward plants and that (2) inter-connections between botany with zoology, ecology and evolution may help with elimination of plant blindness and building positive attitudes toward plants.

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Attitude; knowledge; plants; spontaneous questions; interest in plants

## 1. Introduction

Plants have an irreplaceable importance in every ecosystem and for human life as well. Plants are producers of wood, paper, but they are producers of oxygen, which are necessary for all living organisms on the Earth. Life without plants is not imaginable nowadays. Plants are a source of energy for animals and humans and their healing effects are also a subject of interest in this modern time. Unfortunately, the biological functioning of our planet is critically threatened, and this situation endangers our livelihoods (Rockstrom et al., 2009; Watson et al., 2016). Conservation initiatives do not, however, support plants, but are biased toward certain vertebrate animals (Balding & Williams, 2016).

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Individual decisions, therefore, play a critical role in protecting plants, as inseparable components of the Earth's ecosystems.

Knowledge positively correlates with attitudes (Arcury, 1990; Gonda & Tirpakova, 2018), and the acquisition of new knowledge regarding a certain object is proposed to be one of the most effective methods in influencing attitudes (Alford et al., 2001). Attitudes are influenced by cognitive as well as motivational factors (Albarracin & Wyer Jr, 2000). Consequently, attitudes alter individual's behaviour (Ajzen & Fishbein, 1972; Arroyo et al., 2020; Kals et al., 1999). Research on human attitudes toward plants indicated that both Slovak and Turkish students aged 10–15 years of age manifested a lack of positive attitudes toward plants (Fančovičová & Prokop, 2010; Selvi, 2012). Measuring and improving students' attitudes toward plants is therefore essential to increase their environmental awareness and behaviour. In line with this view, we aimed to investigate personal interest and topic knowledge as predictors of secondary school students' attitudes towards plants.

### **1.1. Educational context**

For a clear idea, on this place, it is important to introduce Slovakian biology curriculum for upper secondary education level with focus on the plant. The education at upper secondary education level took 4 years and it is aimed at acquiring the student with a general educational basis and key competences. It prepares students primarily for further education, but also for application in practice. The subject of biology is part of the educational area 'Man and Nature'. Basic characteristic of this educational area is the search for legitimate connections between observed properties of natural objects and phenomena that surround us in everyday personal and social life. The main form of education becomes the active activity of the student. The emphasis is on development cognitive skills, communication skills and capacity building for science work.

Botany is taught at upper secondary education level within the subject of biology. The plants are in the subject biology taken over in individual thematic units in the first three years of secondary education. The content of the subject of biology is divided into 3 basic thematic areas:

- (1) The world of living organisms
- (2) Basic features, properties and manifestations of living systems
- (3) Human biology and health protection

### **1.2. Topic knowledge, interest and attitudes toward plants**

Naming plants and a basic knowledge of plant species may help students improve their botanical literacy (Nyberg & Sanders, 2014) and consequently better understand connections between human activities and decreasing biodiversity worldwide (Fuller et al., 2007). Poor knowledge about plants is a serious barrier in children's discussion about them, which in turn impairs their observation skills and conceptual learning (Ryplova & Pokorny, 2020; Tunnicliffe, 2001). Finally, a poor knowledge of plants could increase the risk of consumption of toxic fruits (Fančovičová & Prokop, 2011a). Unfortunately,

students do not find botany interesting and view it as difficult to learn (Uno, 2009) and these trends are alarmingly progressive over the past 20 years (Palmberg et al., 2015). For instance, almost half (41%) of British A-level biology students were able to identify 1 or less common wild plants (Bebbington, 2005) and another study in Germany indicated that on average students were able to identify only 2 herbs and 3 trees (Lückmann & Menzel, 2014). Although Slovak students were able to identify on average 64% of 11 common non-toxic plants, the same students correctly identified only about 4.5% of 9 common toxic plant species (Fančovičová & Prokop, 2011a). Students' low interest in botany raise concerns whether factual knowledge can improve attitudes toward plants.

Human low interest of plants, or even their ignorance, is commonly termed 'plant blindness' (Balding & Williams, 2016; Schussler & Olzak, 2008; Wandersee & Schussler, 1999). Briefly, this concept primarily includes (1) the inability to see or notice plants in the environment, (2) the inability to understand the importance of plants in the environment and for humans, (3) the inability to appreciate the aesthetic and unique biological function of plants and (4) the tendency to classify plants as inferior to animals. Low interest in plants may be one of the key factors influencing positive attitudes toward plants and is deserving of deeper attention.

### **1.3. Gender differences in perception of plants**

Evolutionary psychologists are of the opinion that females perceive plants more positively than males due to evolutionary pressures favouring fruit/plant collection by females (Krasnow et al., 2011). Evidence regarding gender differences in knowledge, interest and attitudes toward plants is, however, mixed. Some studies found that females have a better knowledge about plants than males (Fančovičová & Prokop, 2011a; Gatt et al., 2007; Laiacona et al., 2006; Prokop & Fančovičová, 2019; Robinson et al., 2016) and have greater interest in plants than males (e.g. Hong et al., 1998; Lohr et al., 2004; Schussler & Olzak, 2008). Other researchers found no differences, however, in factual knowledge about plants (Fančovičová & Prokop, 2011b; Wiegand et al., 2013), interest in plants (Lindemann-Matthies, 2005; Palmberg et al., 2015) and attitudes toward plants (Fančovičová & Prokop, 2010) or their results were mixed, at best (Harvey, 1989; Tunncliffe, 2001; Lückmann & Menzel, 2014; Pany & Heidinger, 2017). We included gender differences in our research to contribute to the disputes about whether females are more knowledgeable about plants and whether their attitudes and interests in plants are greater than that of males.

### **1.4. Plant cultivation**

Personal experiences significantly influence attitude formation (Ewert et al., 2005). It is therefore expected that plant cultivation has a positive effect on relationships between humans and plants. Indeed, planting cultivation and tree planting positively influenced human attitudes and knowledge of plants (Fančovičová & Prokop, 2010, 2011b; Kim et al., 2020; Leuven et al., 2018; Lohr & Pearson-Mims, 2005). Williams and Dixon (2013) in their meta-analysis found that garden-based learning positively influences academic outcomes but concluded that a number of reviewed studies lacked validity or

scientific rigour and called for more systematic works in this area. We, therefore, investigated whether plant cultivation influences student attitudes toward plants.

This study has two aims. First, we examined whether factual knowledge about monocotyledonous and interest in plants correlates with attitudes toward plants. Second, we examined whether gender, plant cultivation influences student attitudes toward plants in a sample of Slovak students. With respect to interest in plants, we estimated the degree of interest in plants with the total number of spontaneous questions the students produced in our research tasks. This allowed us to compare student interest in plants relative to other science education disciplines.

## 2. Methods

### 2.1. Participants

The sample size was made up of upper secondary school students (ISCED 3A) ( $n = 223$ ). The number of boys was 93 and number of girls was 120. The average age of the students was 16.67 years. All the participants were volunteers, and the research was anonymous. Respondents were students in the 1st–3rd year of four-year study and the 5th–7th year of eight-year grammar school study. The research was carried out in the school year 2018/2019, in which we distributed questionnaires to the Grammar School in Trnava for upper secondary students. Questionnaires were filled in by all the students present in the respective years in biology classes under the supervision of their teacher.

### 2.2. Research tools

#### 2.2.1. Attitudes toward plants

Attitudes toward plants were investigated with the Plant Attitude Questionnaire developed by Fančovičová and Prokop (2010). It consists of 29 Likert type items divided into four dimensions: (1) Interest in plants (10 items); (2) Importance of the plants (9 items); (3) Urban vegetation (6 items); (4) Use of plants (4 items). Points on scale were used from the strongly disagree (1) to strongly agree (5). The negative items were scored in reverse order.

#### 2.2.2. Interest in botany

Student interest in botany was investigated with spontaneous questions as indicators of their scientific interests (Baram-Tsabari & Yarden, 2005; Baram-Tsabari et al., 2006; Chin & Osborne, 2008). Each student was asked to write up to four spontaneous questions from the field of biology, in which students did not know the answer. Students' spontaneous questions were then divided into two main categories: 'Biology' and 'Earth Sciences'. The category 'Biology' was divided into the following subcategories: Botany, Zoology, Human biology, Health and nutrition, Genetics, Ecology, Evolution, Ethology, Microbiology and virology, Extinct organisms, Other questions. The category 'Earth Sciences' was made up of the subcategories Astronomy and Geology. We intentionally did not explicitly ask students to report only questions regarding botany, because this would result in very low variability of results and the true, unmanipulated interest in botany would be hard to estimate. This method of spontaneous questions a better

measure of interest in comparison with questionnaires prepared by the researchers (Baram-Tsabari & Yarden, 2009; Baram-Tsabari et al., 2006). In addition, the use of spontaneous questions across different cultures showed similarities of student interest in science questions (Hagay et al., 2013). Finally, spontaneous questions are stable and similar across students with respect to time, students' age and gender (Swirski et al., 2018). These arguments provide an evidence that results obtained here are reproducible in other countries.

### **2.2.3. Knowledge about monocotyledonous plants**

The third part of the research tool was created by a test focused on monocotyledonous plants. The test included 20 multiple choice questions, where only one possibility was correct. Each test question had one correct answer, which the respondents were required to circle. Each correctly marked answer was evaluated by one point, i.e. the maximum number of points obtained from the test could be 20. If the respondent marked more than one answer in one task, including the correct answer, then no point was awarded. The same was true if no correct answer was indicated. The main goal of the knowledge test was to determine the level of knowledge of students from the thematic unit of monocotyledonous plants. The validity of the research tool was assured by the face validity, where two groups of experts were addressed about the evaluation of the research tool. The first group were biology teachers ( $n = 6$ ) and the second group experts in educational methodology ( $n = 2$ ). Both groups had some comments and suggestions for the revision of the research tool. After the incorporation of the comments, they were again addressed to the final revision of the research tool. When all the experts did not have any other comments the final version of the research tool was administered among the students.

### **2.2.4. Plant cultivation**

A single question was used to examine the presence of a garden in their home (garden present [ $N = 183$ ] or absent [ $N = 40$ ]). Another question was focused on the plant cultivation;  $N = 188$  pupils reported they plant cultivated and  $N = 35$  do not. Plant cultivation was strongly dependent on the presence of a garden, 170 of 183 garden owners reported plant cultivation while only 18 of 43 students who did not have gardens reported plant cultivation, McNemar test, ( $\chi^2 = 112.55$ ,  $df = 1$ ,  $P < 0.001$ ). We, therefore, used exclusively data on plant cultivation and removed owning a garden from the statistical analyses to avoid multicollinearity between variables.

## **2.3. Data analysis**

The reliability of the questionnaire focused on plants attitudes was high (Cronbach  $\alpha = 0.84$ ). The Analysis of Covariance (ANCOVA) with the mean score of plants attitudes as dependent variables and gender and plants cultivation as categorical variables was used for the analyses. Student age, number of spontaneous questions and knowledge score were defined as covariates. Multidimensional regression was used for the determination of the relationship between attitudes toward plants and the number of spontaneous questions in all science subcategories. Gender differences in the total number of spontaneous

questions in botany were examined with the Generalised Linear Model (GLM) with Poisson distribution of data.

### 3. Results

The overall attitudes toward plants were rather positive ( $x = 4.07$ ;  $SD = 0.36$ ). Attitudes toward plants were positively correlated with knowledge about monocotyledonous plants (Table 1). Interest, estimated by the number of spontaneous questions about plants, was associated with more positive attitudes toward plants. Females manifested more positive attitudes toward plants than males. Reported cultivation of plants was not associated with attitudes toward them.

The multidimensional regression was used for the determination of the relationship between attitudes toward plants (dependent variable) and the number of spontaneous questions in the subcategories. The model was significant ( $F = 2.77$ ,  $p < 0.01$ ) and explained 9% of the variability of results. Positive correlations were detected in the subcategories Botany, Zoology, Ecology and Evolution. Additional subcategories were not in significant relationship with attitudes toward plants (Table 2).

The overall success from the knowledge test about monocotyledonous plants was 63.65%. Girls were slightly more successful in comparison with boys (65.50% vs. 61.08%). The most successful were pupils from the third grade, while pupils from the second grade scored worst. The multidimensional regression was used for the determination of the relationship between knowledge about monocotyledonous plants and the number of spontaneous questions in the subcategories. The knowledge about monocotyledonous plants (dependent variable) positively correlated exclusively with the number of spontaneous questions about botany (but not with other science disciplines). Females displayed a better knowledge of monocotyledonous plants than males (Table 3).

The total number of spontaneous questions in botany was similar across gender (GLM with Poisson distribution, gender [categorical]:  $\chi^2 = 0.57$ ,  $p = 0.45$ , age [covariate]:  $\chi^2 = 0.64$ ,  $p = 0.42$ ).

The total amount of spontaneous questions in all categories and subcategories was 710. The most frequent were questions from Human biology ( $n = 282$ ) and the lowest number of spontaneous questions were about Geology ( $n = 4$ ). The distribution of questions among categories and subcategories is presented in Table 4.

As can be seen in Table 4, the highest amount of spontaneous questions was from Human Biology, the girls wrote more questions in comparison with boys (183 vs. 99). The questions were from different aspects of human biology such as anatomy, physiology, diseases, etc. Examples of the questions are the following: 'What is the reason

**Table 1.** Results of ANCOVA on attitudes toward plants.

Variables	<i>F</i>	<i>p</i>
Intercept	84.65	<0.001
Knowledge about monocotyledonous plants	4.20	<0.05
Number of spontaneous questions (interest)	7.30	<0.01
Age	0.01	0.96
Gender	7.41	<0.01
Plants cultivation	1.50	0.22

**Table 2.** Results of multidimensional regression on the attitudes toward plants.

	$\beta$	$\beta$ (SE)	<i>B</i>	<i>B</i> (SE)	<i>t</i>	<i>p</i>
Intercept			3.94	0.04	92.31	<0.001
Botany	0.16	0.07	0.08	0.03	2.37	<0.05
Zoology	0.13	0.07	0.06	0.03	2.02	<0.05
Human biology	0.09	0.07	0.02	0.02	1.43	0.15
Health and nutrition	0.09	0.06	0.06	0.03	1.32	0.19
Genetics	0.11	0.07	0.07	0.04	1.71	0.09
Ecology	0.16	0.07	0.13	0.06	2.39	<0.05
Evolution	0.17	0.07	0.11	0.05	2.54	<0.01
Ethology	0.11	0.07	0.13	0.08	1.70	0.09
Microbiology and virology	-0.10	0.06	-0.16	0.11	-1.48	0.14
Extinct organisms	0.05	0.07	0.08	0.11	0.74	0.46
Other questions	-0.06	0.07	-0.03	0.04	-0.87	0.9
Astronomy	-0.05	0.07	-0.05	0.07	-0.74	0.46
Geology	-0.05	0.07	-0.13	0.17	-0.74	0.46

for nails?' (male, 15 years); 'Why are skin marks formed?' (male, 16 years); 'What is a dream?' (female, 15 years); 'Do tattoos cause cancer?' (female, 16 years); 'Why do people yawn?' (female, 17 years); 'Is homosexuality a mental disorder?' (female, 17 years). Many questions from this subcategory were connected with the brain, for example: 'Why aren't people able to use their own brain at 100%' (male, 15 years); 'Why is the human brain fallible?' (male, 16 years).

The second most popular subcategory was Zoology, where boys wrote more questions in comparison with girls (36 vs. 33). Examples of the questions are the following: 'Which animal has got the most teeth?' (male, 16 years); 'How many insect species exist in the world?' (female, 15 years); 'How many legs does a centipede have?' (female, 17 years).

The third popular subcategory was Botany, where boys wrote 42 questions and girls wrote 23 questions. The questions were from anatomy and physiology of plants and from plants systematic. Examples of spontaneous questions are the following: 'What are the herbal effects of plants?' (male, 17 years); 'Is there an existing plant, which has an animal cell?' (male, 18 years); 'Are plants able to sense music?' (male, 16 years); 'What is the oldest plant in the world?' (female, 17 years); 'How do you correctly take care of carnivorous plants?' (female, 17 years).

**Table 3.** Results of multidimensional regression on knowledge about monocotyledonous plants.

	$\beta$	$\beta$ (SE)	<i>B</i>	<i>B</i> (SE)	<i>t</i>	<i>p</i>
Intercept			-124.26	47.26	-2.63	<0.01
Gender	0.16	0.07	0.94	0.41	2.27	<0.05
Grade	0.11	0.07	0.39	0.24	1.61	0.11
Botany	0.23	0.07	0.90	0.28	3.26	<0.001
Zoology	0.04	0.07	0.15	0.26	0.59	0.56
Human biology	0.08	0.07	0.14	0.12	1.12	0.26
Health and nutrition	0.01	0.07	0.01	0.40	0.02	0.98
Genetics	0.07	0.07	0.39	0.35	1.10	0.27
Ecology	-0.03	0.07	-0.17	0.46	-0.36	0.72
Evolution	0.09	0.07	0.51	0.37	1.36	0.17
Ethology	-0.03	0.07	-0.32	0.65	-0.49	0.63
Microbiology and virology	0.02	0.07	0.23	0.90	0.26	0.80
Extinct organisms	0.07	0.07	0.87	0.88	0.99	0.32
Other questions	0.08	0.07	0.36	0.30	1.19	0.23
Astronomy	-0.02	0.07	-0.13	0.58	-0.23	0.82
Geology	-0.06	0.07	-1.33	1.43	-0.93	0.35

**Table 4.** The distribution of spontaneous questions among categories and subcategories.

Categories and subcategories	Absolute frequency	Relative frequency (%)
<b>BIOLOGY</b>	<b>682</b>	<b>96.06</b>
Botany	65	9.15
Zoology	69	9.72
Human biology	282	39.72
Health and nutrition	37	5.21
Genetics	53	7.46
Ecology	30	4.23
Evolution	52	7.32
Ethology	14	1.97
Microbiology and virology	8	1.13
Extinct organisms	9	1.27
Other questions	63	8.87
<b>EARTH SCIENCES</b>	<b>28</b>	<b>3.94</b>
Astronomy	24	3.38
Geology	4	0.56

In the subcategory of Genetics, the pupils were interested in for example: ‘Will it be possible to clone people?’ (male, 18 years). The subcategory Evolution was focused mainly on human evolution. Examples of questions are the following: ‘How was the first man created?’ (female, 16 years); ‘Why were humans developed into two sexes?’ (male, 15 years). The Health and nutrition subcategory included question regarding prevention such as: ‘Which physical activity is the most useful for us?’ (female, 16 years); ‘Is veganism useful for people?’ (male, 16 years). Some examples of spontaneous questions from the subcategory Ecology were: ‘How is it possible that endemits live only in one place?’ (female, 17 years). The subcategory Ethology included for example: ‘How do animals know how to predict storms?’ (female, 17 years). The subcategory Extinct animals included for example: ‘How did the dinosaurs reproduce?’ (female, 17 years). The subcategory Microbiology and virology included the lowest amount of spontaneous questions, for example: ‘How were viruses created?’ (male, 17 years). In the subcategory Other questions, pupils focused on different aspects such as: ‘Why do people believe in God?’ (female, 17 years) or ‘Will it be possible to be immortal in the future?’ (male, 18 years).

From the category ‘Earth Sciences’, the subcategory ‘Astronomy’ included more questions such as: ‘Do aliens exist?’ (female, 15 years) or ‘Is there existing life in space?’ (female, 18 years). The second subcategory called ‘Geology’ was only interesting for boys and it included questions such as: ‘How was the diamond created?’ (male, 18 years).

#### 4. Discussion

This study revealed that factual knowledge about monocotyledonous plants and interest in plants is positively associated with the lower secondary school pupils’ attitudes toward plants. Gender differences favouring females emerged in attitudes and factual knowledge of plants. Plant cultivation was not associated with attitudes toward plants as we originally predicted.

Significant and positive associations between factual knowledge of monocotyledonous plants and attitudes toward plants provides further support of the existence of links between attitudes and knowledge, not only in botany, and extends our current knowledge

formerly restricted mostly to zoology or the environment (Arcury, 1990). Previous research indicated that botanical experience positively influenced perception and interest in plants (Bokor et al., 2014; Colon et al., 2020). Integration of botany with chemistry and art (Cil, 2016) significantly improved student attitudes toward plants. Both these studies implicitly assume that knowledge could influence attitudes or perceptions, but it is highly likely that various kinds of experiences with conspicuous traits of plant flowers (scents, colours, Bermudez et al., 2018; Hula & Flegr, 2016) influenced these positive effects as well. Our results are not contaminated by additional factors and clearly indicate that factual knowledge about monocotyledonous plants is positively correlated with attitudes toward plants.

It is reasonable to suggest that students with more positive attitudes would like to know more about botany. Our research clearly confirms this idea; interest in plants estimated with the number of spontaneous questions about plants positively correlated with attitudes toward plants. Given that attitudes influence individual's behaviour (Ajzen & Fishbein, 1972; Arroyo et al., 2020; Kals et al., 1999), it can be speculated that interest in plants, or plant blindness, might influence human behaviour toward plants. If so, there is a serious urgency to improve student attitudes toward plants to preserve living organisms on this planet. Of course, this idea requires further research before firm conclusions can be made. Notably, the Plant Attitude Questionnaire (Fančovičová & Prokop, 2010) used in this study has been successfully used to examine attitudes in different cultures (Tukey: Selvi, 2012; Cil, 2016; Selvi & İslam, 2021; Korea: Jeong et al., 2015; UK: Stagg, 2020). Thus, it can be concluded that these results are reproducible, independent on local cultural and contextual practice.

Knowledge of monocotyledonous plants and the total number of spontaneous questions of botany significantly correlated, but there was no correlation with spontaneous questions from other science disciplines. This result provides statistical evidence that knowledge of plants is exclusively associated with interest in plants. This finding is important, because interest was examined with a completely different method than attitudes toward plants, meaning that it is not a statistical by-product of correlation with attitudes.

Biology received incomparably more spontaneous questions than earth sciences. This reflects spontaneous interest in living things compared with non-living motionless objects in humans (Inagaki & Hatano, 1996; Simion et al., 2008). Considering the three most frequent categories of spontaneous questions in biology, botany received a similar number of questions as zoology, but human biology questions were highly outnumbered. Baram-Tsabari and Yarden (2005) demonstrated that 72% of biological questions were zoological and one-quarter addressed issues in human biology. Botanical questions were very rare and accounted for only 2.3% of all biological questions. Similarly, Cakmakci et al. (2012) found similar low frequency of botanical questions (1.9%) in Turkey. It is possible that these differences emerged because of a different culture, age, or source of questions. While we collected data from a homogeneous sample, Israeli children in their study asked questions via an Israeli television programme for children. The latter variable seems to be a hot candidate for these apparent differences, because only highly motivated, perhaps exceptionally curious, Israeli children asked these questions (Baram-Tsabari & Yarden, 2005) while our sample consisted of standard,

whole-class students who were not selected based on their interest in science (c.f. Cakmakci et al., 2012).

Interestingly, a positive and significant relationship between attitudes toward plants and other subcategories of spontaneous questions, namely from zoology, ecology and evolution was shown. Given that all these disciplines are connected to one other (e.g. animal-plant relationships, interspecific relationships of plants, evolution of plants), these results are not surprising. No correlations emerged, however, with more extant disciplines, such as with health and nutrition or microbiology. This means that attitudes toward plants show relatively narrow relationships with interest in closely related disciplines which needs to be considered by science education teachers. Deepening interest in zoology, ecology, evolution, and their connections with plant sciences provides promising possibilities how to build more positive attitudes toward overlooked and boring plants (Balding & Williams, 2016; Schussler & Olzak, 2008; Wandersee & Schussler, 1999).

Evidence for gender differences in attitudes, interest and knowledge of plants are mixed (e.g. Laiacona et al., 2006; Palmberg et al., 2015; Prokop & Fančovičová, 2019; Schussler & Olzak, 2008; Tunncliffe, 2001). Our results suggest that females have more positive attitudes toward plants and scored better in factual knowledge of monocotyledonous plants than males. However, females are similarly interested in plants than males. With respect to attitudes, Fančovičová and Prokop (2010, 2011b) used the same questionnaire as we did in the present study but found no gender differences in attitudes toward plants. Better knowledge of plants (e.g. Fančovičová & Prokop, 2011b; Laiacona et al., 2006; Robinson et al., 2016) and greater interest in plants was also reported previously (e.g. Hong et al., 1998; Lohr et al., 2004; Schussler & Olzak, 2008), but we need to address one notable exception. None of the studies used spontaneous questions to examine student interest in botany. Baram-Tsabari and Yarden (2005) compared gender differences in spontaneous questions in botany (among others) but found no gender differences and concluded that boys and girls share the same fields of interest in biology. Similarly, we also did not find any significant gender differences in interest in plants.

Contrary to our hypothesis, students who cultivated plants, showed no significantly higher attitude scores toward plants in comparison with students, who did not report plant cultivation. This finding contradicts some other research (Fančovičová & Prokop, 2010, 2011b; Kim et al., 2020; Leuven et al., 2018; Lohr & Pearson-Mims, 2005; Relf et al., 1992), who found that people's attitudes toward plants are associated with plant cultivation. Our failure to find any association between plant cultivation and attitudes could be caused by the low variability of results; a vast majority (84%) of students reported plant cultivation, which could cause the absence of statistical significance. Further research would use more sensitive plant cultivation activities measures which could provide more realistic picture of children activities with plants. For instance, Selvi and İslam (2021) in their current study found moderate correlations between attitudes toward plants and picking flowers. These variables provide a more reliable picture about student experiences with plant cultivation. In addition, many gardening activities in students need not be voluntary, but rather parent-directed and, if so, it is difficult to expect any positive influence on attitudes toward plants.

## 5. Conclusion

Factual knowledge seems to be essential in building school students' positive attitudes and interest in botany. These associations seem to be relatively stronger in females than in males. Attitudes toward plants positively correlated not only with interest in botany, but also with closely related disciplines such as zoology, ecology and evolution. We suggest that deeper inter-connections of botany with other biological disciplines may be helpful in elimination of plant blindness and building positive attitudes toward plants and other living things.

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## Appendix. Factual knowledge test focused on monocotyledonous plants (correct answers are in bold)

1. Monocotyledonous plants originate in the family:
  - a) carrots b) hazels c) **waterlilies**

2. Typical veins for monocotyledonous plants is:  
a) reticulated **b) parallel** c) feathered
3. Common reed belongs to the family:  
a) lilies b) irises **c) poas**
4. The grain of sown maize shall contain at most:  
**a) starch** b) protein c) fat
5. The flowers of monocotyledonous plants are usually:  
a) 5-number **b) 3-number** c) 4-number
6. Garlic, onion and chives belong to the family:  
a) amaryllids b) garlics **c) lilies**
7. The hollow articulated stem with elbows is called:  
**a) stem** b) scape c) halm
8. We know ginger as a root with significant antibacterial effects. It belongs to a plant with a botanical name:  
a) Sweet flag b) Alpine arum **c) Zingiber root**
9. Gluten-free food is:  
a) wheat **b) rice** c) oat
10. The most toxic parts of spring snowdrop are:  
**a) onions** b) flowers c) fruits
11. Growing plants in aqueous solution without soil substrate is called:  
a) hydrochoria **b) hydroponics** c) hydrophilia
12. The root system of monocotyledonous plants is:  
a) tap root (main root and lateral roots) **b) adventitious root (secondary bundle roots)**
13. Greenfinch, monstera and scapular are among the plants:  
a) medicinal b) aqueous **c) room**
14. The country of tulips is:  
a) Belgium **b) The Netherlands** c) Luxembourg
15. Slovakian small aquatic plant, which grows directly on the water surface and is not rooted at the bottom, is called:  
**a) Common duckweed** b) Yellow Waterlily c) Broad-leaved pondweed
16. Poa, Cocksfoot, Timothy and Festuca are among the pollinated plants:  
a) insects **b) wind**
17. Monocotyledonous plants do not include:  
a) Wild daffodil b) Siberian iris **c) Alpine aster**
18. The roots of epiphytic species of orchids are:  
**a) aerial** b) rooted in soil c) stock
19. A typical 'messenger of spring' of Slovakian deciduous forests is an important medicinal plant with detoxifying effects, vitamin C and is called:  
a) Yellow star-of-Bethlehem **b) Wild garlic** c) Pilewort
20. Lady-slipper is a protected species in Slovakia and belongs to the family:  
a) water-plantains b) arecas **c) orchis**