Useful Plants as Potential Flagship Species to Counteract Plant Blindness

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Introduction: Plant Blindness

"We are all more interested in animals [than in plants]" (Flannery 1991). This statement captures best the atmosphere a biology teacher is confronted with in any classroom when he/she starts a lesson on botanical content (Wandersee 1986). The low interest in plant science has been lamented for decades by biology educaters on every level – from primary school up to university level (Tunnicliffe and Ueckert 2007). Additionally, major studies on students' interests (e.g. ROSE; Sjøberg and Schreiner 2010) confirm that students do not consider plants to be interesting. Wandersee and Schussler (2001) have coined the term "plant blindness" for this phenomenon, describing how plants are overlooked in many peoples' everyday life. The fragmentary perception of herbal life has serious consequences because students, for example, do not perceive plants as creatures but consider them merely as a kind of "background image" for animal life (Flannery 2002; Kinchin 1999; Sanders et al. 2015).

Plant blindness is a serious problem in botany education, and special efforts must be made to make botanical content more attractive for students (Greenfield 1955; Hershey 1992). Numerous programmes emphasise the importance of plants in school (e.g. "PlantingScience" www.plantingscience.org or "Biological Sciences Curriculum Study – BSCS" www.bcsc.org). These programmes range from plant development observation programmes (Hershey 1992, 2002, 2005), the investigation

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of the diversity of plants through field trips (Dillon et al. 2006; Drissner et al. 2010; Fančovičová and Prokop 2010; Pany 2010; Vaughan et al. 2003) to activities of sorting plants (Frisch et al. 2010; Lindemann-Matthies 2005; Randler 2008).

Our approach to counteract plant blindness presented in this chapter is different. Instead of developing learning environments to enhance students' interest in and awareness of plants, we start one step earlier – by exploring the pre-existing interest of students in plants. Planning botany learning environments based on students' pre-existing interest in plants would have many advantages according to psychological theories on learning and interest: considering an object "interesting" is an important condition to deal with the object more intensively (Deci and Ryan 1993), and pre-existing interests are important keys for building new knowledge and developing long-lasting interests (Hidi and Baird 1986; Hidi 1990; Krapp 1999). Nonetheless, detailed studies about which plants students perceive as interesting are scarce. Hence, exploring which plants are interesting for students is a prerequisite for effectively counteracting plant blindness.

Students' Interest in Plants

A review of recent scientific literature on students' interest in plants is not encouraging for botanists. As noted above, the largest international study on students' interests in science and technology topics ("Relevance of Science Education" – ROSE; Schreiner 2006; Schreiner and Sjøberg 2004; Sjøberg and Schreiner 2010) demonstrates that botanical content is uninteresting. Zoology or human biology is much more interesting than plant science, a result also shown by earlier interest studies (Baram-Tsabari et al. 2010; Baram-Tsabari and Yarden 2005; Kinchin 1999; Wandersee 1986). Moreover, interest in biological content decreases with age (Baram-Tsabari and Yarden 2007, 2009; Kattmann 2000; Löwe 1987, 1992; Potvin and Hasni 2014).

Hence, some scientists in the field of biology education recommend teaching central biological concepts such as evolution only in the context of those organisms that students consider interesting (e.g. animals) (Baram-Tsabari and Yarden 2009). This, however, would lead to many biology lessons not addressing plants at all. Given that knowledge about plants is necessary to become scientifically literate and to understand the major global challenges our society is currently facing, this cannot be an acceptable solution for biology education. From a biological point of view, we need knowledge about plant anatomy and morphology, plant reproduction and flowering ecology in order to understand the role of plants in the world food supply or biofuel production. Furthermore, botany basics such as plant physiology (e.g. photosynthesis) are necessary for developing a deeper understanding of the carbon cycle and climate change. Consequently, students' lack of knowledge about plants hinders them from seeing the full extent of such important problems as global warming. We must therefore face the challenge to make presumably uninteresting but biologically important content interesting for students.

Analysing the recent literature reveals that plants are always treated in a holistic way as a homogeneous group (e.g. Blankenburg et al. 2015; Dawson 2000; Sjøberg 2000). In the ROSE-study, for example, students were asked very general questions about their interest in botanical topics, e.g. "How plants grow and reproduce" or "Plants in my locality" (Schreiner and Sjøberg 2004). Importantly, the context in which a specific content is presented is even more important for developing interest than the content itself (Elster 2007; Häussler and Hoffmann 1998; Sjøberg 2000). This calls for differentiating and identifying distinct plant groups and contexts that may be interesting for students rather than doing research on plants on a very general level.

The first hints that useful plants could be worth further examination came from Mayer and Horn (1993), who show that students prefer living organisms that are of value for human use. In addition, Krüger and Burmester (2005) determined that besides the "beauty of plants" (Kinchin 1999; Tunnicliffe and Reiss 2000), the "usefulness of plants" is the most prominent category students use to classify plants. The study by Lindemann-Matthies (2005) tends to support these findings: organisms which are useful for humans have a higher value for most people. Hammann (2011) also supports the hypothesis that useful plants are interesting for students by showing that students are highly interested in medicinal plants.

On this basis, we designed the present study. We chose the group of useful plants as a starting point in our exploration of students' pre-existing interest in plants. First, we studied whether useful plants are interesting for students and whether students differentiate between specific subgroups of useful plants. Then we investigated whether there are differences between different age groups and genders regarding the interest in useful plants. Based on these findings, we tackle the overall question which plant groups can be recommended as promising "flagship species" to teach and learn botanical content.

Method: The FEIN Questionnaire

In order to investigate students' interest in useful plants, we developed the FEIN questionnaire (Fragebogen zur **E**rhebung des **I**nteresses an **N**utzpflanzen; Pany 2014) since the research of Urhahne et al. (2004) suggests that questionnaires are appropriate tools to explore students' interest. The item development was based on the biological classification of useful plants (Lieberei et al. 2007) in which useful plants are defined as all plant species used by humans and in which various subgroups are differentiated according to their specific purpose (spice plants, edible plants, medicinal plants, etc.).

On this basis, we developed three items for each of the five scales of medicinal plants, stimulant herbal drugs, edible plants, spice plants and ornamental plants. The wording of the items is based on the ROSE questionnaire (Schreiner and Sjøberg 2004). They are formulated as headlines, and students indicate their interest

Table 1 Questionnaire items to investigate interest in useful plants (FEIN, Pany 2014); this translation gives an impression of the items used in the original German questionnaire: the English items are not linguistically validated

English translation of the FEIN questionnaire	German version (original language)
How interested are you in learning about the following?	*Wie interessiert bist Du an folgenden Bereichen?*
1. In which countries do vegetables (e.g. tomatoes) grow naturally (EP)	1. In welchen Ländern verschiedene Gemüsepflanzen (z.B. Tomate) in der freien Natur wachsen
2. Plants used to produce narcotics (SHD)	2. Pflanzen, aus denen Rauschmittel erzeugt werden können
3. Plants used to cure inflammations (e.g. a sore throat) (MP)	3. Pflanzen, die gegen Entzündungen (z.B. Halsschmerzen) helfen
4. Parts of plants used to produce oregano, chilli or caraway (SP)	4. Pflanzenteile zur Herstellung von z.B. Oregano, Chili oder Kümmel
5. Plants for decorating my room (OP)	5. Pflanzen zur Verschönerung meines Zimmers
6. Organic agriculture (EP)	6. Biologische Landwirtschaft
7. Plants which can cause hallucinations (SHD)	7. Pflanzen, die Halluzinationen erzeugen können
8. Plants which enhance the healing process of wounds (MP)	8. Pflanzen, welche die Heilung von Wunden unterstützen
9. Spice plants (SP)	9. Gewürzpflanzen
10. Taking care of house plants (OP)	10. Die Pflege von Zimmerpflanzen
11. Horticulture without pesticides (EP)	11. Gartenbau ohne Spritzmittel
12. Producing opium and heroin from opium poppy (SHD)	12. Die Gewinnung von Opium und Heroin aus dem Schlafmohn
13. Plants which can be used to produce a soothing infusion (e.g. against coughs) (MP)	13. Pflanzen, aus denen man einen heilenden Tee (z.B. gegen Husten) machen kann
14. Substances that make spices taste hot (SP)	14. Inhaltsstoffe, die Gewürze scharf schmecken lassen
15. Balcony flowers (OP)	15. Blumen an Fensterbänken

The assignment to the respective scale is given at the end of each item (*MP* medicinal plants, *SHD* stimulant herbal drugs, *SP* spice plants, *EP* edible plants, *OP* ornamental plants)

by choosing from a four-stage Likert scale (very interested, 4; rather interested, 3; rather not interested, 2; not interested, 1) (Table 1).

A principal component analysis (PCA) revealed a five-factor structure (Pany 2014), confirming the differentiation of subgroups of useful plants according to Lieberei et al. (2007). This shows that students' interest in useful plants is not homogeneous across all subgroups but has to be examined in a more differentiated way.

Reliability analyses (Cronbach's alpha) were calculated for each scale of the FEIN questionnaire. Cronbach's alpha shows values between 0.66 for spice plants and 0.76 for ornamental plants, which is appropriate for scales consisting of only three items each.

Table 2 Descriptive data of the investigated sample (n = 1299)

Age group	<13 years	13–14 years	15–16 years	>16 years	Total
Male students	245	197	159	62	***663***
Female students	236	193	137	70	***636***
Total	**481 (37%)**	**390 (30%)**	**296 (23%)**	**132 (10%)**	***1299***
Mean age (year)	**11.2**	**13.5**	**15.5**	**17.6**	***14.4***

The FEIN questionnaire was administered to 1417 students in and around Vienna, Austria. During spring 2010, 15 secondary schools participated in our study, providing a representative cross section of Viennese schools. Finally, 1299 questionnaires were filled in by 51% male and 49% female students aged between 10 and 19 years (Table 2).

Data Analysis

We analysed the questionnaire data on two levels. In the first step, we sought to identify significant differences between relevant groups in our sample (age and gender) regarding their interest in the five groups of useful plants. We therefore compared the means of interest per scale of the FEIN questionnaire of four age groups (<13, 13–14, 15–16 and >16 years) and the two gender groups using t-test, MANOVA, ANOVA and post hoc tests (Scheffé).

As mean values do not allow conclusions on an individual level (Valsiner 1986), we calculated in the second step an interest profile for every student in the sample. When planning stimulating and interesting learning environments in school, knowing what an "average student" is interested in is not very helpful. It is indispensable to know the interest structure of individual students in a particular class. Therefore, we developed a method to calculate interest profiles on an individual level. For this purpose, we first developed a method to reduce the complexity of the data per participant. This achieved a reduction level which also considers the variation of the individual interest structure of each student and enables clustering students to larger units showing identical patterns of interest in terms of "interest types" (= groups of students with similar interest structure). This process of complexity reduction is described in detail in Pany and Heidinger (2015).

The resulting interest profiles are based on each student's interest in three subgroups of useful plants: medicinal plants, stimulant herbal drugs and ornamental plants.[1] Per subgroup of useful plants, three interest levels are generated, ranging from "low interest – level 1", "medium interest – level 2" to "high interest – level 3". A student's interest profile of "321", for example, means this student has high

[1] We take into account only those subgroups of useful plants, which best enable differentiating between different interest types because they show a clear deviation from an equal distribution in the whole sample (Pany and Heidinger 2015).

interest in medicinal plants, medium interest in stimulant herbal drugs and only low interest in ornamental plants (the amount of interest is always given in the same order: medicinal plants, stimulant herbal drugs, ornamental plants). Subsequently, we calculated whether there are characteristic interest profiles in the whole sample and for different age groups using frequency analysis.

Results

Mean Values

Data analyses using ANOVA show that medicinal plants, stimulant herbal drugs, spice plants, edible plants and ornamental plants raise different degrees of interest ($F_{4,\,6490} = 202.5$, $P < 0.001$). Mean values show that medicinal plants are the most interesting group, followed by stimulant herbal drugs (Table 3).

Additionally, MANOVA results show that there are differences in how interested students of different age groups are in the five plant groups (*Wilks's* $\Lambda = 0.922$, $F_{15,\,3564} = 7.074$, $P < 0.001$). Subsequent univariate analysis (ANOVA) with post hoc Scheffé tests revealed significant differences regarding the interest in subgroups of useful plants between different age groups (Table 4). The interest in medicinal

Table 3 Means (*M*) and standard deviations (SD) of interest in different plant groups measured with the FEIN questionnaire; means above 2.5 indicate above-average interest; all means are significantly different from each other ($P < 0.001$)

Plant group	*M*	SD
Medicinal plants	3.09	0.75
Stimulant herbal drugs	2.90	0.88
Spice plants	2.56	0.78
Edible plants	2.43	0.78
Ornamental plants	2.32	0.89

$F_{4,\,6490} = 202.5$, $P < 0.001$

Table 4 Means (*M*), standard deviations (SD) and univariate F-statistics of interest in the subscales of the FEIN questionnaire for different age groups

	<13 years		13–14 years		15–16 years		>16 years			
Subscale	*M*	SD	*M*	SD	*M*	SD	*M*	SD	$F_{3,\,1295}$	
Medicinal plants	3.19	0.73	2.96	0.76	3.01	0.78	3.26	0.63	14.268	**
Stimulant herbal drugs	2.87	0.88	2.89	0.90	2.90	0.86	3.01	0.86	0.873	
Spice plants	2.67	0.80	2.50	0.80	2.50	0.71	2.52	0.76	10.631	*
Edible plants	2.61	0.79	2.32	0.80	2.30	0.70	2.39	0.74	4.623	**
Ornamental plants	2.54	0.90	2.31	0.90	2.05	0.80	2.16	0.82	20.906	**

*$P < 0.01$, **$P < 0.001$

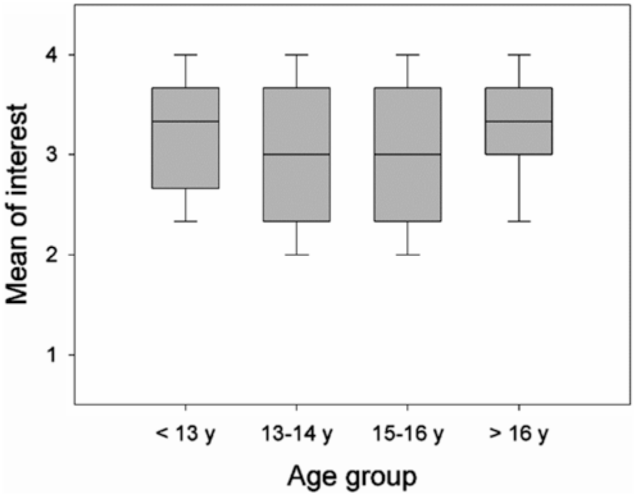

Fig. 1 Means of interest of the subscale "medicinal plants" for all age groups

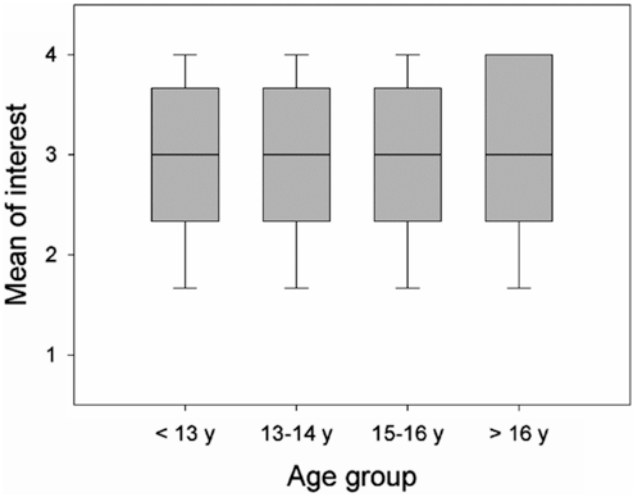

Fig. 2 Means of interest of the subscale "stimulant herbal drugs" for all age groups

plants is higher in younger students (<13 years) and older students (>16 years) but lower in the other age groups (Fig. 1), whereas the interest in stimulant herbal drugs shows no significant differences between the age groups (Fig. 2). Furthermore, only ornamental plants show significant gender differences. They are more interesting for girls than for boys ($t = -11.72$, df = 1298, $P < 0.001$) (Fig. 3).

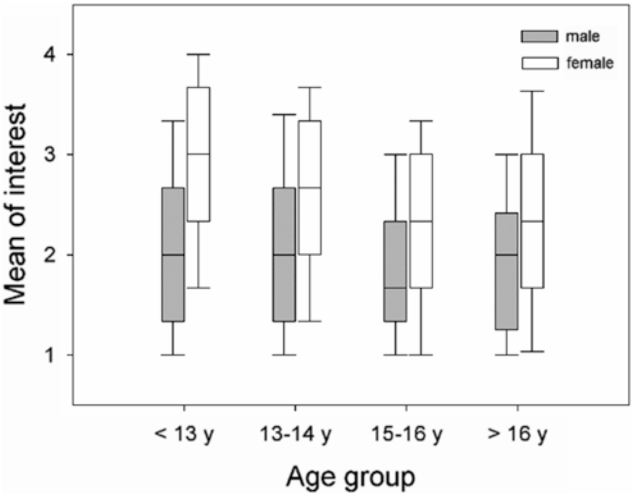

Fig. 3 Means of interest of the subscale "ornamental plants" for all age groups and both genders shown separately

Table 5 Characteristics of the ten most frequent interest types in the whole sample; marked interest types (*) are not evenly distributed among the age groups

	Interest in				
	Medicinal plants	Stimulant herbal drugs	Ornamental plants	Frequency percent	
331	*High*	*High*	*Low*	18.9	*
333	*High*	*High*	*High*	11.6	*
332	High	High	Medium	8.9	
313	*High*	*Low*	*High*	6.7	*
231	Medium	High	Low	6.2	
323	*High*	*Medium*	*High*	5.5	*
311	High	Low	Low	4.8	
131	*Low*	*High*	*Low*	4.3	*
321	High	Medium	Low	4.2	
232	Medium	High	Medium	3.8	

Interest Profiles

The ten most frequent interest profiles were chosen to give an overall impression of the sample. Table 5 shows that most of the students have low interest in at least one of the subgroups of useful plants.

In contrast, we found that most of the students are interested in at least one plant group more than in the others. Moreover, five of the interest types (331, 333, 313, 323 and 131) are not evenly distributed among the age groups (see Fig. 4 and Table 6).

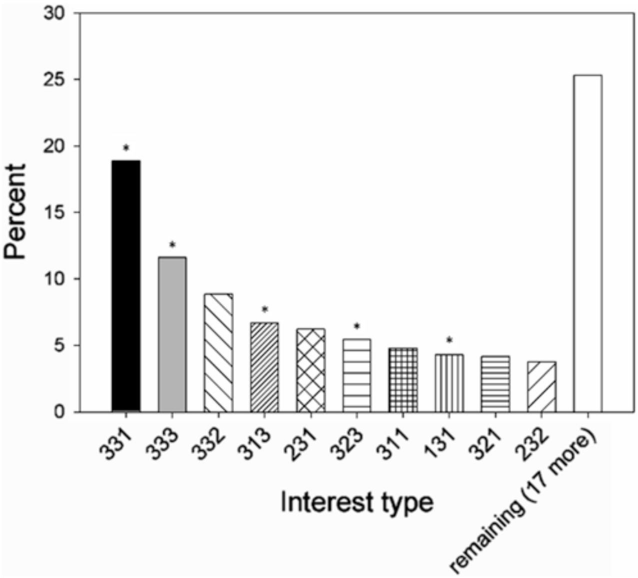

Fig. 4 Frequencies of the ten most frequent interest types within the whole sample; marked interest types (*) are not evenly distributed among the age groups. The amount of interest is always given in the same order: medicinal plants, stimulant herbal drugs, ornamental plants; 3 – high interest, 2 – medium interest, 1 – low interest

The interest profiles 313 and 323 are typical for lower age groups, which means that many younger students are most interested in medicinal plants and ornamental plants but show low interest in stimulant herbal drugs. In contrast, the interest profiles 311 and 321, which indicate a narrow interest restricted solely to medicinal plants, are frequent only in higher age groups. For students between 13 and 16 years old, we found another interest profile occurring only here within the first five ranks: 131 (and also 231), indicating high interest only in stimulant herbal drugs. In summary, there are typical interest profiles for each age group (Fig. 5).

Discussion

Our results show that students do not perceive plants as one homogeneous group of (uninteresting) organisms, as they have often been treated in past studies investigating students' interest in biology (e.g. Blankenburg et al. 2015; Schreiner and Sjøberg 2004). Accordingly, past recommendations for planning biology lessons derived from such a rough scale should be treated with caution: they may yield the misleading conclusion that botanical content and plant science are not interesting for students at all. Quite the contrary, the group of useful plants contains many objects that are suitable to develop interesting learning contexts for botanical contents referring to students' interests.

Table 6 Chi-square values for the distribution of the ten most frequent interest types within the whole sample; marked interest types (*) are not evenly distributed among the age groups

	331	333	332	313	231	323	311	131	321	232
Chi-square	12.008	15.385	4.443	22.003	7.465	8.156	3.169	10.198	4.813	2.215
df	3	3	3	3	3	3	3	3	3	3
Significance	0.007*	0.002*	0.217	<0.001*	0.058	0.043*	0.366	0.017*	0.186	0.529

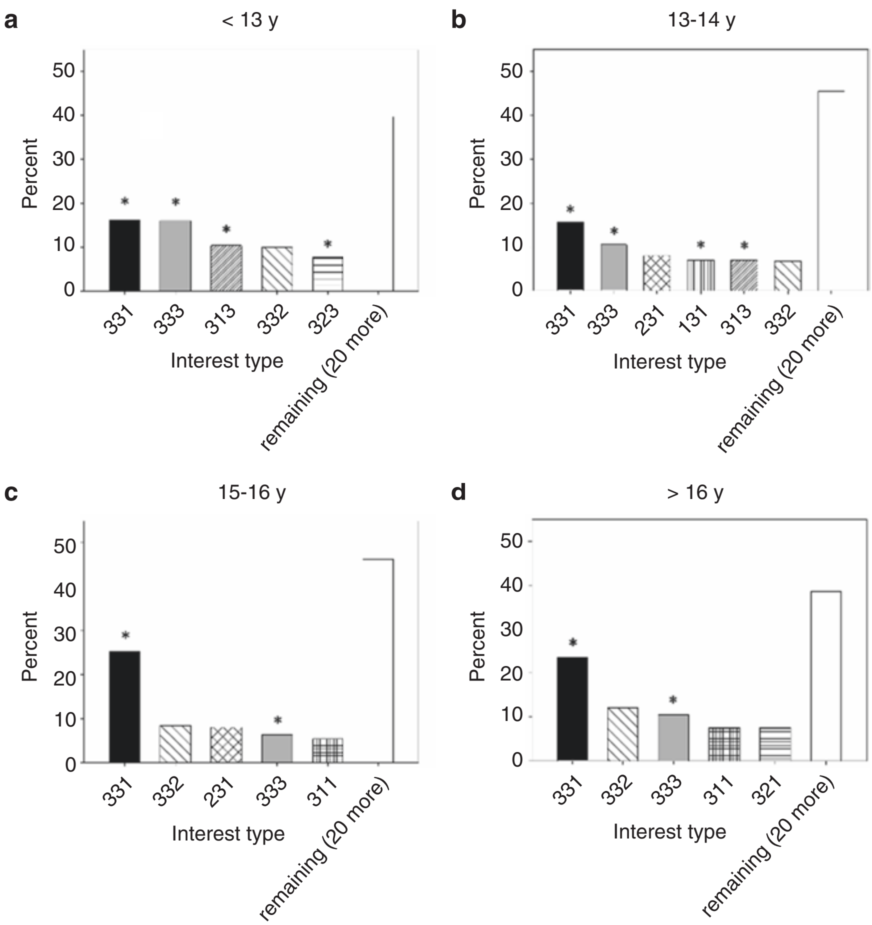

Fig. 5 Frequencies of all interest profiles representing more than 5% of an age group; marked interest types (*) are not evenly distributed among the age groups. The *bars* of identical interest types in the diagram are marked by the same patterns

The mean values seem to point to a clear strategy for botany lessons – medicinal plants and stimulant herbal drugs should be used as study objects in botany lessons. These two plant groups do not show the typical decrease of interest in higher age groups (Elster 2007; Kattmann 2000; Löwe 1987) but instead retain their high interest. However, the analysis of students' interest profiles shows a somewhat different picture. Nonetheless, the most frequent interest types still show high interest in medicinal plants, although stimulant herbal drugs seem to strongly polarise students. Especially in lower age groups, some students show no interest at all in stimulant herbal drugs (e.g. interest profile 313), whereas another group of students shows high interest only in simulant herbal drugs (e.g. interest profile 131). Furthermore, ornamental plants – raising only low interest when examining mean values – are highly interesting for a smaller group of students (e.g. interest profile 313).

Facing the difficulties that plant blindness presents to biology teachers, useful plants may open a wide field of reasonable gateways into botany. We identified interest profiles that are typical only for single age groups, which means that student interest can be addressed very specifically. Students younger than 13 years old may be addressed using medicinal plants (such as sage *Salvia officinalis*, hawthorn *Crataegus* spp. or marigold *Calendula officinalis*) and also ornamental plants (e.g. primroses *Primula* spp., tulips *Tulipa* sp.) but less via stimulant herbal drugs. A subgroup of students between 13 and 16 years can be specifically targeted by using study objects from the only plant subgroup interesting for them: stimulant herbal drugs (e.g. belladonna *Atropa belladonna*). The group of medicinal plants is very interesting for a large number of students across all age groups but especially for older students (above 16 years).

Some stumbling blocks still remain for botany lessons. Biology schoolbooks that cover botany topics listed in the biology curriculum (e.g. the structure of plants and flowers or photosynthesis) (Cholewa et al. 2010; Rogl and Bergmann 2003; Schirl and Möslinger 2011) and even biology textbooks at the university level (Campbell and Reece 2011) introduce such botanical content mostly based on ornamental plants. Our findings demonstrate that this choice complies with the interest of only a small part of learners.

Therefore, incorporating the results of the present study not only in learning environments but also in biology textbooks may help to create interesting contexts in botany lessons, supporting students to find access to botanical contents. One open field for prospective studies remains: experimental designs that enable testing the hypothesis whether study objects which take into account students' interest in plants indeed raise long-lasting interest and lead to higher learning outcome regarding botanical topics. At any rate, the present results offer a promising approach to counteract the unsatisfactory situation in which students neglect the vast majority of life on Earth.

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