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The Development of Students' Interest in and Knowledge of Botany by Means of a Workshop on Pollination and Floral Ecology

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Abstract

This article examines how students' botanical knowledge and interest in plants can be increased in order to counteract "plant blindness", which is a phenomenon describing the lack of people's awareness of plants. Since recent studies point to a continuous decline of students' interest in biology, especially in botany, during secondary education, a workshop on pollination and floral ecology has been designed. 100 students (N=100) from five different schools took part in the workshop. By means of a pre- as well as a post-test and a questionnaire directly after the workshop, data regarding the students' interest, knowledge and intrinsic motivation has been collected. Results show that the workshop has a positive impact on the students' interest in the pollination and floral ecology. Additionally, the findings indicate that the workshop leads to an increased botanical knowledge as well as development of intrinsic motivation.

Introduction

Taking into consideration the fact that plants form the basis of life, it is even more regrettable that nowadays human beings neither notice nor value plants in everyday life. Indeed, research studies and surveys have already demonstrated that people are more interested in animals rather than in plants (Allen 2003; Sundberg et al. 2001). For this purpose, Wandersee und Schussler (1999) introduced the term "plant blindness". Plant blindness not only refers to the lack of people's interest in as well as general awareness of plants (Balas and Momsen 2014); the term also includes the insufficient knowledge about several species and the diversity of plants and finally, the ignorance of the importance of their role in the ecosystem (Bebbington 2005; Schussler and Winslow 2007; Wandersee and Schussler 1999).

As a result, both our environment as well as we as human beings are negatively affected (Pany and Heidinger 2017). For instance, it has already been shown that humans make less effort to preserve plant species in contrast to animal species (Baldings and Williams 2016). Therefore, public funds and personal donations are used to protect animals rather than plants, even though many plant species are already endangered due to climate change. To counteract the limited interest in plants, a workshop on pollination and floral ecology for secondary school students has been designed (International Union for Conservation of Plants (IUCN) 2019a, 2019 b; Cires et al. 2013; Havens et al. 2014).

Interest in Botany and the Pollination by Insects

In general, a distinction is made between short-term and long-term interest. Long term-interest refers to a stable willingness to occupy oneself with an object of interest; therefore, it is called personal interest (Krapp 2002; Schiefele 1999) or individual interest (Hidi and Renninger 2006). On the contrary, short-term interest – or situational interest – is often triggered by external factors, such as the creation of special teaching and learning environments. In addition to the integration of "catch" and "hold" facets, the satisfaction of all three basic psychological needs – self-determination, competence and interpersonal relatedness – should also be provided so that students' situational interest can ideally lead to an enduring personal interest (Deci and Ryan 2000; Hidi and Renninger 2006; Krapp 2002; Wehmeyer and Little 2013).

Children are initially interested in plants (Schneekloth 1989); however, several studies have already demonstrated that during the years of schooling students show more interest in animals rather than in plants due to their animistic, anthropocentric conception of the world (Yorek, Sahin, and Aidin 2009). Although girls seem to be more interested in plants than boys, they tend to prefer animals as well (Pany 2014; Wandersee and Schussler 1999). Therefore, not only boys but also girls develop a lack of interest in botany in the course of secondary school (Jidesjo 2008). When it comes to specific topics regarding botany, secondary students are not really interested in plants in the surrounding environment as well as in the reproduction systems of plants (Jidesjo 2008; Trumper 2006). As a result, the underestimation of the importance of plants leads to the fact that people, especially students, hardly notice and observe plants in their everyday life (Wandersee and Schussler 2001; Wandersee and Clary 2006). This is why different didactic approaches should be applied when teaching botany in order to lessen the so-called plant blindness and simultaneously foster students' interest in botany.

Fostering Awareness of Plants

Children need to become aware of plants in their environment in order to care about, appreciate and finally, protect them. Since an early, well-planned education as well as interaction with plants are the key to prevent plant blindness, the strategy how teachers present the subject to students is crucial. An effective approach should include opportunities or so-called "catch" facets in which students can use their sense of touch and encounter plants directly. In the consequent learning process, teachers should also integrate different "hold" facets, for example by presenting the same amount of plant and animal examples, so that students become familiar with and interested in plants as well. Thus, both organisms are covered equally and so neither animals nor plants are emphasized (Krapp 2002; Schussler and Olzak 2010). Additionally, teachers can also help students to see plants from different perspectives; in fact, plants are linked to several other disciplines such as ecology, economy, chemistry, art, pharmacology or food security. For example, teachers could invite students to grow a plant from seed and observe its development. Working with real objects and connecting certain plant species with these disciplines might help students overcome plant blindness and increase their appreciation and attention for plants (Cil 2015; Drea 2011). However, not only children and teenagers but all human beings should be informed about the importance of plants in our life in order to overcome plant blindness and increase funds allocated to their conservation among others. Therefore, the love for plants should be spread as widely as possible via social media, TV, radio, magazines or

other media channels (Balding and Williams 2016; Krosnick, Baker, and Moore 2018; Wandersee and Schussler 2001).

Selecting Plants Thoughtfully

When giving examples of plants, teachers should use the most memorable pictures known from everyday life. For instance, pictures of carnation, rose, daisy or venus flytrap are common among students and so they can remember those examples more easily. Choosing medicinal plants may also be helpful as they are especially interesting to students (Pany 2014; Pany and Heidinger 2017). When working with real objects, the Austrian curriculum advises to focus on species that are local to the respective region (BMUKK, 2008). This implies that teachers can either take these indigenous plants into the classroom or make use of learning environments outside the classroom such as school gardens, botanical gardens or flower meadows. Indeed, studies have already shown that outdoor educational programmes make biology more attractive to students and influence the students' knowledge of and attitude towards plants (Fancovicova and Prokop 2010; Pany 2014; Pany and Heidinger 2017). Finally, when growing plants in school, it is important to start small so that children are successful in their endeavours and are not overwhelmed. Depending on the space, suitable examples are peas, beans, herbs or sunflowers (Stoecklin 2009).

Using Learning Environments Outside the Classroom to Foster Interest

Since the environment in which learning happens has a significant impact on how students engage with a subject, using learning environments outside the classroom in which direct experience is of prime importance is a powerful approach. Learning outside the classroom indicates the use of places other than the classroom for teaching and learning such as school grounds, sports fields or school gardens but also places beyond the school gates like parks, botanical gardens, zoos, museums and town halls. Experiences outside the classroom are more authentic to students; therefore, it is a tool which has been proven to raise students' attainment as well as achievement and improve students' engagement, especially for those who face difficulties in engaging inside the classroom environment (Braund 2004; Sedgwick 2012; Waite 2017).

Facilitating Positive Emotions through Direct Experiences with Plants

Direct contact with plants and being able to examine them with all senses fosters students' interest in plants (Strgar 2007). This direct experience with plants can either take place while taking the objects into the classroom or making use of learning environments outside the classroom instead of just using traditional classroom-based methods (BMUKK 2008). The direct learning experience is also ensured when students grow plants by themselves since it is a hands-on approach which engages students and raises their environmental consciousness (Klemmer, Waliczek, and Zajicek 2005). Indeed, the best teaching occurs when the emphasis is more on joining students in hands-on interaction and discovery than on imparting knowledge. In fact, students have a natural curiosity that requires direct sensory experience. Therefore, researchers advocate gardening as an effective method for fostering authentic learning, which indicates that students can apply their knowledge to real world situations and in turn

become aware of plants in their surrounding environment (Krosnick, Baker, and Moore 2018; Stoecklin 2009).

Method

Workshop on Pollination

Due to the continuous decline of students' interest in botany during secondary education, the overall aim of this workshop on pollination and floral ecology is to encourage students to develop positive emotions for and situational interest in plants by means of innovative and research-based teaching and learning methods. Hence, the workshop has been designed based on theoretical background of interest research (Deci and Ryan 2000; Krapp 2002; Hidi and Renninger 2006; Wehmeyer and Little 2013). Additionally, the model of competence (Upmeier zu Belzen and Krüger 2010) and the curriculum for the first and second grade of Austrian secondary schools (BMUKK 2008) have been integrated into the workshop design. Moreover, it uses the advantage of the botanical garden as extracurricular workspace in order to foster student's awareness of and interest in plants in their surrounding environment (Braund 2004; Waite 2017).

Phase 1: Activating pre-existing knowledge

At the beginning of the workshop, students review their pre-existing knowledge concerning the components of blossoms by means of a structural model as well as real objects, such as creeping cinquefoil, geranium or loosestrife. In this way a direct experience with plants is provided and so the students' situational interest is caught (Baker and Moore 2018; Hidi and Renninger 2006; Krapp 2002).

Phase 2: Introducing Tubular Flowers and their Components

After this initial phase, students have to search for specific tubular flowers in the botanical garden and dissect blossoms into their components, which is a rather practical approach. Additionally, during the execution of this task all three psychological basic needs – self-determination, competence and interpersonal relatedness – are fulfilled because students can freely choose how to execute this task while finally feeling competent about their achievements (Deci and Ryan 2000; Klemmer, Waliczek, and Zajicek 2005; Krosnick, Baker, and Moore 2018; Strgar 2007).

Phase 3: Focusing on the Pollination by Insects

After concentrating on the chalice in more detail, students are introduced to the pollination by insects by integrating another "catch" facet. Since students can try out the process of pollination on their own by means of an experiment using models of different blossom types, their situational interest is again generated (Hidi and Renninger 2006; Krapp 2002).

Phase 4: Introducing Asters and their Components

In the second part of the workshop, similar tasks are carried out and so several "hold" facets are integrated; however, the focus is on asters instead of tubular flowers. Again, students learn about the components of asters by means of a hands-on approach. While students dissect asters into their components, they take a closer look at them (Deci and Ryan 2000; Klemmer, Waliczek, and Zajicek 2005; Krosnick, Baker, and Moore 2018).

Phase 5: Focusing on the Interplay of Asters and Insects

Finally, students learn about the interplay of insects and asters and another interactive experiment using a model of an aster helps them to understand this process better. Since students can again try out the process of the pollination on their own, they get actively involved in the learning process and students' situational interest is triggered and maintained (Hidi and Renninger 2006; Krapp 2002).

Phase 6: Revision and Final Questions

As a last point, students review the content of the workshop by means of a game. In addition to this final "hold" facet, students can ask questions if something is still unclear or if they want to know more about plants (Krapp 2002).

Research Questions

(1) Is there a difference between the students' interest in the general process of pollination and their interest in pollination as interplay of insects and blossom?

Numerous results of previous studies point to a continuous decline of students' interest in biology during secondary education. While the students' interest in animals is always at the same medium-level, students notably lose interest in botany after the first year of secondary school (Elster 2007). Whereas the formulation of interplay between insects and blossom includes two components, namely plants and animals, the term pollination is rather complex and is often not immediately linked to animals. Although those two expressions describe the same concept, students might perceive the interplay of insects and blossom as more interesting due to their greater interest in animals. Therefore, it is supposed that the students' interest in the interplay of insects and blossom is higher than in the general process of pollination.

(2) Does the workshop on pollination and floral ecology have an impact on students' interest in pollination by insects?

In general, using attractive teaching methods when imparting new learning content has an influence on students' interest. Therefore, not only the integration of "catch" and "hold" facets, which trigger and maintain interest, but also the three basic psychological needs – self-determination, competence and interpersonal relatedness – are of great significance (Deci and Ryan 2000; Krapp 2002; Wehmeyer and Little 2013). Since the workshop on pollination and floral ecology provides all these aspects, it is assumed that it has a positive impact on the students' interest in the pollination by insects.

(3) Does the workshop on pollination and floral ecology have an impact on the students' botanical knowledge?

The development of situational interest by means of special teaching methods also helps students learn more effectively. Indeed, using interactive learning strategies can serve as a powerful engine of conscious learning (Bladwin and Sabry 2010; Klemmer, Waliczek, and Zajicek 2005; Larson and Rusk 2011). Due to the implementation of innovative and research-based teaching methods, such as hands-on and minds-on approaches in which students are encouraged to be active participants, it is assumed that the workshop leads to an increase of knowledge in terms of pollination and floral ecology.

(4) Does students' evaluation of the workshop (mark for the workshop as well as intrinsic motivation) and their knowledge growth correlate with the students' interest in botany after the workshop?

As already mentioned above, the satisfaction of all three basic psychological needs – self-determination, competence and interpersonal relatedness – will likely lead to a flow state, which is also comparable to intrinsic motivation. Indeed, the development of intrinsic motivation is crucial because when students are intrinsically motivated, they are eager to learn and finally get personal satisfaction from it (Deci 1975; Deci and Ryan 2000). Since the aim of the workshop on pollination and floral ecology is to fulfil the three basic psychological needs, it is supposed that during the workshop students are intrinsically motivated as well as intellectually curious and eventually get interested in the subject.

Sample and Study Design

One hundred secondary-school students (n=100) from five different schools took part in the workshop. While 56% of the participants attended the first year of secondary school, 44% were in their second year. Their average age was 11.43 years (SD= 0.66). The proportion of female and male participants was quite balanced with 53% to 47% (see Figure 1).

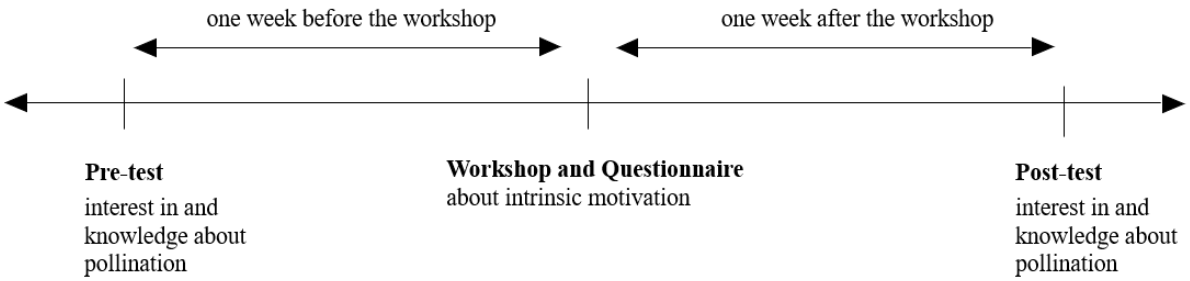

Figure 1. Study design

The framework of the study was a pre-, and post-test design (figure 1). While the pre-test was conducted at least one week before the workshop, the post-test was handed out to the students one week after the workshop. By means of the pre- as well as the post-test, data regarding the students' interest and knowledge has been collected. Referring to Roesler, Wellnitz & Mayer (2014), six items about their interest in the general process of pollination and nine items about their interest in the interplay of insects and blossom were formulated. All items regarding interest were evaluated by use of a five-point Likert scale. In terms of the questionnaire on students' knowledge, fifteen items were created.

While five items focus on the components of blossoms, ten items are about pollination in general and pollination as interplay of insects and blossom. The questionnaire includes different types of questions like short answers, true or false and matching exercises. Moreover, a questionnaire directly after the workshop was conducted in order to collect data concerning the students' intrinsic motivation. The questionnaire on students' intrinsic motivation consists of twelve items, which were developed according to a short scale of intrinsic motivation from Wilde, Bätz, Kovaleva and Urhahne (2009). All items concerning the intrinsic motivation were evaluated by use of a five-point Likert scale. Finally, the students were also asked to evaluate the workshop using grades from 1 to 5. While 1 is the highest grade, 5 is the lowest. Additionally, they could leave a comment explaining in more

detail what they liked or disliked (see Table 1).

Table 1. Research Tools

Interest in the general process of pollination 6 items (Cronbachs`s α: pre-test: .93; post-test: .89)	I like finding out something about pollination
Interest in the interplay of insects and blossom 9 items (Cronbachs`s α: pre-test: .93; post-test:.95)	I like finding out something about pollination as interplay between blossom and pollination
Knoweldge about the components of blossoms 5 items	Name the different components of the model-blossom
Knoweldge about pollination 10 items	Explain the term pollination in your own words
Intrinsic Motivation	
Interest: 3 items (Cronbachs`s α: .88)	The tasks during the workshop were interesting.
Feeling of competence: 3 items (Cronbachs`s α: .62)	I am satisfied with my work during the workshop.
Feeling of pressure: 3 items (Cronbachs`s α: .66)	During the workshop I felt pressured.
Feeling of autonomous choice (Cronbachs`s α:.73)	During the workshop I could execute the tasks like I wanted to
Evaluation of the workshop 1 item	Grade the workshop. Reason your grade.

Results

To answer research question 1 - can the interest in pollination be seen as one construct or are there two different constructs of interest (e.g. pollination in general and pollination as interplay of insects and blossom), we performed a Principal Component Analysis (PCA). The Kaiser–Meyer–Olkin measure of sampling adequacy was .928 in pre- and .915 in post-test, representing a good factor analysis, and Bartlett's test of Sphericity was significant in both testing conditions ($p < .001$), indicating that correlations between items were sufficiently large for performing a factor analysis. Examination of Kaiser's criteria and the scree-plot yielded empirical justification for retaining only one factor, which accounts for 62.60 % of the total variance in pre- and for 63.64 % in post-test. All 15 items showed factor contents from .613 to .892 in pre- and from .644 to .912 in post-test, with a reliability from Cronbach's Alpha .96 in pre- and in post-test. Concerning these results, we dismissed the hypothesis of two dimensions of interest in pollination (pollination in general and pollination as interplay of insects and blossom).

For further investigation, the item "interest in pollination" was calculated from all 15 items concerning this topic for pre- ($x_{pre} = 3.52$; $sd_{pre} = 0.98$) and for post-test ($x_{post} = 3.89$; $sd_{post} = 0.92$). To answer research question 2, a paired t-test for determining the difference between the interest in pollination in pre- and post-test reveals a significant difference with middle effect size ($t(99) = -5.11$; $p = .000$; $d = 0.51$) (see Table 1). As far as botanical

knowledge is concerned (research question 3), students also showed a higher level in the post-test (x_{pre} = 8.87; sd_{pre} = 3.15; x_{post} = 17.49, sd_{post} = 4.34; t(99) = -19.89, d = 1.98).

Table 2. Factor Contents for the Items "Interest in Pollination" and "Interest in Pollination as Interplay of Insects and Blossom"

	pre-test	**post-test**
The topic pollination is interesting.	.821	.789
I like finding out something about pollination.	.775	.835
I like executing tasks on pollination.	.805	.773
I enjoy learning about pollination.	.806	.761
I like being well informed about pollination.	.791	.693
I want to learn more about pollination.	.847	.870
The topic pollination as interplay of insects and blossom is interesting.	.806	.780
I like finding out something about pollination as interplay of insects and blossom.	.772	.823
I like executing tasks on pollination as interplay of insects and blossom.	.821	.870
I enjoy learning about pollination as interplay of insects and blossom.	.862	.912
I like being well informed about pollination as interplay of insects and blossom.	.727	.843
I want to learn more about pollination as interplay of insects and blossom.	.892	.854
Tasks on pollination by insects are important.	.741	.780
The topic pollination by insects is important.	.751	.723
The interplay of insects and blossom is important.	.613	.644

To answer the research question 4, if students' evaluation of the workshop (mark for the workshop and intrinsic motivation) and knowledge growth had an impact on interest in pollination, a univariate variance analysis (ANOVA) was computed. It was controlled for pre-existing knowledge and class level. Results show effects for "marks for the workshop" (F(1.98) = 11.29, p = .000; partial Eta Squared = 0.210) as well as for intrinsic motivation (F(1.98) = 10.64, p = .002; partial Eta Squared = 0.111). No effect could be found for knowledge growth (F(1.98) = 2,30, p = .133; partial Eta Squared = 0.023) (see Table 2).

Discussion and Conclusions

Even though according to previous studies students notably lose interest in botany during the years of schooling whereas their interest in animals is always at the same medium-level (Allen 2003; Elster 2007; Sundberg et al. 2001), no statistically significant difference could be found in terms of students' interest in the general process of

pollination and their interest in pollination as interplay of insects and blossom. This result is incommensurate with the plausible hypothesis that students perceive the interplay of insects and blossom as more interesting due to their greater interest in animals. An explanation for this result is that students might have already correctly understood that both constructs refer to the same concept. Indeed, when reasoning their answer, some students explicitly mentioned the link between those two formulations. This implies that different formulations for the concept of pollination have no appreciable effect on the students' interest.

Moreover, because of the continuous decline of students' interest in biology, especially in botany, during secondary education (Allen 2003; Elster 2007; Sundberg et al. 2001), the overall aim of the workshop is to increase students' interest in as well as general awareness of plants. Indeed, the results revealed that the workshop has a positive impact on the students' interest in the pollination by insects and floral ecology. This significantly rising interest can be attributed to the research-based teaching and learning methods which trigger and maintain interest, for example, the integration of "catch" as well as "hold" facets and also the hands-on procedures during the workshop (Krapp 2002; Wehmeyer and Little 2013). Additionally, the intended satisfaction of all three basic psychological needs – self-determination, competence and interpersonal relatedness – as well as the usage of the botanical garden as learning environment outside the classroom have most likely had a positive impact on the development of students' interest in plants (Braund 2004; Deci and Ryan 2000; Sedgwick 2012; Waite 2017). Therefore, it can be said that a well-elaborated workshop based on theoretical background about biology education increases the students' interest in botany and helps them overcome plant blindness.

Additionally, the findings indicate that the workshop has not only a positive effect on students' interest but also on their botanical knowledge. In fact, the results show that students notably increased their knowledge in terms of blossoms and their components as well as the interplay of blossom and insects. One the one hand, this might have been due to the direct experience with plants, which is an effective method fostering authentic learning. On the other hand, the implementation of practical approaches during the workshop might have also led to the significant knowledge growth, since it is a method in which students get actively involved in the learning process and finally construct their own knowledge (Baldwin and Sabry 2010; Klemmer, Waliczek, and Zajicek 2005; Larson and Rusk 2011). From this it follows that the integration of different innovative teaching methods helps students to actively engage with a subject, which in turn leads to an increase in their knowledge.

Finally, students' evaluation of the workshop shows that they were intrinsically motivated and enjoyed the workshop. The satisfaction of all three basic psychological needs – self-determination, competence and interpersonal relatedness – might be the reason for this result since the students could decide how they want to execute the tasks during the workshop without feeling pressured or stressed (Deci and Ryan 2000; Wehmeyer and Little 2013). Whereas the students' intrinsic motivation during the workshop had a positive impact on development of students' interest in pollination and floral ecology, only a low correlation between the development of interest and knowledge growth was found. While only some students already expressed great interest in botany in the pre-test and significantly increased their botanical knowledge in the post-test, others did not really improve their knowledge; however, they developed an increasing interest in botany. To sum up, the results show that the workshop on pollination and floral ecology does not only have a positive effect on students'

situational interest, but also on their botanical knowledge as well as their intrinsic motivation.

Recommendations

Since the workshop on pollination and floral ecology was a great success, similar workshops on other botanical topics, which also take place in the botanical garden, might be effective as well. Therefore, in the future it would be of advantage to provide more workshops and use the botanical garden as a learning environment outside the classroom. Not only the implementation of innovative and research-based teaching methods but also the usage of learning environments outside the classroom encourages students to develop positive emotions for plants, which again might counteract the limited interest in plants of secondary school children. Additionally, it would be interesting to compare the workshop on pollination and floral ecology to traditional lessons, covering the same learning content but without integrating attractive learning and teaching methods. Thus, a control group could be evaluated and the results could be finally assured.

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