Interest and Learning in Plant Biodiversity, as Influenced by Teaching Contexts.

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Abstract

The understanding of nature and biodiversity throughout the general populace is currently not sufficient to guarantee sustainable modes of action and environmental conservation in Germany.

Knowledge concerning flora and fauna species is a prerequisite for the development of a meaningful relationship between human beings and their environment and, on a conceptual-procedural competence level, results in the informed management of biotopes and ecosystems. However, pre-service teacher students and graduates generally have little interest in flora, the ecological producers responsible for much of our livelihood.

What didactic organization of botanics training courses can serve to stimulate the situational interest (interestedness) and competence of future teachers with regard to botany? Previous research studies have shown that, in comparison with other topics (e.g. human biology, zoology), there is likely to be little lasting interest in botany topics. The low level of interest for botanics is exhibited by both teachers and students, the graduates´ knowledge is insufficient too.

A teacher training course based on practical contexts, hands-on science, and interaction with nature and specific species was developed by taking into account the theory of intrinsic motivation. A combination of indoor and outdoor activities was employed for cognitive background.

Over the course of a semester, knowledge acquired by pre-service teachers increases significantly. Interest generated through context-oriented organization can be high, while stress and effort are low. However, the resulting long-term personal interest may increase only slightly.

(230 words)

Introduction

Biodiversity in the Context of Sustainable Development Education (SDE)

A large number of international programs, as well as national strategies within Germany, have been implemented for the preservation of biodiversity, a term which is generally used to refer to the number and variety of flora and fauna species, their genotypes and ecosystems. However, an alarmingly rapid extinction of species continues to occur.

In recent decades conservation of nature and environment protection have become important themes in educational programs, at least in value-oriented natural science courses (e.g. Bolscho & Seybold, 1996). This emphasis continues to date with increasing focus on *sustainable development education* (SDE) (e.g. Jahnke, 2011), whereby not only the ecological perspective but also socio-economic factors are examined, i.e., a holistic approach is taken in the teaching of the various aspects of biodiversity.

SDE is concerned with the manifold ways in which human activity interacts with nature. Successful SDE-oriented education programs have been examined in an initial series of empirical studies (Ramadoss & Poyya Moli, 2011; Hagenbuch et al., 2009; Kostova, 2007; Schaal et al., 2012). For example, Ramadoss & Poyya Moli (2011) have studied not only theoretical education concerning biodiversity but also the combination of active, participatory and collaborative learning methods and experiences within outdoor field activities which, in turn, resulted in improved biodiversity knowledge and attitudes.

Sustainability means securing the quality of life of the current generation while maintaining a certain degree of freedom for future generations to choose and shape their own lifestyles and living standards. Ekardt (2011) has defined sustainability as a long-term and globally maintainable way of life and economic activity. Thus, in this context, social justice and equity, ecological compatibility, as well as economic strength and performance are goals of equal importance.

The emphasis on human activity within the concept of *species knowledge* is reflected in its definition as *biotope management* (Blessing & Hutter, 2004; Hutter & Blessing, 2010). Thus, species knowledge is much more than the simple learning of the names and characteristics of individual organisms; it means achieving the highest level of conceptual and procedural competence (Bybee 1997, Weinert 2002) involving human interaction with species in real situations and the sustainable management of biotopes and ecosystems.

The loss of species over the last century has been mainly due to human influences and is currently about 10 times the natural extinction rate, whereby the causes include urban sprawl into the countryside and intensification of agriculture, which lead to the fragmentation of habitats. The current Red List shows that nearly 28% of the evaluated vertebrates are endangered and about 8% have become extinct or are no longer observed. For some animal families, such as reptiles, the number of endangered species has reached 60% or more (BfN, 2012). While the loss of animal species may be more readily apparent, plants and other organisms also suffer from accelerated extinction: "*…plants form the basis of most animal habitats and all life on earth, although animals frequently steal the spotlight when the specter of extinction is raised*" (Wandersee, 2001).

An important step in environment protection is the recognition and resulting appreciation of the organisms which need protection (Lindemann-Matthies, 1999, 2002a,b; Jäkel, 2005). Research studies demonstrate that frequent work in the field as well as active learning in school via the inquiry-based study of species and their diversity can promote increased appreciation of the richness of species and its importance (Lindemann-Matthies, 2002). Thus, research confirms the old proverb: We only appreciate what we know.

There is a clear tendency for school children and untrained adults to appreciate or prefer exotic or attractive species rather than the more common or unassuming local organisms. However, among school children an improved knowledge of local wildlife and plants results in a clear increase in their appreciation and the desire for their protection (Lindemann-Matthies, 2005). It is apparent that situational interest (interestedness), as stimulated by instruction, can apply to species that offer fascinating effects or opportunities for interaction (e.g. impatiens), that are dangerous (stinging nettle) or consumable (black raspberry) (Jäkel, 1995).

Awareness of Biological Diversity

In a representative national study carried out in Germany in 2009, Rädiker and Kuckartz (2012) examined awareness concerning biological diversity in terms of three components: knowledge, attitude and behavioral willingness. In this so-called nature awareness study with 2000 subjects, knowledge about biological diversity was identified as the "bottle neck", although an increase in knowledge alone is not sufficient for a change in behavior with regard to biodiversity. In 2009 only 22% of the German population met the test's criteria for the three components listed above, as required for the realization of the national strategy for conservation of biodiversity. This study, as well as a follow-up study in 2011-2012, differs in its emphasis on living organisms and habitats compared with other studies concerning a more general environment awareness with emphasis on the handling of abiotic factors such as energy, waste management, recycling and flow of resources.

Knowledge of Species

In addition to the nature awareness study described above, the results of other research projects concerning knowledge of species proved to have a sobering effect. In his report on youth and nature entitled *Nach Jahren der Naturpädagogik: Nachhaltige Naturentfremdung* (After years of nature pedagogy: sustainable nature estrangement), Brämer (2010) repeatedly expressed disappointment about children's views of nature: the “Bambi syndrome”, where oversimplified concepts and attitudes inhibited the understanding of sustainability.

As institutions, schools generate little lasting knowledge in the general public. What does this mean for the future of biotope management? A recent study (Klingenberg & Brönnecke, 2011) confirmed previous results (Hesse, 2000) concerning discrepancies in the basic biological knowledge acquired by graduates. For example, Klingenberg & Brönnecke (2011) found that more than half of the tested adults could not correctly identify the leaves of trees such as beech (*Fagus sylvatica*) or linden (*Tilia*). Therefore, it was concluded that only a minor degree of cumulative or cross-linked knowledge had been generated. Jäkel et. al. (2004) have shown that the names of well-known tree species (oak, linden, beech, maple) frequently do not invoke a correct description of the tree’s characteristics.

In India it was found that secondary school students have only a moderate awareness of biodiversity. “*Both male and female students have average level of awareness on biodiversity…Therefore special training programmes and other educational programmes may be offered … in order to enhance their level of awareness.*” (Chandrasekhar et al., 2012)

The term plant blindness has been introduced to indicate lack of primary knowledge concerning local plants. “*Plant blindness may exhibit symptoms such as …lacking hands-on experiences in growing, observing, and identifying plants in one's own geographic region.*” Wandersee (2001)

Plant Blindness and the Role of Teachers

In the USA Wandersee & Schussler (1999) examined the question of why commonly occurring, local plants often escape awareness – a situation for which they coined the term *plant blindness*. According to their theory, plants represent an anonymous green mass which normally does not move, look at us through eyes or threaten us.

“*When flowering plants are not flowering or possess inconspicuous flowers, the chromatic homogeneity, the spatial homogeneity, and the overlap of their green leaves makes edge-detection difficult... The members of plant populations typically grow in close proximity to each other, whether cultivated or natural, and they rarely move… In most people’s minds, plants are typically rather non-threatening elements of an ecosystem and incidental contact with them can usually be ignored without dire consequences… Because they are immobile autotrophs, plants generally offer fewer spacing-based, time-based, or color-based visual cues for humans to observe than animals do…*” (Wandersee, 2001).

Thus, plants tend to generate little interest because of their anonymous green color, slow growth and movement, and the absence of strong optical stimuli, except perhaps in the case of certain flowers (Wandersee 2001, Hershey 1996). Interest in plants is significantly lower than interest in animals or human biology (e.g. Löwe, 1992; Vogt et al., 1998), as confirmed by the international *Relevance of Science Education* (ROSE) study involving 15-year-old students in Europe.

Holstermann & Bögeholz (2007) presented the results for the German students in this study, who showed much less interest in plants compared to topics in human biology or animal behavior. "*While boys were found to be more interested in research, dangerous applications of science, physics and technology, females showed a higher interest in diseases, bodily functions, awareness of the body, transcendental and natural phenomena. Findings from the German sample are mostly in the line with results obtained from Swedish and English students.*"

Many studies concerning environment education or biology ignore the differences in interest described above (e.g. Randler & Bogner 2007, 2009) or, regarding didactic design, do not emphasize that botanic themes are much more challenging compared to animal topics due to the imbalance of interests throughout all age groups. If teachers wish to introduce biodiversity and environment protection in an enthusiastic educational program, then it is imperative that they themselves possess the necessary interest, knowledge, and didactic competence (pedagogical content knowledge, PCK).

Empirically, three main types of biology teachers have been identified and can be distinguished on the basis of their attitude toward biology science and education: the conventional practitioner, the innovative professional, and the innovative pedagogue (Neuhaus & Vogt, 2005). In any event general requirements for successful teaching are solid professional skills and knowledge, personal charisma, and authenticity (Wilhelm, 2007).

Didactic Design Possibilities

Schaal et al. (2012) are of the opinion that, in comparison with conventional botany courses (whatever that may mean), positive developments in motivational and cognitive areas for pre-service teachers can be achieved when outdoor learning tasks are handled in an autonomous, computer-assisted manner after a predetermined location has been found using GPS. Thus, for students who felt ill-equipped to adequately teach about biodiversity, an inquiry-based course was created employing modern technology in a collaborative learning environment.

What distinguishes "conventional" botanic education from other forms? What elements of instruction stimulate the situational interest of student teachers in their confrontation with the subject material?

Wolff (2011) examined to what degree the collecting of flora in a herbarium can enhance awareness of the characteristics and diversity of plant species. Students who created and worked with a herbarium, compared with those without this experience, were able to correctly identify a larger number of submitted plants (Wolff, 2011).

Haugwitz & Sandmann (2009) found that context-oriented instruction, i.e., learning environments embedded in situations relevant to students, leads to enhanced situational interest and achievement. Comprehensive national studies have shown that the *Biology in Context* project provides a successful strategy for strengthening biology didactics in Germany (Elster 2007, Bayrhuber et al., 2007). The term *context* is used here to represent a topic or aspect which is helpful in making accessible the structured knowledge and domain-specific systematics of a particular area of science. These contexts must be chosen to encompass a representative segment of the concepts involved in the natural sciences (Elster, 2007).

Interest and Interestedness

The person-object theory of interest developed by Krapp & Prenzel (1992) differentiates between situational interest (*interestedness*, an often temporary state) und a more lasting individual or personal *interest* (as a general personal trait). Interests are assumed to be specific person-object relationships which emerge from an individual's interaction with the environment (Krapp, 2005). Interest consists of intrinsic emotion- and value-related valences (Schiefele & Krapp, 1996). Many studies have shown that there is an important influence of interest on the level of learning, academic performance and the quality of learning experience (Randler & Bogner, 2007; Schiefele et al., 1993).

In recent years the theory of intrinsic motivation has had a strong influence on educational design. To a certain extent, successful learning is promoted by self-determined learning processes, competence experience, and a comfortable social climate. This approach (Deci & Ryan, 2000) has been substantiated in numerous empirical studies. Thus, self-regulated learning in biology classes can improve the intrinsic motivation (Reinmann & Mandl, 2006; cf. Deci & Ryan, 1985, 2000).

In a study reported by Meyer-Ahrens et al. (2010) it appears that an awareness or feeling of autonomy (operationally defined as student participation) is more important in improving motivation than the actual realization of the student's specific intentions. Previous research has frequently highlighted that an inquiry-based approach and field work are important and essential elements of teaching and learning about ecology (e.g. Ramadoss & Poyya Moli, 2011; Bell et al., 2010).

For chemistry and physics it has been recognized that student interestedness is less dependent on the specific content being taught and more dependent on the context in which the content is embedded (e.g. Häußler & Hoffmann, 1998). Girls tend to react more strongly to changes in context than boys do, either with increased or decreased interest. Contexts which exhibit high relevance to everyday life provide the best opportunities for stimulating interest, especially for girls (Kessels, 2002).

Emotions in Learning about Subjects that generate little Interest

Rhöneck & Laukenmann (2003) examined the effects of emotional and cognitive variables (well-being, joy, fear, boredom, interest) on learning in physics courses. Here we distinguish between current, situational emotional *states* (interestedness) and more enduring biographical emotional dispositions or personality *traits* (interest). The emotional states include situational well-being, situational anxiety, and situational interest.

For physics classes (which not everyone enjoys) it was found that cognitive factors have a stabilizing influence on learning outcome (Rhöneck & Laukenmann, 2003). However, it became clear that well-being and interest as cognitive-emotional constructs are important for successful learning, more so in the knowledge acquisition phase and less so for practical exercises. For both boys and girls in the acquisition phase, the degree of learning is correlated with the degree of situational interest and the feeling of well-being, independent of whether or not there are positive feelings for the subject matter as a whole (Rhöneck & Laukenmann, 2003, p. 62).

Research Questions and Rationale

In view of the fact that the level of interest exhibited by teachers will have a significant influence on the learning process for students, it is important to clarify how prospective teachers themselves can become interested in the local flora and what their dispositions toward botanic subject material are. In the current study we focus on the learning processes involved in basic botany courses for pre-service teachers, whereby for these students only one mandatory seminar in biodiversity may be required during their entire biology studies program.

What didactic design will be found to be interesting for the participants, at least for the moment? Which factors are suitable for generating a high level of learning motivation? In short, what didactic design promotes interestedness?

- Can interestedness be developed over the period of a semester?
  Our hypothesis is that context- and problem-oriented learning situations promote interestedness and that there is a strong correlation between intrinsic motivation and the degree of self-determination or autonomy.
- Over a study period of 14 weeks can an enduring interest in plants as a person-object relationship be strengthened?

Our hypothesis is that the long-term interest for botany will remain lower than that for zoology or human biology. Modulation of interest will be a slow process but temporary interestedness can be converted to lasting personal interest.

- Can cognitive progress be measured?
  Our hypothesis is that the depth of species knowledge will increase, that the awareness of biodiversity will increase through seminars conceived with a context- and problem-oriented design, and that the relevant terminology will be learned despite context orientation.
- Can the strategy of context orientation reach all students or are different responses expected?
  Our hypothesis is that a context-oriented seminar design will not achieve equal levels of interestedness or acquired knowledge for all participants.

Methods

Research Study Design

The study described below was carried out over the spring/summer semester 2012 at the Pedagogic University of Heidelberg, Germany, and employed several techniques. Subjects of the study were students who were being trained as biology teachers and were enrolled in the mandatory introductory course in botanics/biodiversity during semesters 1-4. Their mean age was 22 years, and they typically had 13 years of prior schooling.

The study was organized with a classical before-after design to assess lasting interests and knowledge gained through the intervention provided by a series of 10 seminars. In a preliminary test all subjects were questioned with regard to their experiences during their prior education, and measures of intrinsic motivation were obtained. All students were asked to assess their interest in various areas of biology, their previous practical work at school, and their knowledge of plant species and a variety of technical terms (xylem, epidermis, anthocyanin, chlorophyll, sorus, etc.).

One notices only things that one is familiar with. This concept was confirmed by Lindemann-Matthies (2002) and in previous studies involving original objects (Jäkel, 1992), where it was shown that the self-assessment of students with regard to their open responses to known plants (free naming of species) can be trusted. Subjects were asked to list the names species that were known to them, and they could correctly name these species, but not others, when viewing original samples (Jäkel et. al, 2004). Thus, the free naming of plant species which were recognized outdoors during the walk to the University, for example, served as an indicator of species knowledge. This capability was pre- and post-tested, and the responses were compared with regard to the number of species named and degree of differentiation. The specification of plant form (e.g. tree or bush) is less differentiating than the naming of genus and species.

The subject's knowledge of concepts and terminology was also measured by self-assessment in before-after testing. A good correlation (Spearman's rank correlation ρ) between actual knowledge and self-assessment was previously found for human biology (Jäkel, 2012) and botanics.

At the beginning and end of this study (pre-test and post-test) the students filled out a self-assessment questionnaire designed to measure their interest in a variety of topics in biology. The questionnaire contained a total of 22 items (Cronbach's α = 0.856), and the responses (rankings on an integer Likert scale of 1 for highest to 8 for lowest agreement) for related items were combined to obtain indices for interest in each of six fields: botany, ecology, field biology, molecular biology, zoology, and human biology.

For example, the three items used for assessing interest in the field of botany were as follows:

1. I am interested in botany.
2. Given a free choice of topics within my required study program, I would be happy to attend a presentation involving plants.
3. I enjoy working with plants in my biology studies.

Analogous items were used for zoology and human biology; only two items were used to assess interest in molecular biology and ecology. The matrix of indices obtained for all subjects were used as input data for an ordinal multidimensional scaling (MDS) analysis (PROXSCAL, SPSS). Furthermore, mean values of interest, averaged over all students, were computed and compared for the various biology fields.

In addition, before each seminar (two hours per week) a short questionnaire for the measurement of intrinsic motivation (Deci & Ryan, 2000) was employed (validity given by Cronbach's $\alpha > 0.719$). The employed Intrinsic Motivation Inventory (IMI) is a multidimensional measurement device which has been used in several experiments related to intrinsic motivation and self-determination (autonomy) and is intended to assess a participant's subjective experience related to a target activity in laboratory experiments. This instrument assesses interest/enjoyment, perceived competence, effort, value/usefulness, experienced pressure and tension, and perceived autonomy while the participant performs a given activity. The interest/enjoyment subscale is considered the self-assessed measure of intrinsic motivation. Thus, although the overall questionnaire is called the Intrinsic Motivation Inventory, only one subscale assesses intrinsic motivation, *per se*.

The botanics course material is summarized in Table 1.

Table 1. Botanics Course Content, 2012

Seminar Nr.	Date	Topics
1	26.04.	Introduction into the field of botany with two examples: bear's garlic (*Allium ursinum*) and anemone (*Anemone nemorosa*). Fundamentals of plant and flower morphology.
2	03.05.	Presentation of examples of two plant families: *Brassicaceae*, *Lamiaceae*.
3	10.05.	Presentation of the red campion *Silene dioica* (family *Caryophyllaceae*) as an example of a dioecious plant; use of a magnifying glass to study the seeds of several *Caryophyllaceae*; plant organs and identification; anthocyanin as flavanoid pigment in vacuoles of red onions (*Allium cepa*); examination of the stinging hairs of the nettle (*Urtica dioica*).
4	24.05.	Identification of selected plants from *Fabaceae* family; familiarization with various legume fruits.
5	14.06.	Microscopy of vascular bundles in maize (*Zea mays*) and the genus *Ranunculus*, as examined in fresh and fixed cross sections of stems.
6	21.06	Presentation of self-devised didactics for the theme Light and Plants; testing with school children, age 8 – 15, under outdoor learning situations.
7	28.06.	Evaluation of the teaching situations from the previous week; introduction to the family *Asteraceae*: plant pigments; plant identification.
8	05.07.	Introduction to the carrot or parsley family *Apiaceae* (*Umbelliferae*): identification of examples, examination of seeds with a stereo magnifier, sensory tests (taste and odor).
9	12.07.	Introduction to gymnosperms: presentation of leaves and seed cones from native conifers (*Pinaceae*).
10	19.07.	Microscopy of wheat grains; study of other grains or fruits; extraction of gluten from wheat flour.

A problem- and inquiry-oriented style was adopted for the course work. The use of a dichotomous identification key, for example, was introduced with a collectively discussed example. Basic biological techniques were learned through appropriate examples, e.g., the use of specialized literature for the identification of plants. The result of a previous study was applied here, namely, that biodiversity can be better understood through the study of a small rather than a large number of species ("less is more"). The seminar included activating autonomous exercises alternating with direct instruction. For example, the plants to be identified could be chosen from a collection of many species, or other phenomena or characteristics could be examined. Following instruction sessions, autonomous exercises could be pursued or repeated in subsequent seminars.

It became readily apparent that the participants in the study possessed a strong ambition to develop their own learning pathways, even before instruction began, with tendencies to avoid sophisticated or demanding strategies and to find quick methods for problem solving. Illustrated books (even incomplete ones without a dichotomous key) were preferred over the more accurate scientific literature.

The pre-service teachers, the student subjects of this study, were given the opportunity, with a large degree of autonomy in content and methods, for developing “Light and Plants” didactics for small groups of school children. Constructive feedback was provided to the students frequently during their planning phases and after sessions with the school children.

The application of microscopy, in particular the preparation of drawings, has proven to be unpopular among students. From previous studies with human biological preparations we know that there is no positive correlation between the length of time spent at the microscope and the resulting learning motivation, while motivation can be increased when microscopy alternates with other methods (Jäkel, 2012). Therefore, a broad choice of alternative methods and strategies was offered during the semester.

The course was structured with intense focus on just a few species selected from plant groups which, in turn, were chosen to stimulate respect and appreciation for their value and performance – performance in terms of their basic roles in the associated ecosystems as well as their roles for human utilization. Thus, the classical concept of biodiversity as genetic variety was extended to include functional variety in resources for human endeavors.

A conscious decision was made to avoid flooding the students with a bewildering array of species. Awareness of the abundance of species can be more effectively gained in a step-by-step manner rather than by attempting to deal with an excessive number of unknown flora in a short time. Thus, a number of genera and families were omitted from the course, with the expectation that the interaction between the students and a small number of species would be all the more intensive and lasting.

The series of seminars outlined in Table 1 integrated a broad range of contexts (edible plants, tasting of spices, phenomena with an “aha” effect, interesting “horror” stories, etc.) and alternatives, indoor study and outdoor excursions, and a didactic design exercise for the teaching of school children (cf. Jäkel, 2005). Some of these elements have been used in other programs (Ramadoss & Poyya Moli, 2011; Schaal et al., 2012).

Results and Discussion

In the following all statistical analyses were performed using IBM SPSS 20.

Which activities lead to the best results in the Intrinsic Motivation Inventory (IMI)?

The results for the Intrinsic Motivation Inventory (IMI) (Deci & Ryan 2000) obtained before each of the ten seminars listed in Table 1 are summarized in Figure 1. The mean values (over all subjects) for the perception indices for interestedness (situational interest), competence, autonomy in the learning process, and stress were evaluated by combining the responses for appropriately selected items in the questionnaire (total of 9 items, Cronbach's α = 0.719). In addition, these four rectified indices were also evaluated specifically for the tasks involving microscopy.

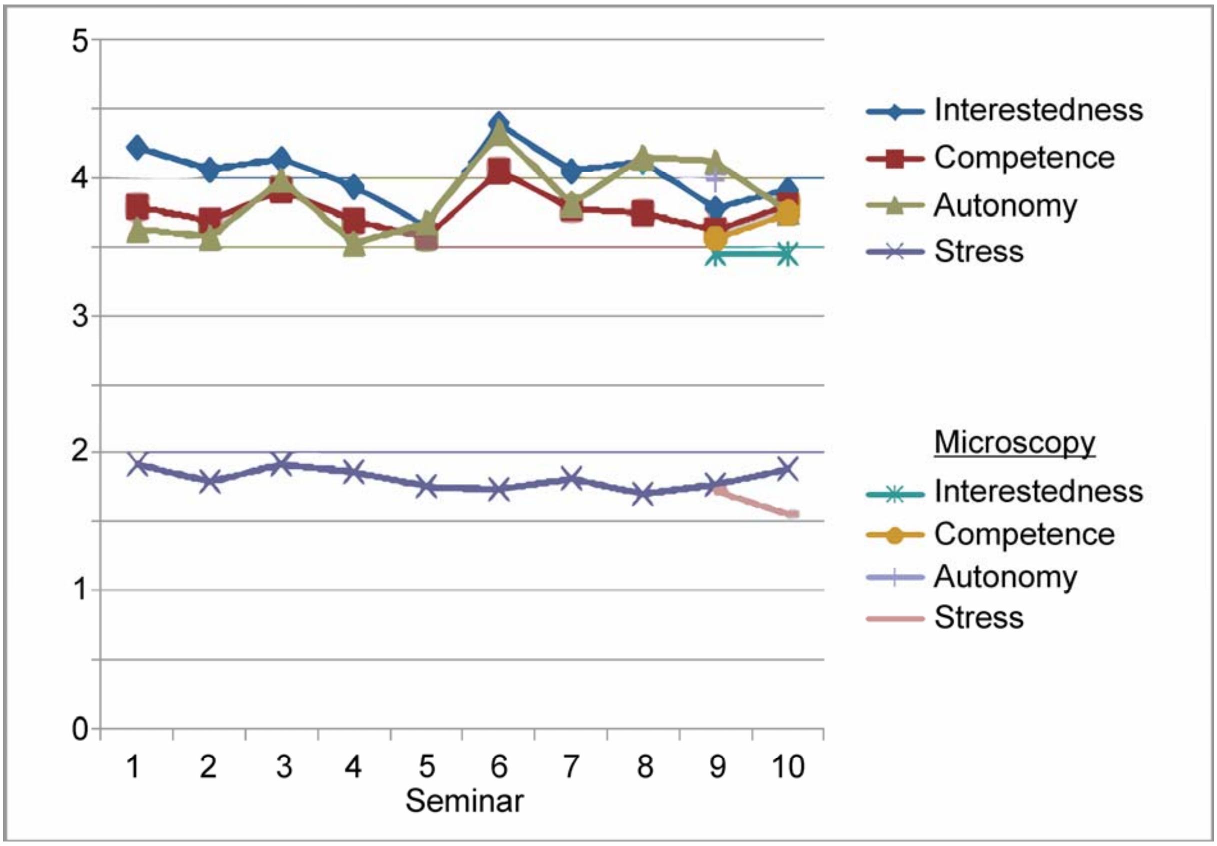

Figure 1. Analysis of the IMI questionnaires for seminars 1 – 10 (Table 1); vertical scale shows mean response (n = 66 – 82) on a 5-point Likert Scale: 1 (no agreement) to 5 (full agreement). Legend: top four symbols are for the general categories of situational interest, perceived competence, perceived autonomy of the learning process, and feeling of stress; bottom four symbols are for the same categories but specifically referring to the use of microscopy.

The results show for each seminar date that the perceptions of interestedness, competence, and autonomy were relatively high (3.5 – 4.5) while the stress factor remained relatively low (1.5 – 2). This does not necessarily mean that long-term levels have been developed in the person-object relationships. Interest research (Löwe, 1992) has shown that generally at the beginning of a new learning phase interestedness is high and declines somewhat during the learning period. This behavior is apparent as a minor trend for the periods of seminars 1 – 5 and 6 – 10, whereby the downward trend up to seminar 5 is broken by a surge in interestedness with the particularly demanding seminar 6. Seminars 3 and 8 also represent minor exceptions to the downward trends, whereby interestedness was stimulated by the introduction of a magnifying glass or stereo magnifier for examining exotic structures (e.g. seeds from *Caryophyllaceae*) or the use of taste and smell as sensory inputs (fruits and leaves of herbs and legumes).

The levels for the three indices interestedness, competence, and autonomy all reached their highest levels for the challenging seminar 6. In this case the pedagogic students were asked to design a didactic program in botanics with the theme “Light and Plants” and to test this program with school children, outdoors in the University’s ecological biotope (hands-on science) on June 21 (summer solstice). Thus, the perception of autonomy reached a maximum due to the requirements of designing a teaching program and using it to generate motivation and interest in others. The prospective teachers were challenged in a direct career-oriented manner; therefore, their perceived competence also reached a maximum level. This form of competence in developing man-environment relationships includes one or more aspects of the *Gestaltungskompetenz* concept formulated by De Haan & Gerhold (2008). As expected, the increase in interestedness for seminar 6 parallels the increase in perceived autonomy and competence. Following the peak in the indices at seminar 6, the downward trend noted earlier reappeared.

The identification of species using the expert literature (e.g. seminar 4) proved to be less popular because it is tedious and difficult to learn. However, competence in this area is of key importance for biotope management and science-oriented teaching. A low level of autonomy and the lowest levels of competence and interestedness were found for seminar 5, the simple examination and comparison of vascular bundles in plant stem cross sections. Other practical but more problem-oriented microscopy exercises received higher ratings, e.g. seminar 3, the study of nettle stinging hairs or pigment in red onions. This situation is analogous to that known for microscopy in the context of human biology (Jäkel, 2012). Thus, tasks which involve a more specific research-oriented approach appear to promote increased motivation (interestedness, curiosity).

Discrimination of Biology Teacher Types

It is our intention to utilize the knowledge acquired concerning the effectiveness of various biodiversity learning situations for the improvement of the education and advanced training of biology teachers.

With regard to biology as a science, biology instruction and school in general, there are, according to Neuhaus & Vogt (2005), various types of biology teacher, among them the pedagogic-innovative type, who chooses to primarily stimulate active, self-motivated learning among school children. Up to now a discrimination between teacher types has not been made with respect to their interest in particular biological subject areas. If these types exhibit different long-term interests in botanics, for example, then it is necessary to investigate whether or not the various teacher types profit in a similar way from problem- or context-oriented learning.

Figure 2 presents the results of an ordinal multidimensional scaling (MDS) analysis concerning interest in six fields of biology, as expressed by the subjects of our study. The students were asked to fill out a self-assessment questionnaire containing 22 items, and related responses (rankings) were appropriately combined to generate a set of indices representing interest (see Methods). In the two-dimensional plots shown the distances between the various fields (object points) represent proximities in terms of interest.

Initially, students with a strong interest in botany also tended to be interested in ecology and field biology, while other students expressed a predominant interest in either zoology, human biology or molecular biology. Following the seminar series, the basic clustering of interests did not change significantly (post-test results are roughly comparable with a reflection of the pre-test results about the diagonal) with the exception that zoology moved somewhat closer to field biology and ecology. In future studies it will be of interest to determine whether or not all pre-service biology teacher types can benefit from context-oriented education in botanics and how the learning process in this domain can be optimized for the various types.

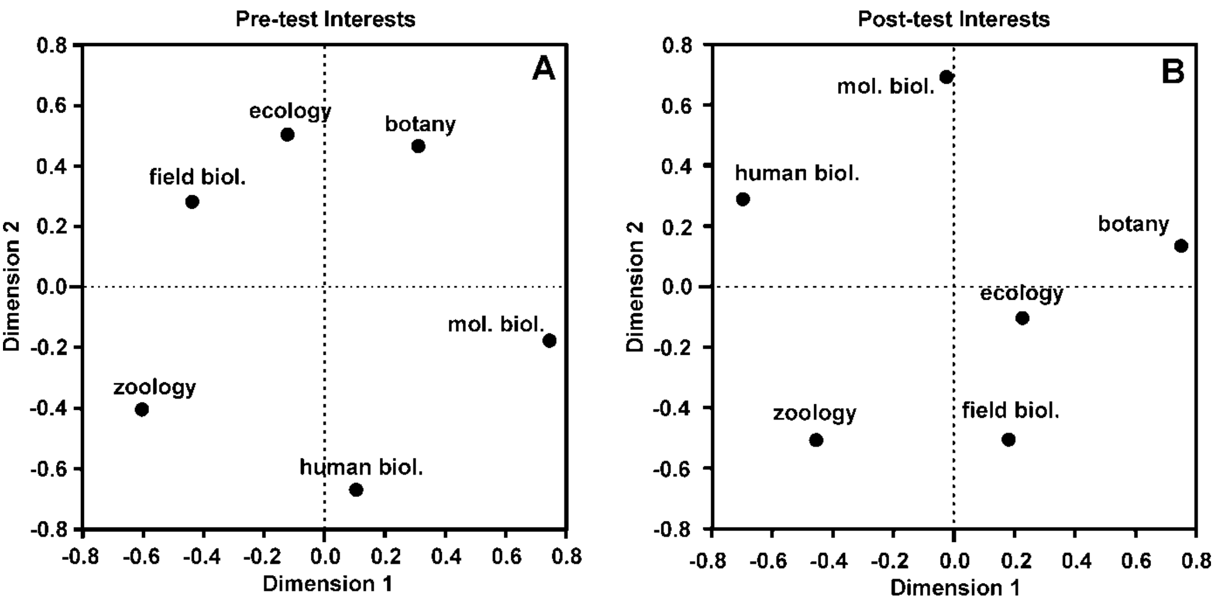

Figure 2. Multidimensional Scaling (MDS) analysis of student interest in various areas of biology, comparing pre-test (**A**, raw stress value = 0.032) and post-test results (**B**, raw stress value = 0.026).

Did Interest in Botanics increase?

The results summarized in Table 2 were derived from the MDS input data matrix and indicate that the interest of the students in six fields of biology did not change in a statistically significant manner over the 14-week period of this study. For each field the mean pre- and post-test scores differed by less than the standard deviation. However, the mean scores for botany, ecology, and field biology did exhibit the largest decreases (increase in interest) in comparison with other areas. In particular, botany had the lowest pre-test interest (rank 6) but improved to rank 5, ahead of molecular biology, for the post-test evaluation. Thus, although the relatively short intervention (seminars of Table 1) resulted, on the average, in an improved interest in botany, ecology and field work, the effect or success of the program was not statistically convincing.

Table 2. Pre- and post-test measures of interest in six biology fields: mean (SD) of summed indices. A total of 22 questionnaire items were evaluated (Cronbach's $\alpha = 0.856$) on an 8-step scale of agreement (1 = highest, 8 = lowest).

	Botany	**Zoology**	**Human Biology**	**Molecular Biology**	**Ecology & Environment**	**Field Biology**
Pre-test ($n = 70$)	3.68 (1.63)	2.52 (1.46)	2.65 (1.69)	3.64 (1.57)	3.43 (1.65)	3.21 (1.69)
Post-test ($n = 62$)	3.33 (1.51)	2.35 (1.07)	2.90 (1.60)	3.63 (1.54)	3.02 (1.29)	2.81 (1.33)

Pre-service Teachers' Assessment of Practical Work During Previous Schooling

During their education as teachers, students can utilize experience gained during their previous primary or secondary schooling. It is expected that such experience, especially practical expertise and skills in gaining knowledge, will have an influence on a student's interest. Expertise provides competence in problem solving so that students with experience should be able to handle the demands of learning better than novices. On the other hand, experience may lead to certain preferences or dislikes which can hinder further learning. Such a situation is frequently encountered in physics courses and could also be relevant in botanics.

For the data of Table 3 students were asked to assess on a Likert scale of 1 to 4 the frequency of specific practical activities, as experienced in their previous schooling. Surprisingly, use of a microscope had the highest frequency among the activities listed in Table 3, more frequent than dissection or the planning and execution of experiments.

Table 3. Pre-service teachers' assessment of previous practical work: mean and standard deviations (*n* = 81) evaluated on a Likert scale: 1 = never, 2 = occasionally or only in some years, 3 = several times per year, 4 = very often.

Activity	**Mean score (SD)**
Keeping Pets	1.52 (0.64)
Use of Microscope	2.42 (0.71)
Dissecting Animals	1.48 (0.53)
Dissecting Organs	1.68 (0.57)
Gel Electrophoresis	1.74 (0.92)
Laboratory Visit	1.94 (0.76)
Planning/Executing Experiments	2.15 (0.87)
Preparing Food	2.06 (1.06)
Seed Germination	2.04 (0.72)

Cognitive Growth Resulting from the Botanics Study Module

The intervention represented by the botanics seminar series resulted in a significant improvement in the pedagogic students' ability to recognize specific plants outdoors along their route to the University. The comparison of pre- and post-test data obtained 14 weeks apart showed clearly that after intervention the number of taxa listed by the students as a group increased by a factor of 2.5 and identification was more precise (see Table 4). The post-test list contained completely different plant families or individual species of local wild plants as well as the genus *Arum* with its characteristic funnel-shaped flower.

The students were also asked to designate which plants they found interesting. (see Table 5). Typically, children and novices will be interested in those plants which present noticeable or exotic features. This was also the case for our pre-test student group. Furthermore, several plants that were initially not recognized were termed post-test as interesting, e.g., *Arum maculatum*, *Daucus carota* or *Cichorium intybus*. Of course, the differences in pre- and post-test results will also reflect the 14-week time difference (seasonal effects). Thus, recognition of early blooming plants will tend to decrease while late-bloomers will increase from the pre- to post-test phase.

Table 4. Recognition of plant species outdoors by pre-service teachers along their walk to the University.

Pre-test (*n* = 81), 33 Taxa		Post-test (*n* = 66), 84 Taxa	
Plant	**Number of Students**	**Plant**	**Number of Students**
Clover	10	Dandelion	25
Daffodil	8	Daisy	15
Cherry	15	Chicory	33
Birch	10	White Clover	16
Dandelion	60	Wild Carrot	12
Daisy	44	Ribwort Plantain	5
Tulip & others	31	Brown Knapweed	8
		Fleabane	5
		Red Clover	5
		Common Ragwort & others	3

Table 5. Plants designated as interesting by two or more pre-service teachers. Several additional plants were listed by individual students.

Pre-test (*n* = 81), 33 Taxa		Post-test (*n* = 66), 84 Taxa	
Plant type	**Number of Students**	**Plant type**	**Number of Students**
None	24	Composite (*Asteraceae*)	10
Carnivores	7	Legume (*Fabaceae*)	7
Orchids	9	Wild Arum (*Arum maculatum*)	6
Roses	6	Tree	6
Tulips	7	Medicinal	4
Flowering	5	Chicory	4
Poisonous	2	Mint (*Lamiaceae*)	4
Medicinal	3	Mustard (*Brassicaceae*)	4
Edible	3	Herb	4
Tree	3	Sunflower	4
Nettle	3	Wild Carrot	3
Magnolia	3	Rose	3
Cactus	5	Meadow Sage (*Salvia pratensis*)	2
Early Flowering	5	& others	
Dandelion	3		

Cherry & others	2

Nearly all of the students assessed their knowledge of botanic terminology (cell or tissue types, cell organelles, contents of organelles) as significantly improved following the seminar series (see Table 6). While conclusions concerning specific learning situations are not possible, it is apparent that the basic organization with context-oriented didactics and emphasis on human utilization of natural resources exerts a positive influence on the learning process for topics in botany and biodiversity. Following the seminars the students felt more competent in these fields so that they are more likely to employ similar inquiry-based approaches in their own teaching careers.

Table 6. Pre-service teachers' self-assessment of knowledge of botanic terminology (Likert scale: absolute number of responses).

	Anthocyanin		**Xylem**		**Chloroplast**		**Epidermis**	
	Pre-test	**Post-test**	**Pre-test**	**Post-test**	**Pre-test**	**Post-test**	**Pre-test**	**Post-test**
Never heard	49	2	39	1		1	1	1
Heard, cannot define	24	1	23	2	1		13	2
Have idea of meaning	4	7	9		33	8	28	6
Can definitely explain	1	51	7	57	44	52	36	52

Summary

Learning methods which included responsibility and experience in outdoor field activities resulted in the highest degree of situational interest. In this study, a combination of indoor and outdoor activities was employed for cognitive background. We have shown that a context-orientated design of training in botanics can stimulate interest in plants, a prerequisite for success in establishing sustainable development. However, further positive interventions are necessary to achieve a long-term change in personal interest in botanics.

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