

Article

Promoting Pro-Environmental BEEhavior in School. Factors Leading to Eco-Friendly Student Action

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Abstract: Many insects, including numerous species of wild bees, are currently threatened with extinction. Environmental education in schools is a suitable starting point to draw attention to this problem, to raise awareness of biodiversity, and to highlight potential actions to protect wild bees and other insects. This study examined the relationship between pro-environmental behavior intentions and knowledge, attitude, fear, interest, and enjoyment of learning in a school intervention involving hands-on activities with living bumblebees. In total, 188 German 10- to 14-year-old high-school students participated in the project and took care of bumblebee colonies. Environmentally friendly behavioral intentions increased significantly between the pretest and posttest; however, no significant increase was found between the pretest and follow-up test. Bumblebee-friendly, pro-environmental behavior intentions correlated highly with attitude and interest, and correlated with knowledge and learning enjoyment with a medium effect size.

Keywords: environmental education; bumblebees; pollinators; knowledge; attitude; interest; biology education; insect decline; biodiversity; environmental behavior



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1. Introduction

Insects are the most species-rich class of animals on our planet [1,2] and because the pollination of plants by insects is essential for terrestrial ecosystems, the loss of pollinators affects the complex ecosystem balance. Nearly 90% of wildflower species depend at least partly on animal pollination and 75% of the world's major crops benefit from insect pollination [3,4]. Insect decline is driven by habitat loss, the spread of parasites and diseases, increased pesticide use, climate change, loss of flowering opportunities due to more intensive agricultural land use such as manuring and more frequent mowing, and monocultures. The individual causes of insect decline are mutually dependent [4,5]. A decrease in pollinator diversity leads to the genetic impoverishment of pollinator-dependent crops [6]. To counteract declining crop yields and preserve terrestrial ecosystems, strategies for the protection of pollinating insects and public awareness of their importance must be developed.

One important way to approach this challenge is via education [5,7,8]: Environmental education is a suitable way to increase awareness and willingness to act in an environmentally friendly way. Education also offers an opportunity to question the approach of individuals to nature and personal consumption behavior, as well as to strengthen the acceptance of biodiversity protection measures by politicians [9]. Raising environmental awareness and a willingness to behave in an environmentally friendly way should not be limited to nature conservation organizations, but should reach a broader range of society, because members of nature conservation organizations already have a great level of knowledge, a positive attitude, and a high willingness to protect nature [10]. School education therefore represents a special opportunity to reach the broad majority of society.

1.1. Pro-Environmental Behavior

Depending on the milieu and lifestyle, environmental behavior is based on several motives and is also limited by various barriers [11]. Nevertheless, there is a well-documented gap between knowledge, attitude, behavioral intention, and actual environmental behavior [8,11–13]. Overall, these studies show that pro-environmental behavior can be influenced by a variety of factors and is extremely heterogeneous for an individual: While single actions to protect nature and the environment are adopted very willingly, the implementation of other actions is rejected. The low-cost hypothesis of Diekmann and Preisendörfer [13] attempts to explain this behavior in that individuals act on the basis of their environmental insights only if it does not involve great effort. The greater the behavioral cost of environmentally friendly behavior, the smaller the effect of environmental awareness on environmental behavior. Accordingly, environmental awareness influences an individual's behavior primarily in situations that are associated with the least inconvenience [13]. Additionally, Stern [14] emphasizes the importance of incentives, for example in financial form, or the removal of barriers in combination with knowledge acquisition and attitude change.

1.2. Promoting Pro-Environmental Behavior at School

Direct experiences of nature have effects of varying degrees on perceived threats, attribution of responsibility, and action-outcome expectations. The acquisition of direct experiences of nature is a suitable way to influence the environmental behavior of students [15–18]. Direct experiences with nature can also promote a connectedness to nature and environmentally friendly intentions [19–21]. Moreover, direct contact with nature can promote positive perceptions [16], and positively influence attitudes, knowledge and interest towards nature [22–28], which in turn may influence environmental behavior. Furthermore, direct nature experiences are particularly suited to foster the interest, motivation, and perceived competence of students, compared with other teaching media [26]. Schönfelder and Bogner [15] also emphasize the importance of direct nature experiences to increase the willingness to protect nature. Therefore, students should acquire direct experiences with nature and the target in need of protection [15].

A study by Ballouard et al. [29] concluded that students perceive particularly exotic animals such as the panda or polar bear as being in need of protection, but consider native diversity and species on the Red List to be much less worthy of attention. Therefore, environmental education should raise awareness in a particular way for native species that are directly threatened.

1.3. Impacts on Pro-Environmental Behavior

Human behavior is extremely complex and is influenced by a variety of factors. The literature primarily focuses on attitude and knowledge as variables that influence pro-environmental behavior, but also includes a variety of other factors, e.g., [11,30–33]. The variables considered in this study are described below (Figure 1).

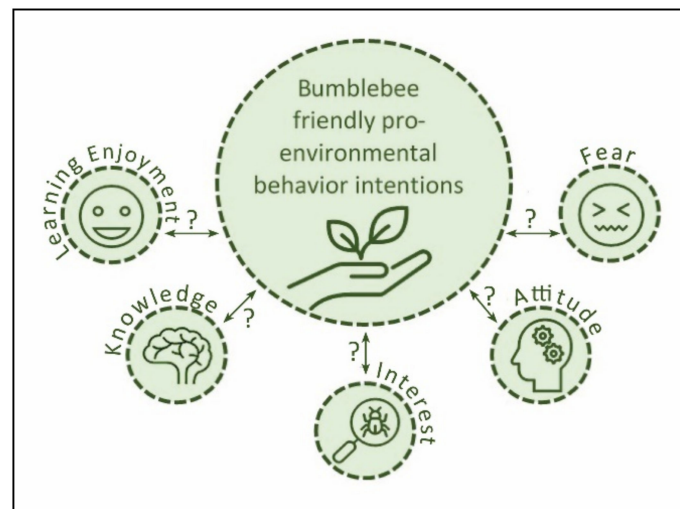


Figure 1. The factors that potentially influence pro-environmental behavior investigated in this study.

2. Knowledge and Attitude

Knowledge and attitudes correlate positively with pro-environmental behavior, but the effect sizes vary widely [22–26,30,33–36]. The type of knowledge is important and according to Frick et al. [37], environmental knowledge can be divided into the sub-categories of system knowledge, action knowledge, and effectiveness knowledge. In a comparison of the three dimensions, action-related knowledge has the greatest effect on pro-environmental behavior, and system knowledge the least effect [37,38]. However, the observed correlations of all dimensions of environmental knowledge have small effects on pro-environmental behavior [37,38].

Attitudes have an even stronger effect on pro-environmental behavior than knowledge [8,11,12,30,36]. Vested interest was found to mediate between attitudes and behavior [39,40].

Knowledge and attitude are also positively correlated [32,33,36]; however, the interaction between knowledge and attitudes remains unclear. Serpell [41] assumes that increasing knowledge affects attitudes, and thus in addition to a direct effect on behavior, also has an indirect influence on behavior. He assumes that attitude consists of two emphases: Affect and utility. Whereas affect represents people’s emotional perception of animals, utility represents personal benefits or harm that can be traced back to the existence of the species. Martín-López et al. [30] suggest that increasing knowledge could give more weight to the utility component, whereas the affective constituent is weakened.

Other studies have identified no effects of attitude and knowledge on pro-environmental behavior [24,42]. This indicates that the effects vary greatly depending on evaluated behavior, knowledge, and components of attitudes, and that human behavior is extremely complex.

2.1. Interest

Interest is a part of the affective component of attitude [43] and might therefore indirectly influence pro-environmental behavior. The direct effect of interest on pro-environmental behavior has to date been considered subordinate. Interest is described as a subjectively important perceived relationship between a person and a specific object [44,45]. Ainley et al. [44] describe three types of interest:

1. Situational interest (triggered by certain aspects of the environment).
2. Individual interest (an individual and persistent tendency to attend to certain stimuli, events, and objects and to engage in particular activities).
3. Topic interest (when a specific topic is presented and includes situational and individual aspects of interest).

Interest leads to focused attention and better learning results, and therefore, it influences the process of learning and educational performance [44–46]. Research on interest in biology education has focused on the link between interest and knowledge, e.g., [45], factors of influence, e.g., [47], and change of interest, e.g., [48].

By contrast, findings on the effect of interest on pro-environmental behavior and behavioral intentions are largely lacking and there is considerable need for research on the relationship between interest and willingness for pro-environmental behavior. Only vested interest could be identified as a mediator between attitude and pro-environmental behavior [39,40].

Suggestions for the basis of the influence of interest on pro-environmental behavior can be found in interest research: Interest affects self-regulated behavior according to self-determination theory [49] and is considered beneficial to achieve goals [46,50]. Accordingly, interest could also play an important role in the context of pro-environmental behavior and support students in deducing behavioral intentions from acquired knowledge and attitudes.

2.2. Fear

Insects are commonly associated with fear, disgust, and aversion [15,33,51]. However, fear negatively influences attitudes and individual willingness for pro-environmental behavior [15,30,52–54]. Fear of insects is based on the personal experiences of students [15,41], myth, and socialization [55–57]. In particular, fear of insects such as honeybees appears to be greater than that of other animals [58–60]. According to Schönfelder and Bogner [15], this is related to the perceived danger of being stung by honeybees. However, fear can be reduced by direct experience and physical contact with fear-associated organisms [16,51,61–63]. A reduction in perceived fear, however, is not always possible [64].

Because dangerous mammals, such as predatory cats, are viewed much more positively than insects [59], fear does not appear to be the only factor that influences negative perceptions of insects.

Because bumblebees can sting when used as a hands-on species of evaluated intervention, it should be analyzed whether fear of bumblebees reduces the willingness for bumblebee-friendly, pro-environmental behavior intentions.

2.3. Learning Enjoyment

Fostering positive affective emotional attitudes in students towards learning and school is an important goal of education. Therefore, the situational-specific emotion of joy is a quality attribute of school education [65]. Learning enjoyment affects the quality of learning, learning achievement and individual wellbeing of students [66,67]. A negative learning enjoyment leads to more negative behavior in class, because students with high learning enjoyment only perceive a small degree of boredom [65]. Furthermore, high learning enjoyment can generate learner interest [68]. Accordingly, it is conceivable that students who enjoy learning about bumblebees and interacting with them also show a higher willingness for pro-environmental behavior intentions.

2.4. The Educational Research Project

The research presented in this paper belongs to an educational research project named “Hallo Hummel!” (English: “Hello Bumblebee!”), whose goal is to implement bumblebees as a flagship species in biology classes. In the project, students took care of a colony of the buff-tailed bumblebee (*Bombus terrestris*), practiced observation and experimental tasks, and identified bumblebee species in different ecosystems. Thus, students obtained direct experience with living bumblebees and acquired knowledge and competencies in handling bumblebees. Moreover, the students developed strategies for protecting bumblebees and other insects in everyday life. A more detailed description of the project content is available in three articles published in German [69–71]. This project was awarded by the German strategy of the UN Decade of Biodiversity in 2019.

2.5. Research Questions

The specific research questions for this study were:

1. Does project participation increase willingness for pro-environmental behavior intentions?
2. Do the following factors correlate with pro-environmental behavior?
 - 2.1. Does knowledge affect willingness for pro-environmental behavior intentions?
 - 2.2. Do attitudes towards bumblebees affect willingness for pro-environmental behavior intentions?
 - 2.3. Does interest in bumblebees affect willingness for pro-environmental behavior intentions?
 - 2.4. Does fear of bumblebees affect willingness for pro-environmental behavior intentions?
 - 2.5. Does learning enjoyment affect willingness for pro-environmental behavior intentions?

3. Methods

In total, 188 German high school students from grades five to seven (lower and intermediate secondary-school levels) from three schools in the metropolitan area of the Rhine–Main region participated in the project (Table 1).

Table 1. Descriptive statistics of the grade and gender of study participants.

	5th Grade	6th Grade	7th Grade	Total
Age in years	10–11	11–12	12–14	10–14
Male	15	44	48	107
Female	11	27	39	77
No indication of gender	1	0	3	4
Total	27	71	90	188

The project was conducted between April and June 2019. The approval of the state school authority and nature authority was obtained in advance. Bumblebee research by students took between three to five weeks, depending on the number of biology lessons per week. Teachers were provided with the required teaching material and participating teachers instructed their classes mostly alone. We conducted classroom observations at selected times and were available to answer questions from teachers and students. Moreover, we initially accompanied teachers in learning the basics of indoor bumblebee keeping, because none of the participating teachers had previously worked with live bumblebees in a class or private context.

3.1. Educational Program

Students participated in a basic teaching unit, as well as units on ecology, neurobiology and ethology.

In the basic teaching unit, students learned the technical and practical basics of hands-on activities with bumblebees. The unit also covered the ecological importance of pollinators, the annual cycle of a bumblebee colony, and the physical characteristics and body language of bumblebees. In addition, students developed rules of conduct that ensured the safety of hands-on activities with bumblebees. For example, bumblebees raise their middle leg when they feel threatened. In general, bumblebees only sting in exceptional cases; nevertheless, only students without a bee allergy conducted direct hands-on activities involving bumblebees.

The ecology teaching unit covered topics on insect decline, and students determined the number and species diversity of bumblebees in different habitats. They captured bumblebees, identified the species, and physically marked bumblebees to ascertain the absolute population size and diversity of bumblebee species for each studied habitat.

By comparing habitats that supported a high number and diversity of bumblebees, students deduced the characteristics of actual bumblebee habitats. Moreover, students developed opportunities for bumblebee-friendly behavior in their daily lives.

In the neurobiology and ethology teaching unit, students temporarily kept a bumblebee colony in the classroom. This enabled the students to observe the bumblebee nest directly and to conduct experiments on conditioning of odor or pheromone communication, for example. Furthermore, students fed and cared for the colony before it was returned to the schoolyard.

3.2. Instruments

The participants completed a pretest and posttest, as well as a follow-up test three and a half months after the posttest. The summer holidays occurred between the posttest and the follow-up test, which meant that participating teachers and school classes were reallocated, and this greatly reduced the sample size of the follow-up test. All questions were posed in a paper-and-pencil test in the German language. Students completed the survey voluntarily and independently during class. They were asked not to cheat and to fill out the questionnaire carefully. The answers did not influence the students' grades.

3.3. Pro-Bumblebee Behavior Intentions

The scale of bumblebee-friendly, pro-environmental behavior intentions consist of 19 items and was developed for this evaluation (Table 2). We provided statements about pro-bumblebee behavior intentions that students could implement in their behavior. Participants rated their agreement with each statement on a five-tier Likert-scale ("agree", "rather agree", "am undecided", "rather do not agree", "do not agree").

Table 2. Summary of exploratory factor analysis results of bumblebee-friendly, pro-environmental behavior intentions of pretest ($N = 120$) posttest ($N = 78$) and follow-up test ($N = 30$). Participants answered the behavior intentions on a five-tier Likert-scale ("agree", "rather agree", "am undecided", "rather do not agree", "do not agree"). The questionnaire was in German; items have been translated into English for this article.

Item	Factor Loading		
	Pretest	Posttest	Follow-Up Test
I advocate in my family that we should avoid using pesticides in our garden.	0.68	0.71	0.43
I advocate in my family that we should plant native flowers on our balcony and in our garden.	0.68	0.69	0.32
I advocate in my family that we should avoid planting flowers with double blooms.	0.52	0.59	0.51
I take the time to feed a weakened bumblebee I find on the ground and offer it sugar water on a spoon.	0.70	0.59	0.59
When I am older, I will vote for a political party that supports insect conservation.	0.64	0.57	0.37
I advocate in my family that we should buy food from farmers who use fewer pesticides.	0.68	0.62	0.75

Table 2. Cont.

Item	Factor Loading		
	Pretest	Posttest	Follow-Up Test
I advocate in my family that we should buy food from farmers who plant flower strips between their fields.	0.66	0.55	0.77
When I get extra pocket money, I use it to protect bumblebees.	0.64	0.55	0.53
I would like to become a member of an environmental organization to fight against bumblebee decline.	0.65	0.62	0.46
I will send a letter to our mayor asking him to turn the public spaces into insect-friendly places.	0.67	0.59	0.70
I advocate in my family to turn part of the lawn in our garden into a wildflower meadow.	0.70	0.63	0.51
I will transform public places into bumblebee-friendly areas by spreading wildflower seeds.	0.74	0.54	0.56
I often try to convince other people that bumblebees are useful and we need to protect them.	0.67	0.59	0.55
I walk short distances instead of being driven by car to protect the climate.	0.62	0.42	0.34
I turn off the light when I don't need it anymore to protect the climate.	0.51	0.43	0.61
I advocate in my family to buy regional and seasonal food to protect the climate.	0.70	0.61	0.70
In winter, I make sure that the heating in my room is not turned up too high to protect the climate.	0.55	0.64	0.66
I advocate in my family that we take our holidays nearby and avoid flights to protect the climate.	0.56	0.55	0.63
I advocate in my family to eat less beef to protect the climate.	0.61	0.56	0.49
Eigenvalues	7.99	6.43	6.04
% of variance	43.07	33.84	31.77
α	0.92	0.89	0.87

3.4. Knowledge

Participants answered ten general-knowledge questions about bumblebees and four knowledge questions about insect decline. The questions about bumblebees enquired after knowledge of morphology, way of life, as well as pollination and were in a closed-question format. Those about insect decline dealt with the comparison of wild bees and honeybees (closed questions), as well as causes and consequences of insect decline (open questions). We applied the construct of face validity.

3.5. Attitude, Interest, Fear, and Learning Enjoyment

The attitude of participants towards bumblebees was measured by a five-tier Likert-scale (“agree”, “rather agree”, “am undecided”, “rather do not agree”, “do not agree”) developed and presented by Sieg et al. [72]. We recorded interest and fear in single questions as part of the attitude scale. Participants evaluated the statements “I think bumblebees are interesting” and “I am afraid of bumblebees”. Moreover, we measured learning enjoyment by a five-tier Likert-scale according to a validated questionnaire developed by Hagenauer [65]. We chose Hagenauer’s learning enjoyment scale because the questionnaire was developed in the German language and validated for secondary-school students.

3.6. Data Analysis

Data were analyzed with SPSS (Version 23.0) following Field [73]. Pro-environmental behavior intentions with a focus on bumblebee protection were evaluated by analyzing Cronbach’s α and a principal axis factor analysis (PCA). Moreover, we calculated the mean of behavior intentions per person for all single items, and possible values ranged from one to five, with higher values representing greater willingness to carry out pro-environmental behavior intentions. This also applied to learning enjoyment and attitude. Values of fear and interest also ranged between one and five, but consisted of only one item. Learning enjoyment referred directly to the bumblebee project and therefore, could not be measured in the pretest or follow-up test and was only assessed in the posttest.

To evaluate knowledge, we counted the correctly answered items; items that were answered with “do not know” and wrong answers, were combined. We awarded one point for correct answers to closed questions. In the open questions, one point resulted from each correct example, with a maximum of three points per question. The sum of the correct answers was divided by the maximum number of possible points for each category “bumblebee” and “insect decline”. Therefore, the maximum value was 1 and the minimum value was 0.

We used non-parametric tests because the collected data were not normally distributed. The Wilcoxon signed-rank test was used to compare the variables between the pretest and posttest, as well as between the pretest and follow-up test. We used Spearman correlations to identify relationships between pro-environmental behavior intentions and knowledge, attitude, interest, fear, and learning enjoyment of participants.

4. Results

The results will be reported in the order of the research questions.

4.1. Increasing Pro-Environmental Behavior Intentions

The scale of bumblebee-friendly, pro-environmental behavior intentions (Table 2) showed a high reliability at all three timepoints of investigation: Pretest Cronbach’s $\alpha = 0.92$; posttest Cronbach’s $\alpha = 0.89$; follow-up test Cronbach’s $\alpha = 0.87$.

A PCA was conducted on the 19 items of bumblebee-friendly, pro-environmental behavior intentions (Table 2). The Kaiser-Meyer-Olkin measure verified the sampling for the analysis; KMO = 0.88 in pretest, KMO = 0.76 in posttest and KMO = 0.61 in the follow-up-test. Bartlett’s test of sphericity was significant ($p < 0.001$) at all time points, indicating that correlations between items were sufficiently large for performing a PCA. While four factors had an eigenvalue ≥ 1 , only one factor could explain at least 10% of the variance, what is a recommendation of factor selection of Urdan [74]. Furthermore, the scree-plots of all three time points of measuring yielded empirical justification for one factor. The one factor solution accounted for 43.07% of the total variance of pretest, 33.84% of variance of the posttest and 31.77% of variance of the follow-up test. While in pretest and posttest all items loaded highly on the factor, there were three items in the follow-up test which loaded >0.4 on the factor. The PCA results indicate that the scale of bumblebee-friendly, pro-environmental behavior intentions has no subgroups but consists of only one factor.

The willingness for bumblebee-friendly, pro-environmental behavior intentions was significantly higher after participating in the project ($Mdn = 3.43$) than beforehand ($Mdn = 3.14$), $z = -2.45$, $p = 0.014$, $N = 73$. The change corresponds to a medium effect, $r = 0.29$ [75]. There was no significant difference between pretest ($Mdn = 3.14$) and follow-up test ($Mdn = 3.29$).

4.2. Relationships of Factors on Pro-Environmental Behavior Intentions

Pro-environmental behavior is affected by various factors. Hereafter, we focus on knowledge, attitudes, interest, fear, and learning enjoyment (Table 3).

Table 3. Spearman correlations of bumblebee-friendly, pro-environmental behavior intentions and surveyed variables (n.s. = not significant; information concerning learning enjoyment could only be assessed in the posttest).

	Pretest	Posttest	Follow-Up Test ¹
Bumblebee knowledge	n.s.	n.s.	n.s.
Knowledge on insect decline	$r_s = 0.325$ $p < 0.001$ $N = 132$	$r_s = 0.302$ $p = 0.006$ $N = 82$	n.s.
Attitudes	$r_s = 0.532$ $p < 0.001$ $N = 103$	$r_s = 0.342$ $p = 0.005$ $N = 66$	$r_s = 0.581$ $p < 0.001$ $N = 32$
Interest	$r_s = 0.584$ $p < 0.001$ $N = 127$	$r_s = 0.532$ $p < 0.001$ $N = 85$	$r_s = 0.616$ $p < 0.001$ $N = 35$
Fear	n.s.	n.s.	n.s.
Learning enjoyment	/	$r_s = 0.378$ $p = 0.003$ $N = 61$	/

¹ A small sample size was the result of reallocation of teachers and classes after the summer holidays and voluntary completion of the questionnaire. Despite the small sample size, the follow-up test provides valuable insights.

While no significant correlation between knowledge about bumblebees and bumblebee-friendly, pro-environmental behavior intentions was found, a significant correlation with a medium effect in pre- and posttest was observed between knowledge about insect decline and bumblebee-friendly, pro-environmental behavior intentions. Attitude correlated with pro-environmental behavior intentions in the pre-test and follow-up test, with a large effect, and with a medium effect in the post-test. Interest correlated with bumblebee-friendly, pro-environmental behavior intentions with a strong effect at all measurement timepoints. By contrast, fear did not correlate with total bumblebee-friendly, pro-environmental behavior intentions at any measurement timepoint. Because of the measurement method, learning enjoyment could only be recorded in the post-test, when it correlated with bumblebee-friendly, pro-environmental behavior intentions with a medium effect.

When fear was correlated with single items of bumblebee-friendly, pro-environmental behavior intentions, we only identified three significant negative correlations in the pretest. The items “I advocate in my family that we should avoid using pesticides in our garden” ($r_s = -0.166$, $p = 0.039$; $N = 155$), “I would like to become a member of an environmental organization to fight against bumblebee decline” ($r_s = -0.167$, $p = 0.039$; $N = 153$), and “I advocate in my family to turn part of the lawn in our garden into a wildflower meadow” ($r_s = -0.193$, $p = 0.021$; $N = 143$) correlated negatively with bumblebee-friendly, pro-environmental behavior intentions, but only with small effect sizes [75]. We did not identify any correlations between fear and single items of pro-environmental behavior intentions in the posttest or follow-up tests.

Moreover, a PCA was conducted on bumblebee-friendly, pro-environmental behavior intentions, bumblebee knowledge, knowledge on insect decline, attitudes, interest, fear,

and learning enjoyment for pretest, posttest, and follow-up test to see how the variables are organized in the common factor space (Figure 2). The Kaiser–Meyer–Olkin measures verified the sampling for the analysis; pretest KMO = 0.67; posttest KMO = 0.68; follow-up test KMO = 0.60. In the posttest and follow-up test, two factors had eigenvalues over Kaiser’s criterion of 1. The two factors explained 64.30% of the variance in the posttest and 67.39% of the variance in the follow-up test. Regarding the pretest, there was only one factor over Kaiser’s criterion of 1. The second factor had a value of 0.98 and explained more than 10% of variance [74]. The screen plot was inconclusive. Therefore, a two-factor solution was chosen and explained 66.68% of the variance. While the factor representing the X-axis focuses on knowledge and thus cognitive abilities, it can be assumed that the second factor, the Y-axis, represents affective abilities (Figure 2). It is noticeable that the variable “fear” differs from the other variables which do not show a high degree of variability between tests.

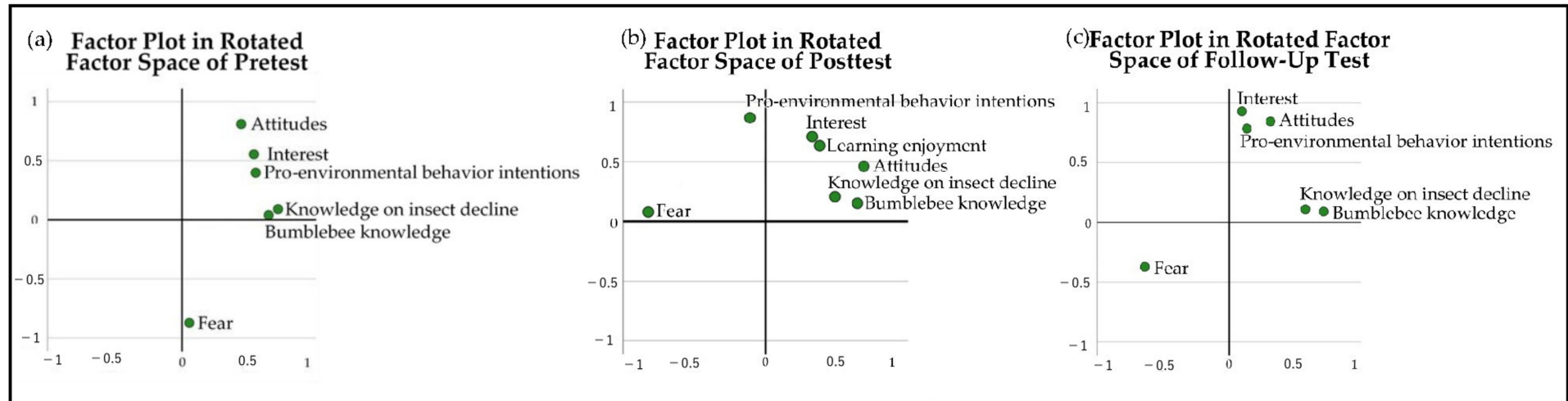


Figure 2. The plots of a PCA in the rotated factor space show bumblebee-friendly, pro-environmental behavior intentions, bumblebee knowledge, knowledge on insect decline, attitudes, interest, fear, and learning enjoyment for pretest (a), posttest (b), and follow-up test (c). The x-axis focuses on knowledge and thus cognitive abilities and the y-axis represents affective abilities.

5. Discussion

The results will be discussed in the order of the research questions.

5.1. Project Participation Increases Willingness for Pro-Environmental Behavior Intentions

Participation in the bumblebee project successfully increased student willingness for bumblebee-friendly, pro-environmental behavior, with a medium effect size. However, we detected no significant difference in this index between the pretest and follow-up test. The absence of a long-lasting effect may also be due to the small sample size of the follow-up test. The small sample size is a result of the high drop-out rate of participants between the posttest and follow-up test because of new class compositions after the summer holidays. Hence, it was not possible to achieve all students. This should be reexamined in future studies where a larger sample is available in the follow-up test. Nevertheless, the results indicate that hands-on activities with living bumblebees are a successful way to improve students' willingness to adopt bumblebee-friendly, pro-environmental behavior intentions. The single items of pro-environmental behavior intentions (Table 2) show that the majority not only promoted bumblebee protection, but also that of other insects and native pollinators. This illustrates that bumblebees are an effective umbrella species and that participating in their promotion can successfully promote pollinator conservation in general. Other research has shown that hands-on activities with living animals in biology classes can promote willingness to protect them: Schönfelder and Bogner [16] found a significant increase in willingness to protect honeybees after a short-term classroom intervention with honeybees. They also detected a medium effect between pretest and posttest. However, they also observed a small effect between pretest and follow-up test. Moreover, Fančovičová and Prokop [34] detected a better woodlouse conservation score after hands-on activities in biology classes in the experimental group, but not in the control group.

5.2. Knowledge Influences Pro-Environmental Behavior Intentions

Knowledge about insect decline correlated with the willingness for pro-environmental behavior intentions in the pretest and posttest, with a medium effect size [75]. No significant correlation was observed in the follow-up test, which might be due to the small sample size. Correlations between knowledge and pro-environmental behavior are also reported by Bamberg and Möser [11,33], Prokop and Tunnicliffe [33], and Roczen et al. [36]. By contrast, we observed no correlation between knowledge about bumblebees and pro-environmental behavior. The correlation between pro-environmental behavior intentions and knowledge about insect decline, but not about bumblebees in general, is intriguing, because the influence of knowledge on pro-environmental behavior is controversial, see, e.g., [13]. Frick et al. [37] assume that the type of knowledge is relevant and they divide environmental knowledge into action-related knowledge, effectiveness knowledge, and system knowledge. While the knowledge obtained here about bumblebees consisted mainly of system knowledge, recorded knowledge about insect decline predominantly contains action knowledge. While Frick et al. [37] and Roczen et al. [36] reported a small effect of action knowledge on pro-environmental behavior, they identified no significant correlation between system knowledge and behavior. Instead, Braun and Dierkes [38] found small effects of system knowledge and action knowledge, whereas the effect size of action knowledge was slightly higher. However, effect sizes observed by Braun and Dierkes [38], Frick et al. [37], and Roczen et al. [36] were crucially smaller than the correlations detected here between knowledge about insect decline and pro-environmental behavior intentions.

5.3. Attitudes Influence Pro-Environmental Behavior Intentions

Attitude is a complex construct and is associated with influencing pro-environmental behavior in the literature, e.g., [11]. Our results confirm a relationship between attitude and pro-environmental behavior intentions. While the results reveal a high correlation

between attitudes and pro-environmental behavior intentions in the pretest and follow-up test, similar to those reported by Roczen et al. [36], the correlation in the posttest was similar to that of other research that showed a medium effect [11,31,32]. The differences in effect sizes might reflect the findings of Serpell [41] that increased knowledge reduces the influence of the affective component of pro-environmental behavior. Nevertheless, it remains unclear why the correlation observed here was stronger in the follow-up test.

5.4. Interest Influences Pro-Environmental Behavior Intentions

High interest in bumblebees leads to a high willingness to implement bumblebee-friendly, pro-environmental behavior intentions. Interest is inherent to attitude [43]. Therefore, it can be assumed that it also influences the correlation between attitude and behavior. Nevertheless, interest itself correlated strongly with pro-environmental behavior in the pretest, posttest, and follow-up test. There is a lack of other research with which to compare the relationship between interest and environmental behavior, which highlights a need for further research. Interest showed the greatest effect on the pro-environmental behavior of the variables we tested. This emphasizes the extraordinary potential it has for environmental education projects. While it is difficult for teachers to address attitude, interest appears to be a clearer link for creating teaching structure.

5.5. Relationship between Fear and Pro-Environmental Behavior Intentions

In addition to interest, fear is also inherent to attitude [43]. In this study, fear of bumblebees did not correlate with all bumblebee-friendly behavior intentions at any measurement timepoint. This contrasts with research by Prokop and Fančovičová [54] and Schönfelder and Bogner [15], who identified a negative correlation between a willingness to protect species and perceived danger.

Among the single pro-environmental behavior intentions, a negative correlation with perceived fear was only observed in the pretest. In the posttest and follow-up test, no significant correlation was identified between perceived fear and single behavior intentions. This suggests that the negative influence of fear on environmental action might have been reduced by project participation. Moreover, bumblebees are perceived in a comparatively positive way and with little fear [72], which might explain the few observed significant correlations here. Martín-López et al. [30] reported that increased knowledge strengthens the willingness to protect even less popular animals. They suggest that the reason for their findings is that the affective component no longer predominantly affects attitude, due to increased knowledge; instead, the benefits of environmental protection are becoming increasingly important. In our evaluation, students also acquired knowledge through participation in the bumblebee project, such that the benefits of pollinators became clearer to students. This strengthened their willingness for pro-environmental behavior intentions, despite perceived fear. However, it is relevant that the emotional level was also addressed through project participation and direct experiences with bumblebees, which can also influence the degree of willingness for pro-environmental behavior. Overall, fear influenced the willingness for single pro-environmental behavior intentions only with a small effect size and only in the pretest. As to our aforementioned PCA analysis (Figure 2), the variable “fear” differs from the other variables which do not show a high degree of variability between tests. While fear is oriented along the affective axis in the pretest, it is oriented along the cognitive axis in the posttest. This could be attributed to the fact that students learned during the project about not to be afraid of bumblebees. In the follow-up test, however, fear lies between both axes and might reflect long-term effects which combine both cognitive and affective components.

5.6. Learning Enjoyment Influences Pro-Environmental Behavior Intentions

The learning enjoyment of students during the bumblebee intervention correlated positively with a willingness for bumblebee-friendly, pro-environmental behavior intentions. Because we could only assess learning enjoyment in the posttest, we can only draw

conclusions for that timepoint. However, it remains open whether students who are particularly willing to behave in a pro-environmental way also claim a high learning enjoyment, or whether a high learning enjoyment can increase the willingness for pro-environmental behavior intentions.

Overall, pro-environmental behavior can be influenced by many factors, but we assume that participation in the project led to changes in pro-environmental behavior intentions via various factors. Pro-environmental behavior intentions could be improved through the developed teaching concept, because a well-designed teaching concept facilitates successful environmental education.

5.7. Limitations

We did not select the participants randomly, but invited interested teachers to participate in the project with their classes. Furthermore, a large drop-out rate occurred between the posttest and follow-up test, because the summer holidays fell between the second and third measurement timepoints and during the summer holidays, teachers and students of classes in German schools are partly reallocated. This resulted in a reduced accessibility to participants and a small sample size. However, despite the smaller number of participants, the follow-up test provided valuable insights.

In addition, we did not measure general pro-environmental behavior, but intentions of the willingness to protect bumblebees, which also represents the willingness to protect other insect pollinators. Therefore, we could only draw conclusions concerning project participation towards bee-friendly behavior intentions. Moreover, the gap between behavioral intentions and actual behavior should be considered [11]: Actual behavior is expected to be influenced by project participation to a lower degree than behavioral intention [13].

Furthermore, our study did not contain a control group; therefore, we cannot conclude to which aspects of the intervention the changes in behavioral intentions are attributable. We attempted to find school classes willing to serve as control groups. However, according to the description of the project, the teachers and their classes preferred to participate in the project themselves, instead of serving as a control group.

5.8. Educational Implications and Conclusion

The evaluated bumblebee project aims to educate students about insect decline and encourages students to adopt bumblebee-friendly, pro-environmental behavior. Bumblebees serve as a useful umbrella species. The observed behavior intentions confirm the successful implementation of the school intervention and demonstrate that hands-on activities with living animals can be successfully used to teach biology.

The effects of influential variables on pro-environmental behavior intentions suggest that pro-environmental behavior intentions are accompanied by a positive attitude, action knowledge, and great interest. The fact that it is not the knowledge of bumblebees in general, but knowledge of the causes, contexts, and effects of insect decline that influence willingness to act in a pro-environmental way, highlights the need to teach students about the contexts and effects of their behavior. In view of the influence of interest and attitude on pro-environmental behavior, it might be easier from the teacher's point of view to focus the interest of students. Whereas the influencing of attitudes is difficult, increasing students' interest might be a more concrete starting point for teachers in biology education. Moreover, interest showed the highest measured correlations with pro-environmental behavior intentions. Promoting interest in endangered animal and plant species should thus be an important goal of environmental education and should be given special consideration in biology education. Therefore, focus should be placed on including interest-building methods in curricular settings, to promote pro-environmental behavior.

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