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Be(e) Engaged! How Students Benefit from an Educational Citizen Science Project on Biodiversity in Their Biology Classes

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Abstract: Citizen Science initiatives and their underlying concepts play an increasingly important role in getting the public interested in science and current scientific topics—one more reason to include Citizen Science in the school context. We develop a teaching concept with the aim of raising students' awareness of the importance of wild-bee biodiversity by involving them in scientific investigations. By addressing the issue, we hope to change student's attitudes towards wild bees as represented by common native bumblebees and encourage them to participate in pro-environmental behavior (PEB). A total sample size of 437 German high-school students from grades five to seven participated in the project. We examine students' knowledge about bumblebees and insect decline, students' attitude toward wild bees, and their PEB intentions before and after the project. Learning enjoyment is also measured in the post-test. Our results show that students' knowledge increases and they positively change their attitudes toward wild bees by participating in a Citizen Science project. Furthermore, we show that although knowledge and attitude significantly correlate with PEB intentions, no strong difference between pre- and post-tests can be observed.

Keywords: Citizen Science; environmental education; bumblebees; conservation; knowledge; attitude; learning enjoyment; environmental behavior

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1. Introduction

1.1. Citizen Science and Its Implementation in Schools

Citizen Science is commonly defined as public participation in scientific research [1,2] and is used in many fields to collect a large amount of data, for example, for biodiversity research [3,4]. The 'Christmas Bird Count', which was initiated in 1900, is the longest running Citizen Science project in North America and similar initiatives exist in the UK ('Big Garden Birdwatch') or in Germany ('Stunde der Gartenvögel', in English: 'Hour of the Garden Birds'). While older projects focused on individual countries, more recent projects are aimed at regions or even continents. For example, the ongoing 'Bumble Bee Watch' initiative invites the general public to monitor North American bumblebee species [5], while the terminated 'Evolution Megalab' project addresses polymorphisms in European banded snails, and is conducted in 15 European countries [6]. In addition, and more seminal from an educational point of view, public participation can include an active involvement in hypothesis-driven science as well as designing projects by, e.g., students themselves [7], which is a major competency to be taught in German biology classes. Furthermore, the term is used to refer to knowledge obtained through experience and knowledge about one's local environment [8]. Extrinsic factors, such as increased knowledge, especially improved species knowledge, and conservation support, are considered to be the most important motivating factors for participants in Citizen Science projects [9]. Citizen Science can be categorized based on the level of participation and the time and resources invested [7], or on the access of citizens, alternatively. For example, Wiggins and Crowston [10] distinguish between action (collaboration between citizens and scientists), conservation (educating the public about the protection and management of natural resources), investigation (answering scientific questions), virtual (activities via online platforms), and education. Haklay [11] established a four-level scheme for classifying Citizen Science based on the intensity of volunteers' engagement. The first level, 'Crowdsourcing' describes projects that use volunteers to collect data without further involvement in the scientific research. When participants are taught some basic skills before collecting and interpreting the data, it is termed 'Distributed Intelligence'. At level 3, which is named 'Participatory Science', citizens are more involved in defining a research problem and the subsequent data collection. The fourth and final level, 'Extreme Citizen Science', allows citizens to be involved in all phases of a research project, which includes the analysis of data. Here, Haklay [11] assumes that participants benefit most from projects that have the highest level of engagement.

Through the involvement and participation of citizens, Citizen Science is observed as having the potential to create a more conservation-sensitive society [12]. For this, the public should be involved in the development and design of projects to solve real-world problems [10]. In this context, citizens' exploration not only provides value to science, but also plays an increasingly important role in environmental education [13] as well as science education [14]. Citizen Science can help participants develop curiosity towards science in general and environmental sciences in particular, on the other hand [15]. Furthermore, it positively influences their attitudes towards the environment [16]. Moreover, it has the ability to create a connection between students' everyday lives and science [17]. In the context of biodiversity research, Peter et al. [13] show that in addition to a change in attitude and behavior, there is an increase in learning about biodiversity among participants. Hence, Mueller et al. [18] suggest that redesigning science education systems might lead to societies that have a more participatory role in the decision-making process.

While in large Citizen Science initiatives the quality of the collected data is an important issue [19,20], in the context of schools, however, the focus should be less on the quality of the obtained data and more on the educational benefits of Citizen Science projects. These benefits can especially be achieved in projects that can be classified as 'Distributed Intelligence' or 'Participatory Science' [11] and can be integrated into school lessons in terms of time. Nevertheless, participation may include the transmission of, e.g., in-class collected monitoring data to local nature-conservation authorities.

In this study, we report the results of the in-class evaluation of a Citizen Science teaching concept, which, by involving students in scientific investigations, aims to increase their awareness of the importance of bumblebee and wild-bee biodiversity. Moreover, we address students' attitudes toward wild bees and how an educational Citizen Science approach in regular biology classes affects their pro-environmental behavior (PEB).

To distinguish well-known honeybees (*Apis mellifera*) from other bees, including bumblebees (*Bombus* spp.), the German word 'Wildbiene'—literally 'wild bee'—was coined. Wild bees comprise all species of bees of the superfamily Apoidea within the order Hymenoptera. Even though it is not a scientific term of taxonomic relevance, it is used both in everyday language, e.g., in the context of so-called wild-bee nesting boxes (German: 'Wildbienennisthilfe'), as well as by nature conservationists. This occurs in peer-to-peer conversations as well as when addressing the general public. In English, bee species other than bumblebees and honeybees are commonly referred to as 'solitary bees' due to their life cycles.

1.1.1. The Educational Research Project

In Spring 2021, the educational research project "Hummeln helfen! Rhein–Main" (English: 'Help Bumblebees within the Rhine–Main metropolitan area') started at schools located in the Rhine–Main metropolitan area in Germany. As shown in a preceding project, bumblebees are a well-known and positively perceived genus; they are suitable flagship species for wild bees in general [21,22]. The major objective of the project is that students develop a positive attitude toward, as well as a comprehensive knowledge about, wild bees, in order to encourage their pro-environmental behavior and active engagement with biodiversity issues. The teaching concept fits in the curricula of the German Federal States Rhineland-Palatinate and Hesse, and was designed to be used in regular biology classes from grades five to seven [23,24]. It comprises two main teaching units: A basic unit and a Citizen Science unit. The project was designed in order to follow the concept of scientific literacy to promote the unity of knowledge, evaluation, and action [25]. Thus, on the one hand, curriculum-relevant knowledge can be taught, and on the other hand, biodiversity can be experienced through Citizen Science.

In the basic unit, students learn the importance of both pollinators and biodiversity for an ecosystem and how they contribute to students' daily lives. They also learn facts about bumblebee morphology and their way of living. Furthermore, newly developed teaching materials allow students to analyze the factors influencing insect decline rates. Methods emphasizing learning through play are the focus of the lessons.

In the Citizen Science unit, students monitor their own schoolyard for different species of bumblebees and other common wild bees (Figure 1). In order perform this properly, the unit includes age-based teaching material devoted to species identification as well as monitoring techniques, such as tracking wild bees individually. Thus, students acquire the necessary species knowledge to be a Citizen Scientist whose data sets will be made available to local nature-conservation authorities. They draw conclusions from their data and discuss the school grounds' insect-friendliness. As a result, they take appropriate measures to make it a better habitat for wild bees. For example, they provide nesting opportunities and food by planting suitable flowers. In order to evaluate the impact of the modifications in a scientific way, the students survey the population by repeating their investigations. In the context of the Citizen Science approach, students share their acquired knowledge with the public. Furthermore, they motivate others to take action on behalf of wild bees.

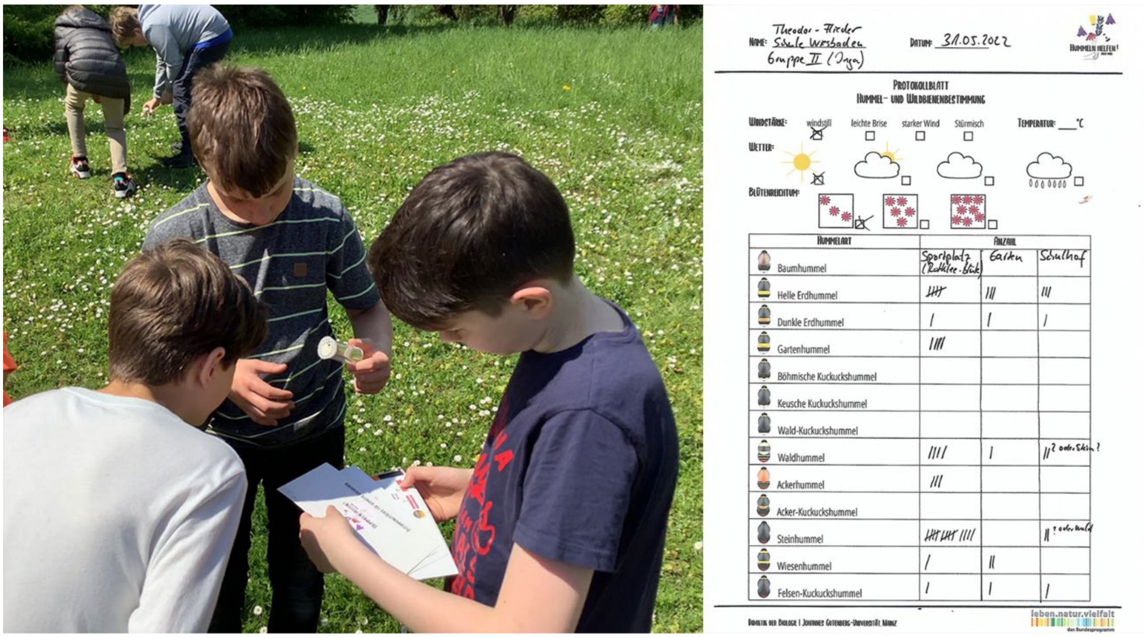


Figure 1. Students exploring their school grounds for bumblebees and other wild bees with material devoted to species identification. They document their results in appropriate tables.

To ensure a comparable implementation of the project, the materials and contents of the project were presented in detail to the participating teachers in a workshop. At the start of the project, they received all the necessary materials, including worksheets, lesson plans, and suggestions for assignments. The participating teachers instructed their classes independently.

1.1.2. Knowledge and Attitude

With regard to wild bees, there still is a lack of research on students' knowledge and attitudes [21]. However, both general and more specific issues of nature conservation and environmental protection are not only visible in the media, but also play a role in the everyday lives of young people, as evidenced by, e.g., demonstrations for climate justice as 'Fridays for Future'. As a consequence, not only the research focusing on wild bees, but also the public interest in conservation of bees has increased. However, although this interest seems to exist, a lack of knowledge is present and reveals a gap between awareness and understanding, e.g., the gap between the willingness to help and the understanding about bees. For example, a general lack of knowledge about the diversity of pollinators (e.g., bees and butterflies) is evident in the majority of the population [26]. In addition, the general public uses the term *bee* as synonymous for *honeybees*, and is not aware of the species richness and importance of wild bees. The majority does not recognize wild bees and identifies only honeybees as bees [26,27]. Educational research often focuses on insects in general or other insect families, such as ants, beetles, or butterflies. Overall, students have a rather limited knowledge and, often, misconceptions about insects. However, advanced elementary students know more than younger students regarding insect taxonomy, characteristics, lifecycles, and impacts on the environment or human beings [28,29]. On the other hand, regarding the knowledge about bumblebees, Sieg et al. [21] observed only minor differences between the grade levels five to twelve (aged 11 to 19 years). Overall, students were not familiar with the biology of bumblebees. Students performed poorly in tasks about morphology and colony life. At least some students knew about the importance of pollinators and were able to distinguish well-known bumblebee species from other insects. The school curriculum of the German Federal States of Rhineland-Palatinate and Hesse, where our study was conducted, only considers insects in general [23,24]. Moreover, most school books introduce just the honeybee as an example for pollinators, e.g., [30–34]. Therefore, the lack of knowledge is hardly surprising.

Moreover, Barrow [28] showed that students have greater knowledge about the negative than the positive characteristics of insects. This could lead to a negative attitude towards insects in general. Since knowledge and attitude are positively related, but the interaction between them remains unclear, one can only assume that they complement each other [35]. Previous studies show that insects often evoke feelings such as disgust or fear [36,37]. Bees are especially associated with anxiety. Bumblebees on the other hand are mostly positively perceived by students [21]. As mentioned above, bumblebees are a well-known genus and are a suitable flagship for wild bees and insects. They can be used as a model organism to learn more about wild bees in order to close the gap between positive attitudes and a lack of knowledge about bees [26].

1.1.3. Pro-Environmental Behavior

At present, the extinction of insects and especially wild bees is omnipresent and requires appropriate conservations that depend on the environmentally friendly behavior of citizens [38]. The motivation for responsible environmental behavior is very complex and highly individual. However, several studies show that psycho-social determinants, such as attitude and knowledge, influence PEB [39,40]. In addition, factors, such as self-interest [39] and beliefs [41], play a key role. Even though Knapp et al. [40] state that knowledge about pollinators and pollinator conservation are far less important than the attitude towards them, both are significantly positively correlated with the engagement in pollinator conservation. On the other hand, there are studies that do not show any effects of knowledge and attitude regarding pro-environmental behavior [42]. This emphasizes the great complexity of the reasons to behave responsibly toward the environment. In order to promote PEB, environmental education is important to enable people to gain knowledge and develop a positive attitude towards nature.

Based on direct experiences with nature, people can establish a connection with the environment. In addition, direct experiences with nature, which can occur, for example, in the context of Citizen Science projects, can positively influence environmentally friendly behavior [43,44]. Therefore, the determination of bumblebees is a highly appropriate way of promoting the PEB of students [37]. Many people are disgusted by insects or even afraid of stinging insects, such as bees. To overcome these negative perceptions, the bumblebee is a suitable flagship species for biology classes. They only sting under exceptional circumstances and are often beloved for their fluffiness and hard work [21,45]. The Educational Research Project "Hummeln helfen! Rhein–Main" uses the direct experience with nature and bumblebees to promote PEB with the aim of saving bumblebees and other insects. This may also be a first step in closing the so-called 'attitude–behavior gap', reflecting the fact that environmental knowledge and attitudes are often not translated into PEB in practice [46].

1.2. Research Questions

Our goal is to develop a Citizen Science project that can be implemented in regular biology classes. As described above in more detail, the project is designed in order to teach basic factual knowledge, as well as to expand and widen it in the context of a Citizen Science approach. The project should be suitable for understanding students' knowledge about bumblebees and insect decline and, furthermore, to lead to a positive change in their attitude towards the animals resulting in them acting in a more environmentally friendly way. In the context of the basic unit, we intend to increase the general knowledge about bumblebees and their life cycle, as well as about insect decline and pollination. In the context of the Citizen Science unit, we aim to investigate whether the knowledge about locally existing bumblebee and wild-bee diversity of participating students can be increased and whether their attitude towards wild bees can be positively changed by encountering the animals in their natural environment. In addition, the willingness to adopt pro-environmental behavior is investigated.

The specific research questions were:

a. Does including Citizen Science elements in biology classes result in an increase in students' knowledge?
b. Does a Citizen Science approach induce changes in students' attitudes toward wild bees?
c. Does the participation in an educational Citizen Science project increase the willingness for pro-environmental behavior intentions

2. Methods

Our study was conducted within the educational research project in which the students participated between April and July 2022. In total, 437 German high-school students from grades five to seven (lower and intermediate secondary-school levels) from eleven schools participated in the project (Table 1). Their age varied between 11 and 15 years. All participating schools were located within the metropolitan area of the Rhine–Main region in Germany. Our study sample was compiled by directly approaching schools in the context of the educational project. Following a project presentation and a workshop, biology teachers from several classes decided to take part in the project and the study. The participating teachers were asked to supervise the survey according to our instructions. All participating schools were located within the metropolitan area of the Rhine–Main region in Germany. Approvals by both state-school and state-conservation authorities were granted in advance.

Table 1. Descriptive statistics of study participants.

	5th Grade	6th Grade	7th Grade	Total
Age	11–12	12–13	13–15	11–15
Female	56	118	36	210
Male	88	87	51	226
No identification of gender	0	0	1	1
Total	144	205	88	437

2.1. Study Design

In our paper–pencil survey, the participants completed a pre- and post-test in the German language. Since our project was composed of two interrelated units, the study not only examined the Citizen Science unit, but also the basic unit, too. Students completed our surveys voluntarily and independently during class. They were asked not to cheat and to carefully fill out the questionnaires, knowing that the survey would not influence their grades. To ask for personal information, we used a closed-question format. In addition, the participants answered knowledge questions (Table 2), questions depicting their attitude, and questions about their willingness to act in an environmentally friendly way.

2.1.1. Knowledge

The students answered nine closed questions about bumblebees. The questions covered their knowledge about their morphology and way of life. In addition, the students worked on seven closed questions about biodiversity, pollination, and insect decline. We applied the construct of face validity and generated items following curricula and common textbooks used in biology classes. Furthermore, students were asked to decide from color photographs whether the species depicted were wild bees or not. As previously described [27], they were shown two pictures of honeybees, seven pictures of other bee species, and three pictures of hoverflies. The response options were ‘Yes’, ‘No’, and ‘Do not know’.

Table 2. Closed questions about students’ knowledge.

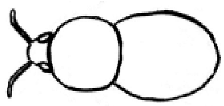
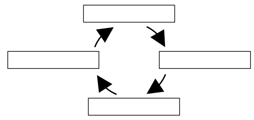
	Question	Response Alternatives
Knowledge about bumblebees	There are native bumblebee species in Germany that are threatened with extinction.	Yes/No/Do not know
	Bumblebees, such as the honeybee, belong to the family ‘Apidae’.	Yes/No/Do not know
	Some bumblebees live in abandoned burrows.	Yes/No/Do not know
	In bumblebee colonies, there are several queens that founded the colony.	Yes/No/Do not know
	The larvae of bumblebees are mainly fed with nectar during their growth.	Yes/No/Do not know
	Sketch in all the legs of the bumblebees in the picture.	
	The following bumblebees have a sting.	All bumblebees Drone Worker and queen None Do not know
	The following bumblebees survive in winter.	All bumblebees The young queen Only the males Do not know

Table 2. *Cont.*

	Question	Response Alternatives
	Put the four developmental stages of bumblebees in the correct chronological order: larva, egg, pupa, adult insect.	
Knowledge about pollination, biodiversity, and insect decline	Successful pollination can occur with pollen from related plant species.	Yes/No/Do not know
	In addition to bees, beetles and butterflies also pollinate flowering plants.	Yes/No/Do not know
	An ecosystem describes the community of life in an area.	Yes/No/Do not know
	The fewer the living organisms linked in an ecosystem, the more stable it is.	Yes/No/Do not know
	Biological diversity describes the variety and genetic diversity of all living organisms and their habitats on Earth.	Yes/No/Do not know
	The use of pesticides in agriculture has an impact on the decline in wild bees.	Yes/No/Do not know
	Insect decline mainly affects honeybees; wild bees are rarely affected.	Yes/No/Do not know

2.1.2. Attitude, Fear, and Learning Enjoyment

The attitude of students towards bumblebees and other wild bees was measured, as previously described by Sieg et al. [21], and measured with a five-tier Likert scale (“agree”, “rather agree”, “am undecided”, “rather do not agree”, “do not agree”). Instead of the term “bumblebees”, the term “wild bees” was used. Fear was examined as a single question, “I am afraid of bumblebees and other wild bees”, as part of the attitude scale. Moreover, we measured learning enjoyment by a five-tier Likert scale according to a validated questionnaire developed by Hagenauer [47]. The highest learning enjoyment corresponds to the value 5; the lowest joy of learning to the value 1.

2.1.3. Pro-Environmental-Behavior Intentions

To inquire about intentions to act in an environmentally friendly way, the participants were confronted with nine statements that were newly compiled for the evaluation. The statements comprised feasible actions related to making one’s own garden more friendly for wild bees, to actively engage in public discourses and show appropriate engagement. The 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”).

2.2. Data Analysis

The data were analyzed using IBM SPSS 27.0 following Field [48]. To evaluate knowledge, we rated each correct answer with 1 point; items that were wrong or answered with ‘do not know’ were combined and scored as 0 in the analysis. The sum of the correct answers was divided by the maximum possible points for each category. 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, as assessed by the Shapiro–Wilk test ($p < 0.05$). Hence, the median values (*Mdn*) were reported instead of the mean values. For items based on Likert scales, mean values (*M*s) as well as standard deviations (SDs) were also calculated. To compare the results of the pre- and post-tests, we used the Wilcoxon signed-rank test. We also calculated an effect size according to Cohen [49] for all statistically significant results.

3. Results

The results were presented in the order of our research questions.

3.1. Knowledge

Through their participation in our Citizen Science project, the students expanded their knowledge about ecosystems and insect decline rates, as well as their knowledge about bumblebees. Students' knowledge about ecosystems and insect decline rates before (*Mdn* = 0.43) and after (*Mdn* = 0.57) the participation presented a significant increase $N = 417$, $z = -9.149$, $p < 0.001$) with a strong effect ($r = 0.448$). In particular, a comparison of students' knowledge about bumblebees between the pre- (*Mdn* = 0.33) and post-tests (*Mdn* = 0.56) differed significantly ($N = 413$, $z = -13.863$, $p < 0.001$), presenting a large effect ($r = 0.678$). In addition, there was an increase in the students' knowledge of species. In the identification task, participants performed significantly better in the post-test ($N = 417$, $z = -3.259$, $p = 0.001$); (*Mdn* = 0.56) than in the pre-test (*Mdn* = 0.42), the effect size being small ($r = 0.159$). A slightly better performance was observed for bumblebees. Here, the implementation of monitoring activities, where the students' data were made available to local authorities, led to significantly ($N = 420$, $z = -3.649$, $p < 0.001$) more correct answers afterwards (pre-test: *Mdn* = 0.20; post-test: *Mdn* = 0.40). Although the effect size $r = 0.0178$ corresponded to a small effect, we considered more correct identifications in our ID task as an increase in species knowledge (Figure 2).

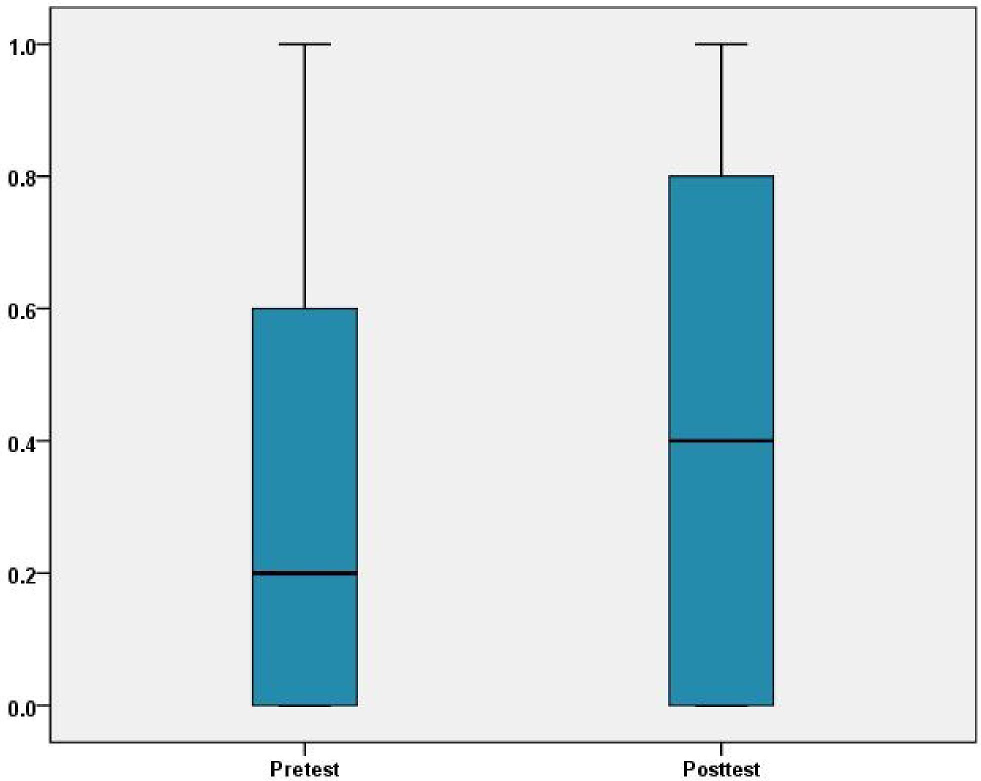


Figure 2. The number of correct answers for the identification of bumblebees differs significantly between the pre- and post-tests ($N = 420$, $z = -3.649$, $p < 0.001$).

The differences in knowledge increase between grade levels are summarized in Table 3. In total, all grades presented a significant increase in their knowledge with a strong effect. Students in grade 5 presented a significant increase in their knowledge with the highest effect ($r = 0.721$). The effect sizes of grades 6 ($r = 0.688$) and 7 ($r = 0.682$) differed only minimally.

Table 3. Case number (N), mean value (M), standard deviation (SD), and median (Mdn) of students' knowledge improvement. The results of the Wilcoxon signed-rank tests show significant differences between the pre- and post-tests in each grade.

Grade	Pre-test			Post-test			Wilcoxon Signed-Rank Test
	N	*M; SD*	*Mdn*	*N*	*M; SD*	*Mdn*	
5	143	$M = 0.365$; $SD = 0.175$	0.375	138	$M = 0.538$; $SD = 0.173$	0.563	$N = 134$, $z = -8.345$, $p < 0.001$
6	202	$M = 0.397$; $SD = 0.168$	0.375	195	$M = 0.559$; $SD = 0.159$	0.563	$N = 192$, $z = -9.529$, $p < 0.001$
7	85	$M = 0.401$; $SD = 0.193$	0.375	86	$M = 0.563$; $SD = 0.186$	0.625	$N = 83$, $z = -6.212$, $p < 0.001$

3.2. Attitude towards wild Bees and Learning Enjoyment

In addition to an increase in both factual and species knowledge, a change in attitude was observed among students as a result of their participation in the project. Students' attitudes before ($Mdn = 4.00$; $M = 3.89$, $SD = 0.693$) and after ($Mdn = 4.12$; $M = 3.99$, $SD = 0.700$) the project differed significantly ($N = 342$, $z = -4.629$, $p < 0.001$). The effect size $r = 0.250$ corresponded to a medium effect. Moreover, a difference between the genders was evident. The attitude of female students before ($Mdn = 4.00$; $M = 3.84$, $SD = 0.743$) and after ($Mdn = 4.18$; $M = 4.01$, $SD = 0.715$) the project significantly differed ($N = 166$, $z = -5.911$, $p < 0.001$). The effect size $r = 0.459$ corresponded to a large effect. For male students, there was no significant difference between the pre- and post-tests ($N = 172$, $z = -8.35$, $p = 0.404$). A comparison of the students' fear of bumblebees between pre-test ($Mdn = 2$, $M = 2.54$, $SD = 1.257$) and post-test ($Mdn = 2$, $M = 2.3$, $SD = 1.223$) significantly decreased during the project ($N = 405$, $z = -3.975$, $p < 0.001$), exhibiting a weak effect ($r = 0.1975$).

The participants ($N = 415$) really enjoyed learning during classes in the project ($Mdn = 3.92$). In addition, learning enjoyment significantly correlated to the students' attitudes toward wild bees after participating in the project ($r = 0.609$, $p < 0.001$, $N = 336$).

3.3. Pro-Environmental-Behavior Intentions

With all items taken together, no significant change was observed regarding the intention to act in an environmentally friendly manner within all of the items evaluated ($N = 318$, $z = -1.309$, $p = 0.191$). However, in more detail, significant differences could be observed for some statements before and after the implementation of the project (Table 4). For example, students' motivation to become active members of an environmental organization significantly differed with a small effect ($r = 0.1777$) between the pre-test ($Mdn = 3$) and post-test ($Mdn = 3$) ($N = 372$, $z = -3.429$, $p = 0.001$). In addition, understanding the responsibilities of policymakers regarding wild-bee conservation significantly changed between the pre-test ($Mdn = 3$) and post-test ($Mdn = 2$) ($N = 376$, $z = -4.176$, $p < 0.001$). The effect size was $r = 0.215$ and corresponded to a small effect. All other intentions to act in an environmentally friendly manner showed no significant changes between the pre- and post-tests. It is conspicuous that some items were answered with indecisiveness or already indicated environmentally friendly behavior in advance.

Table 4. Case number (N), mean value (M), standard deviation (SD), and median (Mdn) of students' pro-environmental-behavior intentions. The results of the Wilcoxon signed-rank tests show differences between the pre- and post-tests. Items with significant differences are highlighted.

Item	Pretest			Posttest			Wilcoxon Signed-Rank Test
	N	*M; SD*	*Mdn*	*N*	*M; SD*	*Mdn*	
I advocate in my family that we should avoid using pesticides in our garden.	413	M = 3.82; SD = 1.27	4	404	M = 3.75 SD = 1.38	4	$N = 380$, $z = -0.747$, $p = 0.455$
I frequently mow the lawn to keep it nice and neat and prevent wildflowers from going into bloom.	412	M = 2.25; SD = 1.33	2	401	M = 2.25; SD = 1.24	2	$N = 377$, $z = -0.024$, $p = 0.981$
I leave nature untidy to create retreats for wild bees and other insects.	410	M = 3.26; SD = 2.01	3	400	M = 3.22; SD = 1.35	3	$N = 375$, $z = -0.377$, $p = 0.706$
When I receive insect-friendly plants, I take the time to plant them in flower beds.	411	M = 3.69; SD = 1.24	4	406	M = 3.62; SD = 1.29	4	$N = 380$, $z = -0.299$, $p = 0.765$
Our politicians already protect wild bees very well, so a letter asking them to protect insects is unnecessary.	**407**	**M = 2.49; SD = 1.11**	**3**	**402**	**M = 2.26; SD = 1.11**	**2**	**$N = 376$, $z = -4.176$, $p < 0.001$**
For the next issue of our school newspaper, I would like to write a report about conservation opportunities for wild bees so that more people will get involved.	408	M = 3.10; SD = 1.26	3	401	M = 3.11; SD = 1.21	3	$N = 373$, $z = -0.602$, $p = 0.547$
I often try to convince other people that bumblebees are useful and we need to protect them.	412	M = 3.22; S = 1.23	3	407	M = 3.30; S = 1.28	3	$N = 382$, $z = 1.547$, $p = 0.122$
People are already doing enough to protect wild bees, so I do not think it is necessary to organize an exhibition with my school class.	408	M = 1.95; S = 1.08	2	409	M = 1.91; S = 1.02	2	$N = 379$, $z = -0.424$, $p = 0.672$
I would like to become an active member of an environmental protection organization to fight against the deaths of bees and insects.	**404**	**M = 2.95; S = 1.12**	**3**	**404**	**M = 2.68; S = 1.21**	**3**	**$N = 372$, $z = -3.429$, $p = 0.001$**

Note: Ratings on a five-point Likert scale from 0 (strongly disagree) to 4 (strongly agree).

As briefly mentioned in the Introduction, pro-environmental behavior is affected, among other factors, by knowledge and attitude. This is why these factors and the learning enjoyment of students were analyzed as part of the study. In our study, knowledge included both species knowledge about bumblebees and factual knowledge about pollination, biodiversity, and insect decline.

Knowledge significantly correlated with pro-environmental-behavior intentions in the pre-test with a medium effect and with a small effect in the post-test (Table 5). A significant correlation with a strong effect in the pre- and post-tests was observed between attitude and pro-environmental-behavior intentions. The learning enjoyment, that was only recorded in the post-test, correlated with pro-environmental-behavior intentions with a strong effect.

Furthermore, a significant correlation between entire knowledge and attitude was observed in a medium effect both in the pre-test (N = 379, r_s = 0.361, p < 0.001) and post-test (N =375, r_s = 0.375, p < 0.001)

Table 5. Spearman correlations of pro-environmental-behavior intentions and knowledge, attitude, and learning enjoyment. Cronbach's α are 0.685 in the pre-test and 0.731 in the post-test.

	Pro-Environmental-Behavior Intentions	
	Pre-test	**Post-test**
Knowledge	N = 360 r_s = 0.379 p < 0.001	N = 368 r_s = 0.250 p < 0.001
Attitude	N = 338 r_s = 0.622 p < 0.001	N = 336 r_s = 0.696 p < 0.001
Learning enjoyment	/	N = 342 r_s = 0.679 p < 0.001

4. Discussion

Citizen Science is considered to have an increasingly important role in science education [13]. However, it is rarely taken into account for scientific educational research [50]. Embedding Citizen Science projects in the school curriculum can bring forth the opportunity for students to directly experience nature, which can positively influence their environmentally friendly behavior [44,51]. Participating in a citizen science project as part of a biology class can also increase students' motivation to become more involved [52]. In addition, hands-on activities related to local species can raise their awareness of local biodiversity [53]. The aim of our study was to determine what may be achieved by integrating the Citizen Science approach in biology classes. Because the factors influencing PEB are multifaceted, we wanted to determine whether students' knowledge and attitudes toward wild bees correlated with their intention to act in an environmentally friendly way. The results show that this is the case before and after the implementation of the project, and are in coherence with the results obtained by Knapp et al. [40].

A considerable increase in knowledge about bumblebees as well as about ecosystems and insect decline was observed among the students through their participation in the Citizen Science project. It can be assumed that this increase in knowledge primarily occurred in the basic unit. In addition, the skill of students to identify bumblebees increased, what can be attributed to the monitoring that required a decent amount of time spent outside to identify bumblebee and wild-bee species in the assigned monitoring plots. An increase in knowledge through monitoring bees was also noted by Ganzevoort and van den Born [54]. Bowler et al. [9] observed that participants in Citizen Science projects were often motivated by improving species knowledge. Further research should determine the extent to which identifications were correctly made during monitoring, and whether the ability to correctly identify bumblebees would continue to improve through further monitoring events [55]. In addition to the increase in knowledge, students' attitudes toward wild bees were positively altered by their participation in the project, and fear levels also decreased. These results are consistent with the other studies that observed a decrease in fear levels through hands-on activities with honeybees [56,57]. Kelemen-Finan's et al.'s [50] results also show that students' interest and positive attitudes toward wild bees and biodiversity increased during a Citizen Science project. It is interesting, however, that only female students presented a strong significant difference in their attitudes towards wild bees, although they presented high values before their participation in the project. Here, it would be necessary to think about how and by which means a transformation could also be evoked in male students.

Although an overall change in knowledge and attitude could be achieved through participation in the educational research project, no final and decisive conclusion can be drawn as to whether students changed their PEB intentions through the Citizen Science approach. Nevertheless, a difference could be detected among the students in selected examples of environmentally friendly actions. This could be explained by the fact that the focus of the project was on the monitoring of wild bees, and that students were less motivated to develop or implement their own actions. Furthermore, the options for action addressed some issues that were dependent on the conditions at home (e.g., 'I advocate in my family that we should avoid using pesticides in our garden') and were less concerned with the students' own behaviors. Following Christ and Dreesmann [58], options for action towards nature conservation should be suggested by students themselves, such as consumption or actions that affect their own everyday lives.

However, the correlation of the knowledge of and attitude towards pro-environmental-behavior intentions suggests that continued exposure to wild bees and the associated conservation measures could lead to an even more positive attitude, which, in turn, could contribute to an increased willingness to act in an environmentally friendly manner. It can be concluded that Citizen Science is suitable as an initial point to make students aware of conservation issues and motivate them to deal with them in out-of-school situations. In this way, greater changes in people's thinking and actions could be achieved from a brief experience of nature through Citizen Science. Moreover, the gap between awareness and understanding could be closed, while the 'attitude–behavior gap' requires other approaches or else a longer examination of the topic.

In addition, learning enjoyment measured after participation in our educational project strongly correlated with the willingness to participate in the project, which is why, in the future, attention should be paid to creating appropriate learning situations. The degree of students' willingness to learn was very high in the project, indicating that hands-on activities in nature and encounters with wild bees can provide learning-efficient classes. Participating in a science project where they contribute to world knowledge can make students feel more engaged in their learning. One factor that in the context of 'Hummeln helfen! Rhein–Main' could have an influence on the motivation, and also enjoyment, of the students is that their monitoring data were actually used to gain new knowledge. This factor might also contribute to getting students excited about participating in Citizen Science projects for longer periods of time. Another possibility is to provide feedback to the participants on how their data contribute to biodiversity research and conservation [9]. Through Citizen Science projects, the work of the students is appreciated and could thus contribute to an increase in individual self-esteem.

5. Limitations

The participants in the study were not randomly selected, but were all from classes that participated in the project. Furthermore, we could not survey every aspect of knowledge, but tried to include the most important questions of a topic. Furthermore, we did not intend to query a general concept of pro-environmental behavior (Cronbach's $\alpha = 0.685$; 0.731), but focused on a selection of appropriate intentions related to wild-bee conservation. As mentioned in the discussion, actions and behavior intentions should be described in the future that involve independent student behavior. However, it should be taken into account that there is often a gap between the intention and active behavior of students [58]. Moreover, only a follow-up test could determine whether the increase in knowledge and attitude change has been sustained. To verify an increase in knowledge or a change in attitude as a result of participation in a Citizen Science project, a study should be designed and implemented to specifically examine this idea.

6. Educational Implications

Citizen Science provides opportunities for students to participate in both meaningful and relevant scientific research, and is a way to bring society and science together [59]. Our research showed that teaching ecology basics through hands-on activities and encounters with bumblebees and other wild-bee species that occur in nature as part of an educational Citizen Science project promoted knowledge, changed attitudes toward wild bees in a positive way, and provided students with a high level of learning enjoyment. When implementing Citizen Science projects in school, however, attention must be taken to find a suitable form to let students work scientifically and at the same time convey curriculum-relevant content. Through a project that can be assigned to the level 'Distributes intelligence' or 'Participatory science' [11], for example, students can be independently active and these goals can be achieved. However, in order to focus more closely on conservation and the implementation of pro-environmental behavior, such a project would have to be conducted for a longer period of time in order to not only present appropriate possibilities for action to students, but to implement further possibilities.

By and large, it can be concluded that educational Citizen Science projects that focus on a few species did not only improve the general knowledge of students about biodiversity and its key role in general. Meaningful in-class Citizen Science activities aim at transforming them into genuine citizen scientists. As such, they can follow the ongoing research and reports on, e.g., insect decline, with more expertise, considering themselves more eligible to engage with and subsequently create their own ideas for how to implement appropriate measures in their personal environment inside and outside schools.

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References

1. Bonney, R.; Ballard, H.; Jordan, R.; McCallie, E.; Phillips, T.; Shirk, J.; Wilderman, C.C. *Public Participation in Scientific Research: Defining the Field and Assessing Its Potential for Informal Science Education: A CAISE Inquiry Group Report*; Center for Advancement of Informal Science Education (CAISE): Washington, DC, USA, 2009.
2. Shirk, J.L.; Ballard, H.L.; Wilderman, C.C.; Phillips, T.; Wiggins, A.; Jordan, R.; McCallie, E.; Minarchek, M.; Lewenstein, B.; Krasny, M.E.; et al. Public Participation in Scientific Research: A Framework for Deliberate Design. *Ecol. Soc.* **2012**, *17*, 29. [CrossRef]
3. Bonney, R.; Shirk, J.L.; Phillips, T.B.; Wiggins, A.; Ballard, H.L.; Miller-Rushing, A.J.; Parrish, J.K. Next Steps for Citizen Science. *Science* **2014**, *343*, 1436–1437. [CrossRef] [PubMed]
4. Theobald, E.; Ettinger, A.; Burgess, H.; DeBey, L.; Schmidt, N.; Froehlich, H.; Wagner, C.; HilleRisLambers, J.; Tewksbury, J.; Harsch, M.; et al. Global change and local solutions: Tapping the unrealized potential of citizen science for biodiversity research. *Biol. Conserv.* **2015**, *181*, 236–244. [CrossRef]
5. MacPhail, V.J.; Gibson, S.D.; Hatfield, R.; Colla, S.R. Using Bumble Bee Watch to investigate the accuracy and perception of bumble bee (*Bombus* spp.) identification by community scientists. *PeerJ* **2020**, *8*, e9412. [CrossRef] [PubMed]
6. Worthington, J.P.; Silvertown, J.; Cook, L.; Cameron, R.; Dodd, M.; Greenwood, R.M.; McConway, K.; Skelton, P. Evolution MegaLab: A case study in citizen science methods. *Methods Ecol. Evol.* **2011**, *3*, 303–309. [CrossRef]
7. Roy, H.E.; Pocock, M.J.O.; Preston, C.D.; Roy, D.B.; Savage, J.; Tweddle, J.C.; Robinson, L.D. *Understanding Citizen Science & Environmental Monitoring*; Final Report on Behalf of UK-EOF; NERC Centre for Ecology & Hydrology and Natural History Museum: Bailrigg, UK, 2012.

8. Science Communication Unit, University of the West of England, Bristol. Science for Environment Policy Indepth Report: Environmental Citizen Science. Report Produced for the European Commission DG Environment. 2013. Available online: http://ec.europa.eu/science-environment-policy (accessed on 30 September 2022).
9. Bowler, D.E.; Bhandari, N.; Repke, L.; Beuthner, C.; Callaghan, C.T.; Eichenberg, D.; Henle, K.; Klenke, R.; Richter, A.; Jansen, F.; et al. Decision-making of citizen scientists when recording species observations. *Sci. Rep.* **2022**, *12*, 11069. [CrossRef]
10. Wiggins, A.; Crowston, K. From Conservation to Crowdsourcing: A Typology of Citizen Science. In Proceedings of the 2011 44th Hawaii International Conference on System Sciences, Kauai, HI, USA, 4–7 January 2011; pp. 1–10. [CrossRef]
11. Haklay, M. Citizen Science and Volunteered Geographic Information: Overview and Typology of Participation. In *Crowdsourcing Geographic Knowledge: Volunteered Geographic Information (VGI) in Theory and Practice*; Sui, D., Elwood, S., Goodchild, M., Eds.; Springer: Dordrecht, The Netherlands, 2013; pp. 105–122. ISBN 9789400745872. [CrossRef]
12. Haywood, B.; Parrish, J.K.; Dolliver, J. Place-based and data-rich citizen science as a precursor for conservation action. *Conserv. Biol.* **2016**, *30*, 476–486. [CrossRef]
13. Peter, M.; Diekötter, T.; Kremer, K. Participant outcomes of biodiversity citizen science projects: A systematic literature review. *Sustainability* **2019**, *11*, 2780. [CrossRef]
14. Wals, A.E.J.; Brody, M.; Dillon, J.; Stevenson, R.B.; Boston, R.; Schnepp, Z.; Nemoto, Y.; Sakka, Y.; Hall, S.R. Convergence between Science and Environmental Education. *Science* **2014**, *344*, 583–584. [CrossRef]
15. Phillips, T.; Porticella, N.; Constas, M.; Bonney, R. A Framework for Articulating and Measuring Individual Learning Outcomes from Participation in Citizen Science. *Citiz. Sci. Theory Pract.* **2018**, *3*, 3. [CrossRef]
16. Lewandowski, E.J.; Oberhauser, K.S. Butterfly citizen scientists in the United States increase their engagement in conservation. *Biol. Conserv.* **2017**, *208*, 106–112. [CrossRef]
17. Jenkins, L.L. Using citizen science beyond teaching science content: A strategy for making science relevant to students' lives. *Cult. Stud. Sci. Educ.* **2011**, *6*, 501–508. [CrossRef]
18. Mueller, M.; Tippins, D.; Bryan, L. The Future of Citizen Science. *Democr. Educ.* **2012**, *20*. Article 2. Available online: http://democracyeducationjournal.org/home/vol20/iss1/2/ (accessed on 30 September 2022).
19. Kosmala, M.; Wiggins, A.; Swanson, A.; Simmons, B. Assessing data quality in citizen science. *Front. Ecol. Environ.* **2016**, *14*, 551–560. [CrossRef]
20. Bayraktarov, E.; Ehmke, G.; O'Connor, J.; Burns, E.L.; Nguyen, H.A.; McRae, L.; Possingham, H.P.; Lindenmayer, D.B. Do Big Unstructured Biodiversity Data Mean More Knowledge? *Front. Ecol. Evol.* **2019**, *6*, 239. [CrossRef]
21. Sieg, A.-K.; Teibtner, R.; Dreesmann, D. Don't Know Much about Bumblebees?—A Study about Secondary School Students' Knowledge and Attitude Shows Educational Demand. *Insects* **2018**, *9*, 40. [CrossRef]
22. Sieg, A.-K.; Dreesmann, D.C. Befriending Bumblebees through hands-on activities in biology classes: Living Bumblebees lead to lasting knowledge and provide high learning enjoyment. *J. Biol. Educ.* **2022**, 1–13. [CrossRef]
23. Ministerium für Bildung, Wissenschaft, Weiterbildung und Kultur (Hrsg.). *Lehrpläne für die Naturwissenschaftlichen Fächer für die Weiterführenden Schulen in Rheinland-Pfalz (Natural Science Curriculum for Secondary Schools of Rhineland-Palatinate)*; Ministerium für Bildung, Wissenschaft und Weiterbildung und Kultur: Mainz, Germany, 2014; pp. S24–S33.
24. Hessisches Kultusministerium: Lehrplan Biologie. *Gymnasialer Bildungsgang Jahrgangsstufe 5 bis 13 (Biology Curriculum for Secondary Schools Grade 5 to 13)*; Hessisches Kultusministerium: Wiesbaden, Germany; pp. S7–S21.
25. OECD (Organisation for Economic Co-Operation and Development). Assessment Framework: Mathematics, Reading, Science and Problem Solving, Knowledge and Skills. 2003. Available online: https://www.oecd.org/education/school/programmeforinternationalstudentassessmentpisa/33694881.pdf (accessed on 28 September 2022).
26. Wilson, J.S.; Forister, M.L.; Carril, O.M. Interest exceeds understanding in public support of bee conservation. *Front. Ecol. Environ.* **2017**, *15*, 460–466. [CrossRef]
27. Christ, L.; Dreesmann, D.C. SAD but True: Species Awareness Disparity in Bees Is a Result of Bee-Less Biology Lessons in Germany. *Sustainability* **2022**, *14*, 2604. [CrossRef]
28. Barrow, L.H. What do elementary students know about insects? *J. Elementary Sci. Educ.* **2002**, *14*, 53–60. [CrossRef]
29. Allen, M. Preschool children's taxonomic knowledge of animal species. *J. Res. Sci. Teach.* **2014**, *52*, 107–134. [CrossRef]
30. Schmidt, H.; Schöntag, J. *Natura 6, Rheinland-Pfalz, [Ausgabe für Gymnasien], 1. Auflage; German Schoolbook*; Ernst Klett Verlag: Stuttgart, Leipzig, 2016.
31. Bickel, H.; Claus, R. *Natura. Biologie für Gymnasien (Natura. Biology for Secondary Schools); [Grundausg, Neubearb.], 1. Aufl., [Nachdr.]; German Schoolbook*; Klett-Schulbuchverl: Stuttgart, Germany, 2002.
32. Markl, J.; Gauß, A. *Biologie. Oberstufe (Biology for Senior Classes); 1. Aufl.; German Schoolbook*; Klett: Stuttgart, Germany, 2010.
33. Konopka, H.-P. *Netzwerk Naturwissenschaften. Ein Lehr- und Arbeitsbuch (Network Natural Sciences. A Text and Work Book); Rheinland-Pfalz, Dr. A 2; German Schoolbook*; Schroedel: Braunschweig, Germany, 2010.
34. Backhaus, U.; Bresler, S.; Bruns, E.; Ehrsberger, E.; Haas, T.; Handschuh, P.; Heepmann, B. *Fokus Naturwissen-schaften (Focus on Natural Sciences); 1. Aufl.; German BarrSchoolbook*; Cornelsen: Berlin, Germany, 2010.
35. Serpell, J.A. Factors influencing human attitudes to animals and their welfare. *Anim. Welf.* **2004**, *13*, 145–151.
36. Prokop, P.; Tunnicliffe, S.D. "Disgusting" Animals: Primary School Children's Attitudes and Myths of Bats and Spiders. *Eurasia J. Math. Sci. Technol. Educ.* **2008**, *4*, 87–97. [CrossRef]

37. Sammet, R.; Dreesmann, D. What Do Secondary Students Really Learn during Investigations with Living Animals? Parameters for Effective Learning with Social Insects. *J. Biol. Educ.* **2016**, *51*, 26–43. [CrossRef]
38. Drossart, M.; Gérard, M. Beyond the Decline of Wild Bees: Optimizing Conservation Measures and Bringing Together the Actors. *Insects* **2020**, *11*, 649. [CrossRef]
39. Bamberg, S.; Möser, G. Twenty years after Hines, Hungerford, and Tomera: A new meta-analysis of psycho-social determinants of pro-environmental behaviour. *J. Environ. Psychol.* **2007**, *27*, 14–25. [CrossRef]
40. Knapp, J.L.; Phillips, B.B.; Clements, J.; Shaw, R.F.; Osborne, J.L. Socio-psychological factors, beyond knowledge, predict people's engagement in pollinator conservation. *People Nat.* **2020**, *3*, 204–220. [CrossRef]
41. Stern, P.C. Toward a coherent theory of environmentally significant behavior. *J. Soc. Issues* **2000**, *56*, 407–424. [CrossRef]
42. Kollmuss, A.; Agyeman, J. Mind the Gap: Why do people act environmentally and what are the barriers to pro-environmental behavior? *Environ. Educ. Res.* **2002**, *8*, 239–260. [CrossRef]
43. Liefländer, A.K.; Fröhlich, G.; Bogner, F.X.; Schultz, P.W. Promoting connectedness with nature through environmental education. *Environ. Educ. Res.* **2013**, *19*, 370–384. [CrossRef]
44. Kleespies, M.W.; Gübert, J.; Popp, A.; Hartmann, N.; Dietz, C.; Spengler, T.; Becker, M.; Dierkes, P.W. Connecting High School Students With Nature—How Different Guided Tours in the Zoo Influence the Success of Extracurricular Educational Programs. *Front. Psychol.* **2020**, *11*, 1804. [CrossRef]
45. Sieg, A.-K.; Dreesmann, D. Promoting Pro-Environmental BEEhavior in School. Factors Leading to Eco-Friendly Student Action. *Sustainability* **2021**, *13*, 6598. [CrossRef]
46. Peattie, K. Green Consumption: Behavior and Norms. *Annu. Rev. Environ. Resour.* **2010**, *35*, 195–228. [CrossRef]
47. Hagenauer, G. *Lernfreude in der Schule (Learning Enjoyment in School)*; Waxmann: Münster, Germany, 2011; ISBN 978-3-8309-2480-7.
48. Field, A. *Discovering Statistics Using IBM SPSS Statistics: And Sex and Drugs and Rock 'n' Roll*, 4th ed.; Sage: Los Angeles, CA, USA, 2013; ISBN 9781446249185.
49. Cohen, J. A power primer. *Psychol. Bull.* **1992**, *112*, 155–159. [CrossRef]
50. Kelemen-Finan, J.; Scheuch, M.; Winter, S. Contributions from citizen science to science education: An examination of a biodiversity citizen science project with schools in Central Europe. *Int. J. Sci. Educ.* **2018**, *40*, 2078–2098. [CrossRef]
51. Hallmann, S.; Klöckner, C.A.; Beisenkamp, A.; Kuhlmann, U. Freiheit, ästhetik oder Bedrohung? Wie Kinder die Natur bewerten (Freedom, aesthetics or threat? How children evaluate nature). *Umweltpsychologie* **2005**, *9*, 88–108.
52. Kreuzer, P.; Dreesmann, D. Museum behind the scenes—An inquiry-based learning unit with biological collections in the classroom. *J. Biol. Educ.* **2016**, *51*, 261–272. [CrossRef]
53. Ballouard, J.-M.; Brischoux, F.; Bonnet, X. Children Prioritize Virtual Exotic Biodiversity over Local Biodiversity. *PLoS ONE* **2011**, *6*, e23152. [CrossRef]
54. Ganzevoort, W.; Born, R.V.D. Counting Bees: Learning Outcomes from Participation in the Dutch National Bee Survey. *Sustainability* **2021**, *13*, 4703. [CrossRef]
55. Falk, S.; Foster, G.; Comont, R.; Conroy, J.; Bostock, H.; Salisbury, A.; Kilbey, D.; Bennett, J.; Smith, B. Evaluating the ability of citizen scientists to identify bumblebee (*Bombus*) species. *PLoS ONE* **2019**, *14*, e0218614. [CrossRef]
56. Cho, Y.; Lee, D. 'Love honey, hate honey bees': Reviving biophilia of elementary school students through environmental education program. *Environ. Educ. Res.* **2016**, *24*, 445–460. [CrossRef]
57. Schönfelder, M.L.; Bogner, F.X. How to sustainably increase students' willingness to protect pollinators. *Environ. Educ. Res.* **2016**, *24*, 461–473. [CrossRef]
58. Christ, L.; Dreesmann, D. Protect + prevent = preserve? Exploring students' arguments for and attitudes toward conservation. *Environ. Educ. Res.* **2022**. [CrossRef]
59. Vohland, K.; Land-Zandstra, A.; Ceccaroni, L.; Lemmens, R.; Perelló, J.; Samson, R.P.M.; Wagenknecht, K. *The Science of Citizen Science*; Springer International Publishing: Berlin/Heidelberg, Germany, 2021. [CrossRef]