education sciences

MDPI

Article

Do Radishes and Carrots Grow in a Bunch? Students' Knowledge about the Growth of Food Plants and Their Ideas of a School Garden Design

Felix Hellinger [1], Dorothee Benkowitz [2,*] and Petra Lindemann-Matthies [1]

[1] Institute of Biology, Karlsruhe University of Education, 76133 Karlsruhe, Germany; felixhellinger@gmail.com (F.H.); petra.lindemann-matthies@ph-karlsruhe.de (P.L.-M.)
[2] Institute of Biology, Weingarten University of Education, 88250 Weingarten, Germany
* Correspondence: benkowitz@ph-weingarten.de

Abstract: School gardens can be places of biodiversity and suitable learning environments for Education for Sustainable Development (ESD). In particular, vegetable patches where students can make their own experiences in food growing are very apt to connect local acting and global thinking, which is one of the main concerns of ESD. Working in a school garden could be a chance to overcome the lack of perception and knowledge about plants and their life cycles, which is described as "plant blindness". Concerning the impact of school gardening, studies often investigate teachers' perspectives only. Therefore, in our study, we focused on students. Participants were mainly fifth and sixth graders in middle and grammar school (mean age 12.3 years, n = 2107). With a paper-pencil test, we investigated their knowledge about the growth of 10 selected crop plants and asked them to rate school garden design elements referring to their importance and suitability for taking over responsibility for nature. In addition, we asked for character traits necessary for a successful school gardener. The results showed that about 40% of the students are convinced that carrots and radishes grow in bunches underground, and nearly 50% thought kohlrabi is growing underground as well. Girls performed better than boys. Increasing age and experience in gardening had a positive effect on the answers. In the students' opinion, fruit trees, birdhouses, and vegetable patches are the most important elements in school gardens. The liking of nature and patience were highly scored skills for successful school gardening. The influence of experiences in gardening on the answers showed the important role that school gardening could play to gain hands-on knowledge about plant growth and thus offer quality education for every student. This would not only contribute to the reduction of plant blindness but answer the requests of ESD and the goals postulated in the Agenda 2030.

Keywords: school gardening; education for sustainable development; food plants; botanical knowledge; garden-based learning

Citation: Hellinger, F.; Benkowitz, D.; Lindemann-Matthies, P. Do Radishes and Carrots Grow in a Bunch? Students' Knowledge about the Growth of Food Plants and Their Ideas of a School Garden Design. *Educ. Sci.* **2022**, *12*, 299. https://doi.org/10.3390/educsci12050299

Academic Editor: Marcia Eugenio-Gozalbo

Received: 15 February 2022
Accepted: 18 April 2022
Published: 22 April 2022

1. Introduction

School gardens can be biodiverse learning environments and offer a wide range of options for students and teachers to make individual experiences with phenomenons of the natural world. Meaningful hands-on learning provides knowledge about ecological processes, life cycles of animals and plants, food growing and, by this means, understanding of sustainable food production, to name just a few. By watching plants grow garden-based learning can counteract plant blindness, a phenomenon described by Wandersee and Schussler [1]: People often do not pay much attention to plants and assess them only as a green background or decoration. School gardens can be very suitable for the implementation of sustainable development goals (SDG) as postulated in the UNESCO Agenda 2030. By growing their food, especially, students learn essential knowledge about responsible consumption and production (SDG 12), the economizing of water (SDG 6, 13), healthy nutrition, and well-being (SDG 3), to point out just some. In a school garden, every child gets a quality education (SDG 4), and inequalities can be overcome.

Central to the work in many school gardens is a vegetable patch where students can take care of plants, cultivate, and finally harvest them; they are learning a lot about food production, seasonality, and regionality. Watching students sowing seeds of carrots and radishes, we often perceived that they did it in rounds—such as bunches presented on sale. Harvesting radish, a girl was surprised that there was only one radish at the end of the leaves and asked where the others were; we asked ourselves if the students think that some plants already grow in bunches. Studies often focus on knowledge about food plants by asking to identify and name different fruits and vegetables [2–4]. Only a few studies examined students' knowledge of the growth of various plants and their crops [5]; therefore, the present study is intended to contribute to remedying this research desideratum. It will also be investigated whether previous experience in growing vegetables has an impact on students' knowledge, as studies suggested [2,4].

For many teachers taking care of a school garden, assuming responsibility is an essential educational goal of their work with children [6–8]. Student teachers also see the assumption of responsibility as an essential element of ESD-related learning [9] as Fisher-Maltese [10] and Passy et al. [11] have already proven; however, there is a need for research into which garden elements are particularly suitable for a school garden in order to initiate a responsible approach to nature. The students' assessment in this study is intended to contribute to this. In this context, it is interesting to see whether previously gained horticultural experience in growing fruits and vegetables has an impact on the assessments.

In previous studies on the impact of school gardening, the perspective of decision-makers is taken, and teachers or school administrators are used as a sample to provide information about the garden design as well as the goals followed by school gardening [6,7,12]. The learner's point of view, as well as their needs and wishes, are investigated less often; therefore, this study is intended to focus on the knowledge, assessment, and opinion of the students and provide information about the garden design elements they would prefer for a fictional school garden.

There is much evidence that school gardening promotes social learning [13,14] as well as cognitive skills in terms of academic knowledge [15]; therefore, we asked the students which personal, social, cognitive, and physical skills they think are required when working in a school garden.

The study also pursues the question of whether students´ knowledge of plant growth, design preferences for a school garden, and school gardening-related skills are related to gender, age, and prior gardening experience. Previous studies indicate that girls are more interested in gaining knowledge about food plants in class [16] and have a greater interest in ornamental plants than boys [17]; however, getting older, their interest in crops decreases as well [18–20]. Younger children prefer species-poor lawns instead of species-rich meadows for playing on the school grounds [21]. School gardening increases interest in and knowledge of food plants [22–24]; however, there is a stronger effect for girls than for boys [23,24]. Living in a rural area showed a positive effect on plant species knowledge [25,26].

The following research questions were focused on in the study:

(1) Do students know how selected food plants grow?
(2) How important are selected design elements for students when creating a new school garden and how suitable do they consider them to be in order to learn how to deal responsibly with nature?
(3) Which character traits in a person are judged indispensable by students in order to work successfully in a school garden?
(4) Are the design wishes for a school garden, the knowledge of the growth of cultivated plants, and the character traits required for working in the school garden correlated in any way with gender, age, and previous horticultural experience of the students?

2. Materials and Methods

2.1. Sampling and Data Collection

In February 2019, 244 primary and secondary schools in the administrative district of Karlsruhe, a city in the county of Baden-Württemberg, Germany, were asked to participate in the study with their 4th to 10th grades. The availability and current use of a school garden was not a prerequisite for participation. The schools were informed that the questionnaire would be carried out in class by the teacher and would take about 10–20 min, depending on the students' age. To increase the number of positive responses, the participating teachers were assured that sufficient color-printed copies of the questionnaire would be provided; they also had the opportunity to take part in a raffle for 3 times 50 euros for the class fund. Ultimately, 29 schools with 92 classes consented to take part in the survey (n = 2107).

The participating teachers received written instructions on how to conduct the survey. They were asked to provide adequate supervision while filling in the questionnaire and to use privacy screens on the table when necessary. To start with, students practiced filling in a questionnaire together using an example on the cover sheet. Above all, they were supposed to gain confidence in answering Likert scales. The teachers were informed that the time could be extended when required. The questionnaires had to be checked at the end by the students themselves to make sure answers were complete.

2.2. Structure of the Questionnaire

The questionnaire was divided into four main topics:

- Knowledge about the growth of 10 selected plants (see Research Question 1);
- Importance of selected garden elements when designing a school garden and their suitability for learning how to deal responsibly with nature (see Research Question 2);
- Required character traits, skills, and competencies for successful school gardening (see Research Question 3);
- Collection of socio–demographic data and previous horticultural experience (see Research Question 4).

The socio–demographic data were collected at the end of the questionnaire to avoid dropout or refusal triggered by sensitive questions at the beginning. Furthermore, the degree of attention was deemed to decrease towards the end which we sought to accommodate for by putting questions that do not require much thinking at the end [27] (pp. 484–485).

To ensure the appropriateness of the questionnaire's design and the linguistic level, we took care that the wording of the questions could be understood by fourth-grade students and at the same time were not too childlike for students of higher grades in secondary schools.

2.3. Response Categories

The questionnaire consisted of closed questions with predetermined response options, 5-point Likert scales were used to determine the importance and suitability of selected garden elements and skills for successful school gardening. This response method has been shown to be preferred by children [28]. The verbal categories chosen were "very unimportant-unimportant-partly/partly-important-very important" (importance and skills) and "poorly suited-rather poorly suited-partly suited-well suited-very well suited" (suitability). The negative or rejecting categories were always listed first, while if students were not familiar with a school garden element, they could choose the option "I don't know". Most items were presented as statements since they have been shown to be more suitable for exploring opinions and attitudes than questions [29].

To examine the students' ideas about plant growth, 10 typical food plants and their harvested fruit or storage organs were selected (apple, tomato, radish, pumpkin, sweet pepper, kohlrabi, potato, carrot, cauliflower, cucumber). The selection was based on frequently cultivated plants in gardens and school gardens and the possibility of regular consumption [2]. For each crop, six possibilities of growth were given via schematic drawings from which students were supposed to choose one correct answer (Figure 1). Each drawing included a headline (e.g., "They grow solitarily underground"); each crop was also accompanied by a photo showing the harvested products.

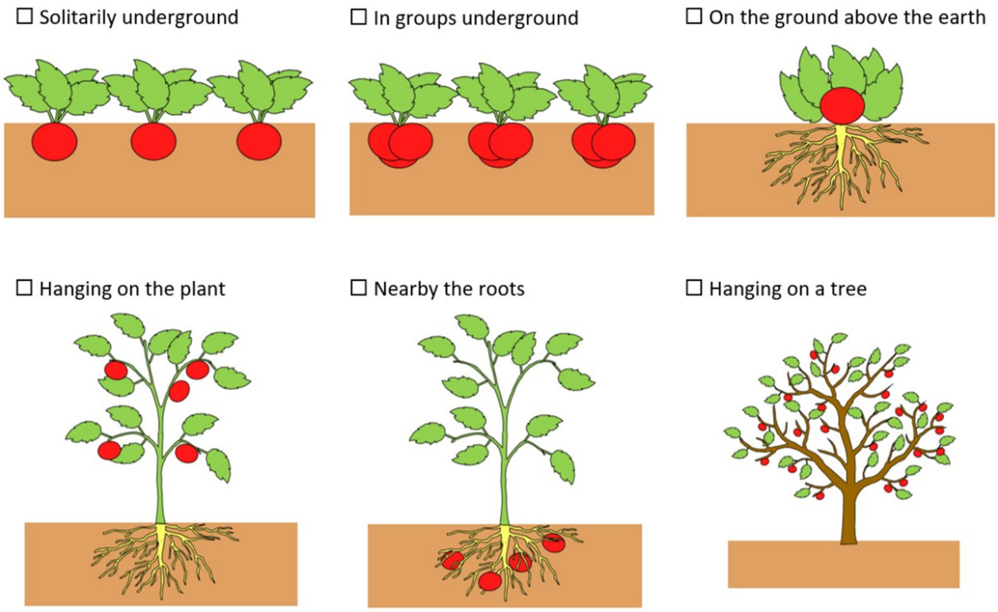

Figure 1. Schematic drawing of possible plant growth using a tomato plant as an example.

For the "hanging on the plant" option, a distinction was made between two schematic drawings depending on the plant: for pumpkin and cucumber, the illustrations were adapted (Figure 2) so that the harvested products touched the ground; thus, the actual growth schemes of these plants could be recognized.

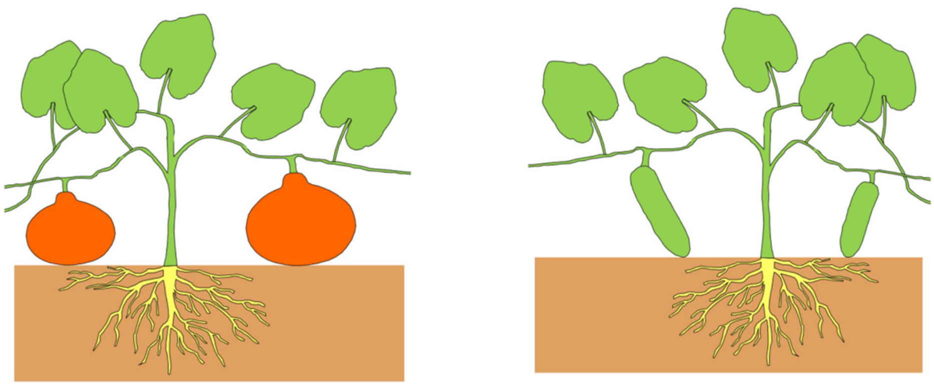

Figure 2. Schematic drawing for pumpkin and cucumber for the answer option "hanging on plant".

2.4. Control Variables and Piloting

The kind of school and the number of inhabitants in the local municipality were provided by the teachers. Further control variables (gender, age, grade level) were determined via the students' answers to the questionnaire. Filter questions were used to gather previous horticultural experiences: students were first asked about the existence of a family garden and whether they are cultivating fruit and/or vegetables. If both questions were answered positively, the student's involvement in this had to be stated. Students should also report if they had already been working in a school garden and, if so, for how many years.

The questionnaire was piloted with students from the third (n = 23), fourth (n = 23), and eighth grades (n = 23). The pupils of the third grade were unable to complete the questionnaire due to difficulties in understanding and a lack of vocabulary. Therefore, third grades were excluded from the study. No problems occurred in the fourth and eighth grades: the wording of the questions as well as the method for responding (Likert scale) proved to be suitable for these age groups. The answer categories showed in the pretest satisfying reliability: character and skill (15 items) 4th-grade Cronbach's alpha 0.892 and 8th grade 0.889; responsibility for nature (15 items) 4th-grade 0.826 and 8th grade 0.881.

It took the students 10–15 min to complete the questionnaire.

2.5. Participants

A total of 2107 students from 29 schools and 92 classes participated in the study (50.3% girls). Students were between 9 and 17 years old (mean = 12.3 years; SD = 1.94; Figure 3), nearly half of them were 5th and 6th-grade students of middle and grammar school between 10 and 12 years old.

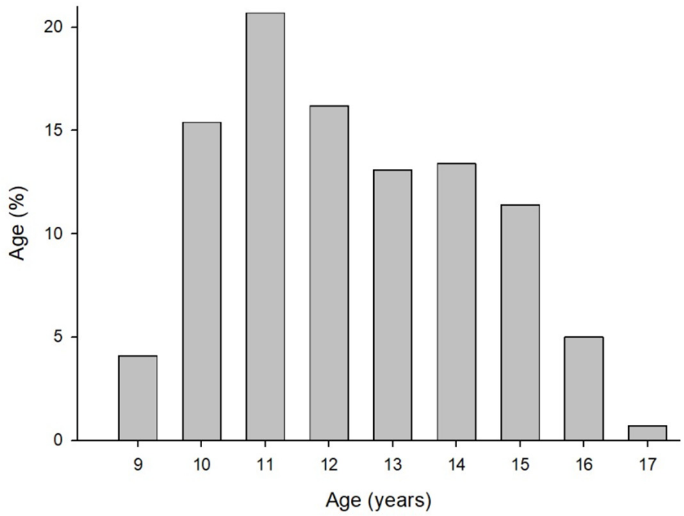

Figure 3. Age of participating students (n = 2074).

The primary school in Germany is generally attended for 4 years (6 to 10 years), the middle school for 6 years (10 to 16 years), and the grammar school for 8 years (10 to 18 years). Of the participants, 8% were primary school children from the 4th grade (age 9 to 10 years), 52% from middle school (age 10 to 17 years), and 39% were grammar school students (age 10 to 17 years). Most of the students attended schools in local communities with 20,000 to 50,000 residents.

Approximately 76% of students stated that they had a garden at home. Fruit or vegetables were often grown in these gardens (83% of responses). Most students reported sometimes helping with cultivation (mean = 3.2 on the 5-point scale from 1: very rarely to 5: very often). Most of the students had no experience in school gardening so far (74%), around 16% had school garden experience from one school year, and 10% from more than one year.

2.6. Data Analysis

For the analyses, linear mixed models were used. As this type of analysis does not allow strong correlations between the explanatory variables, Pearson correlations between binomial and metric explanatory variables were tested first. The rurality of the school location (decreasing population numbers) was positively correlated with the growing of fruits or vegetables at home (Pearson's $r = 0.06$, $p = 0.018$). School garden experience correlated negatively with students' age (Pearson's $r = -0.12$, $p < 0.001$). To avoid collinearity between explanatory variables, prior experience in growing fruit or vegetables and students' age were included in the models.

Linear mixed models were used to analyze whether participants' assessments of the importance of taking responsibility for specific school garden elements and the number of wrong answers in the plant growing test were related to the explanatory variables. Students' gender (1: girls, 2: boys), age (years), and prior experience in growing fruit or vegetables (1: yes, 2: no) were included as fixed factors, while schools and classes within schools were included as random factors.

Linear mixed models of school and class as random factors were also used to test whether the attributes and skills of a successful school gardener were related to the explanatory variables. Before the analyses, the number of items on attributes and skills (15 items) was reduced using factor analysis (eigenvalues > 1). To maximize the variance within the factors, we choose an orthogonal type of factor rotation (varimax) [30] and extracted three factors (see Section 3.3).

The data were analyzed using IBM SPSS Statistics 27.

3. Results

3.1. Knowledge about the Growth of Food Plants (Research Question 1)

The students selected one of 6 growth options for 10 common food plants presented in schematic drawings. Students most often correctly identified the place of growth of apples, tomatoes, and sweet peppers. The least known was the place of growth of kohlrabies, pumpkins, radish, and potatoes (Table 1). Each wrong answer was awarded one point. Of the students who answered all 10 questions (n = 1756), 2.3% made no mistakes at all, 64.3% made 1 to 4, and 33.4% made between 5 and 9 mistakes (mean = 3.8).

Table 1. Students' opinion on the place of growth of 10 selected cultivated plants. Six possible answers were presented per crop. The correct answer is marked in italics, the most frequent answer in each case in bold. In brackets: a number of answering students.

Plants	Answers (%)					
	Solitarily Underground	**In Groups Underground**	**On the Ground above Earth**	**Hanging on Plant**	**Nearby the Roots**	**Hanging on Tree**
Apple (n = 1981)	0.2	0.1	0.1	1.7	0.1	***97.9***
Radish (n = 1967)	*41.6*	**42.3**	6.4	2.5	6.4	0.9
Tomato (n = 1976)	3.6	1.8	2.4	***90.8***	0.7	0.7
Pumpkin (n = 1972)	24.4	2.0	**37.8**	*33.5*	1.8	0.5
Sweet pepper (n = 1914)	8.6	4.5	5.5	***79.6***	1.1	0.6
Potato (n = 1933)	27.1	17.3	2.6	1.0	***51.7***	0.2
Kohlrabi (n = 1910)	**47.7**	13.7	*29.6*	2.4	6.0	0.6
Carrot (n = 1934)	***59.6***	38.9	0.5	0.2	0.9	0.0
Cauliflower (n = 1911)	22.7	5.6	***66.9***	2.8	1.5	0.5
Cucumber (n = 1906)	9.7	6.9	14.5	***65.2***	3.4	0.4

3.2. School Garden Elements (Research Question 2)

In designing a school garden, it was important for the students to have fruit trees, nesting aids for birds, and a vegetable patch, whereas raised beds, fragrant beds, or barefoot paths were only of medium importance (Table 2). Vegetable patches, as well as fruit trees, also seemed particularly suitable for students to take responsibility for nature (Table 2). Around 31% of the students did not know an herb spiral, 22% of students did not know the term "raised bed" and 8% were unfamiliar with a compost heap. The compost was considered moderately suitable for assuming responsibility.

Table 2. Students' opinion on (**a**) the importance of different elements when designing a school garden (5-point scale from 1: very unimportant to 5: very important) and (**b**) the suitability of these elements for assuming responsibility for nature (5-point scale from 1: poorly suited to 5: well suited). Values in brackets: Percentage of students who stated that they did not know the specific element.

Elements (% Unknown)	Mean Scale Value ± 1 SE	
	(a) Importance	(b) Suitability
Fruit trees (1.9)	3.9 ± 0.02	3.7 ± 0.03
Nesting aids for birds (3.0)	3.9 ± 0.03	3.6 ± 0.03
Vegetable patch (2.2)	3.6 ± 0.02	3.8 ± 0.03
Flower patch (2.5)	3.5 ± 0.02	3.7 ± 0.03
Greenhouse (2.9)	3.5 ± 0.03	3.5 ± 0.03
Pond (1.4)	3.5 ± 0.03	3.3 ± 0.03
Herb garden (2.0)	3.4 ± 0.02	3.5 ± 0.03
Flowering meadow (0.9)	3.4 ± 0.03	3.4 ± 0.03
Nesting aids for insects (5.6)	3.2 ± 0.03	3.0 ± 0.03
Rain barrel (5.4)	3.2 ± 0.03	2.8 ± 0.03
Compost (8.3)	3.2 ± 0.03	2.7 ± 0.03
Raised bed (22.2)	3.0 ± 0.03	3.2 ± 0.03
Fragrant bed (13.2)	2.9 ± 0.03	2.9 ± 0.03
Herb spiral (31%)	2.7± 1.15	2.8± 1.17
Barefoot path (9.3)	2.6 ± 0.03	2.7 ± 0.03

3.3. Required Character Traits, Skills, and Competencies for School Gardening (Research Question 3)

Students assessed what character traits, skills, and competencies they regard as necessary for successful school gardening. On average, connectedness to nature, patience, reliability and the ability to work in a team had the greatest importance to students (Figure 4). Sportiness was perceived as unimportant.

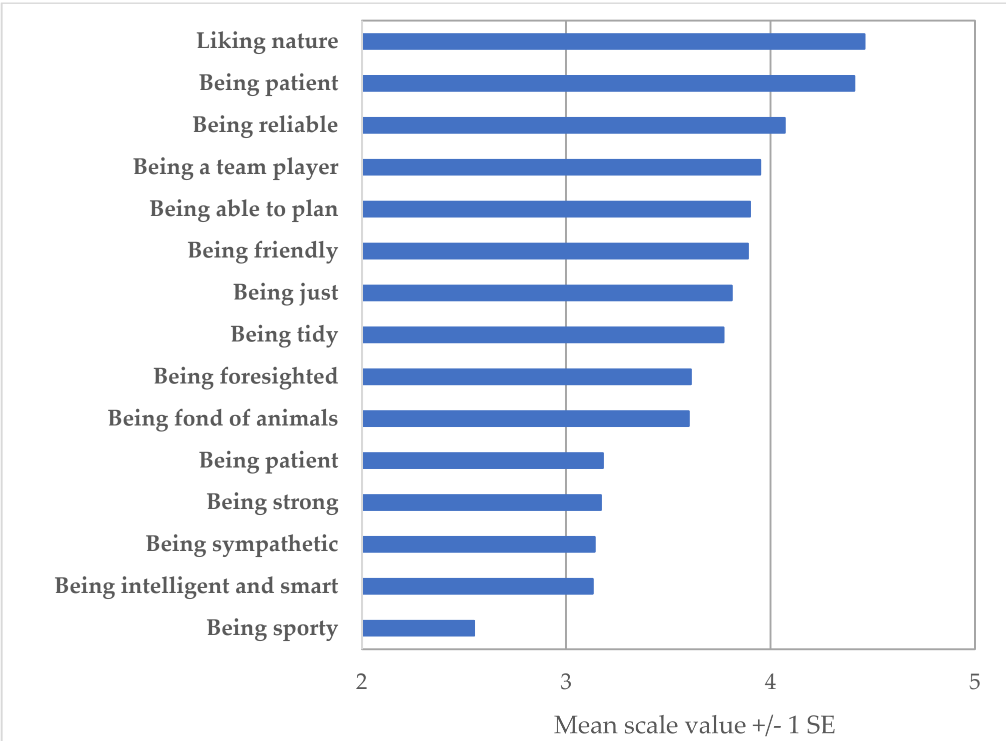

Figure 4. Required character traits, skills, and competencies are regarded as necessary for successful school gardening by the students on a 5-point Likert scale ranging from 1: very unimportant to 5: very important. The number of answering students ranged from n = 1991 to 2020.

By factor analysis, the items were reduced to three factors. The first factor can be titled "personal action competencies", the second "social competencies" and the third "physical and cognitive attributes" (Table 3).

Table 3. Assessment of the character traits, skills, and competencies of a school gardener. The number of items was reduced to three factors using a factor analysis. Factor 1 can be titled as "personal action competencies", Factor 2 as "social competencies" and Factor 3 as "physical and cognitive attributes".

Item	Factor 1	Factor 2	Factor 3
Liking nature	0.688		
Being patient	0.685		
Being able to plan	0.669		
Being reliable	0.648		
Being able to act with foresight	0.595		0.326
Being tidy	0.477		
Being just		0.773	
Being friendly		0.763	
Being sympathetic		0.647	
Being a team player		0.047	
Being fond of animals	0.357	0.403	
Being sporty			0.784
Being strong and powerful			0.707
Having persistence			0.702
Being intelligent and smart			0.612

Averaging the mean scale values of the items included in the individual factors (see Figure 4) that Factor 1 (personal action competencies) was rated as the most important with an overall mean of 4.0, Factor 2 (social competencies) was rated second place with a mean value of 3.7, and Factor 3 (physical and cognitive attributes) was rated least important with a mean value of 3.0.

There was a positive correlation between the sum score on taking responsibility (see Table 2) and Factor 1 "personal action competencies" (Pearson's $r = 0.20$, $p < 0.001$) and Factor 2 "social competencies" (Pearson's $r = 0.11$, $p < 0.001$).

3.4. Correlations with the Explanatory Variables

In the knowledge test on plant growth, girls made fewer mistakes on average (mean = 3.7) than boys (mean = 3.9). In a linear mixed model, there were correlations between mistake frequency and students' age and gardening experience. The older students were, the fewer mistakes they made ($F_{1,122.79} = 24.82$, $p < 0.001$). Those who stated they were growing fruit or vegetables at home also chose wrong answers less frequently than those who did not ($F_{1,1310.77} = 15.69$, $p < 0.001$).

To test for a relationship between students' assessments of the importance as well as the suitability of the 15 school garden elements (see Table 2) and the explanatory variables, 2 sums of scores were calculated first by adding up the assessments for all 15 items in each case. The two cumulative scores were positively correlated (Pearson's r = 0.66, $p < 0.001$). In a linear mixed model, age, as well as gender, and garden experience in growing fruit and vegetables, were correlated with the overall importance assigned to school garden elements. The older students were, the lower their cumulative score was, i.e., the importance they assigned to the 15 elements ($F_{1,116.70} = 6.98$, $p = 0.009$). Girls showed higher agreement than boys ($F_{1,1529.37} = 23.12$, $p < 0.001$). This was also found for students with experience in growing fruits and vegetables ($F_{1,1530.15} = 5.56$, $p = 0.019$).

Significant correlations with age, gender, and previous gardening experiences of the students were also found with regard to the suitability of garden elements for assuming responsibility for nature. The older students were, the less suitable the elements seemed to them for taking responsibility ($F_{1,96.91} = 8.08$, $p = 0.005$). Girls showed higher agreement than boys ($F_{1,1541.12} = 29.43$, $p < 0.001$), which also applied to students with horticultural experiences ($F_{1,1548.04} = 15.01$, $p < 0.001$).

In a linear mixed model, the three factors from factor analysis were correlated with students´ age. The older students were, the higher their scale scored on Factors 1 and 3 (Table 4). The younger they were, the more important the items included in Factor 2 (social competencies) were to them. Girls had higher scale scores on Factor 1 (personal action competencies), whereas boys had higher scores on Factor 3 (physical and cognitive attributes).

Table 4. Linear mixed model with the class as a random factor to test correlations between the three factors identified in a factor analysis and the explaining variables (gender, vegetable growing at home, age, sum score across items in Table 2). Factor 1: personal action competencies, Factor 2: social competencies, Factor 3: physical and cognitive attributes. Bold: *p*-values < 0.05.

Variable	Factor 1			Factor 2			Factor 3		
	df	F	*p*	df	F	*p*	df	F	*p*
Gender	1,1362.58	6.37	**0.012**	1,1371.77	0.78	0.377	1,1353.81	19.58	**<0.001**
Vegetable	1,1371.31	2.08	0.150	1,1378.26	0.03	0.865	1,1375.56	0.46	0.498
Age	1,903.79	20.63	**<0.001**	1,117.07	110.89	**<0.001**	1,108.01	35.97	**<0.001**

4. Discussion

In the knowledge test, most of the students knew how and where apples grow. Even young children are familiar with apple trees and thus can identify its fruit as such [3]. While almost all students knew that potatoes grow underground, only half of them knew the correct place on the plant stem (stolon) nearby but not on the roots. This is remarkable because potatoes are one of the best-known food plants and are very often a topic in primary and secondary school lessons and discussed in many textbooks as typical representatives of a food plant; however, in a study by the British Nutrition Foundation (BNF), 19% of the children did not even know that potatoes grow underground [5].

Almost all the students knew how and where apples and tomatoes grow (see also [3]). Both plants are common nutritional plants [17], and tomatoes are often cultivated at home [2]. Approximately 40% of the students thought that carrots grow underground in a bunch. This idea of growth also applied to radish. It can be assumed that the sale of carrots and radish in a bunch caused this conception. The results show that there can be discrepancies between identifying plants and knowledge about their growth. This was also evident with kohlrabi: although 50% of primary school children in a previous study could correctly identify kohlrabi [2], only a third of the students in our study knew how it grows. Getting older, students scored better on the knowledge test. This suggests that the result is not based on nutritional habits—fewer fruits and vegetables are consumed with increasing age [31,32]—but on students' experiences. School gardens have great potential to close knowledge gaps through hands-on experience with plants from sowing to harvesting and the associated monitoring of the growth process, as studies have shown [2,4]. Primary school students with school gardening experience knew more plants than children without such experience [2,17]; they can also better identify tomatoes, carrots, and sweet peppers [33]. Experiences with vegetable growth could increase the willingness to eat it and so contribute to healthy nutrition and well-being [2,4]. The personal and meaningful experience with plant life cycles could be a chance to overcome plant blindness by training the perception and appreciation of plants and the understanding of the requirements referring to growing space, water, and soil demands, use of fertilizer, etc.

In the present study, none of the given garden elements played an outstanding role for students when planning a fictional school garden; this could be related to the fact that many students in Germany are satisfied with their own school grounds, and they may believe that there is already enough green in their own schoolyard [34,35], or they have no idea about the potential of a school garden because they do not have any experience with it.

The study could show that fruit trees and vegetable patches were particularly important for students when creating a new school garden; we guess that these are the garden elements they are accustomed to in their home garden and are part of their lived-in world. Working in a school garden with more different elements might therefore widen the range of answers.

In contrast to the vegetable patch, a raised bed was rated as less important, although both are used to grow food plants. It is possible that the students in the present study did not have a clear idea of what a raised bed is; about a quarter of the respondents did not know the term, so they may not have come in contact so far. In a photo survey, students scored raised beds on the school ground as being beautiful, interesting, and tidy and rated them higher than the vegetable beds presented [21].

Students who had previous experience in growing fruit or vegetables rated the presented elements as more important than those without this experience. The potential of these elements for taking responsibility for nature was scored higher when students had experience in gardening; they also knew more about plant growth in the knowledge test. Students who already experienced cultivating plants in their parents' garden may be more interested in creating a fictional school garden and also have more knowledge about food plants [23].

The vegetable patch was seen as having the greatest potential for teaching responsible contact with nature. This is understandable, since cultivating food plants requires constant care from sowing to harvesting and it is something they already know from their home garden. At the same time, interest in food plants, and thus presumably interest in planting them on a vegetable patch or herb garden, declines with age [16,18,19]. Previous studies showed that students were less interested in farming and fruit and vegetable growing [36]. Nevertheless, girls showed greater interest in the two issues than boys; this gender difference was also found in the interest in lessons on food plants in the classroom [16]. Girls rated the design elements of a school garden as more important and more suitable for taking responsibility for nature than boys did. This can be due to a higher interest of females in plants [10,20,37]. In addition, girls have a stronger preference for (wild) plants and garden elements in schoolyards [21,38,39]. Girls also spend more time in green areas of the school grounds [40] and are more likely to want a school garden to enhance the school grounds [35]. The girls' greater interest in plants was also expressed in the fact that they rated flower meadows and flower patches as more important than boys did (as in [17]). They also tended to give more correct answers than the boys in identifying places of plant growth. There are a lot of findings that girls know more about plants and show greater interest, the explanations range from innate interest to cultural influence.

With increasing age, the importance given to school garden elements as a promoter for nature care decreased. Similarly, in Jansson et al. [41], younger children used the school grounds more often than older ones after the school grounds had been enriched with vegetation. With increasing age, the suitability attributed to the garden elements for taking responsibility for nature also declined. This may reflect younger people's greater sense of responsibility for environmental protection [42]. Taking care of a school garden could play an important role in developing responsibility for older students. With increasing age being not so interested in growing food plants, they might like to follow their own research questions in projects, e.g., about the coevolution of flowers and insects, making climate measurements, or experiments on the decomposition of materials; they could also be involved in the care of biotopes or nesting aids and so take responsibility for nature.

Comparing the students' preferred elements for school gardens with the existing elements shows that these preferences are partially taken into account in school gardens and schoolyards already [6,8]. In addition to vegetable patches, students consider flower and herb patches as suitable for a school garden. This coincides with the findings of Almers et al. [22]: being asked about plants in their own schoolyard, children most frequently mentioned aesthetic qualities, as well as possible consumption, as an important aspect. These traditional garden elements are available in about 80% of all school gardens [6,8]. Fruit trees and nesting aids for birds are also judged to be important. They also exist in 65% of the school gardens in Baden-Württemberg. More than 60% of the schools have compost [6,8]; however, the students in our study rated it of medium importance. Its suitability for assuming responsibility for nature was considered even lower. Thus, the compost's importance for ecological gardening was not recognized. A compost heap is very appropriate to explain and understand food webs and cycles of materials as basic ecosystem knowledge. Learning about ecological gardening, the structure and consistency of soil, and the demands of crops in a school garden can promote discussions about the cultivation of food plants worldwide, especially focusing on the use of water and fertilizer; indeed, it would also have been interesting to investigate if students had a compost in their home garden.

Social skills (see Factor 2 of the factor analysis), especially the ability to work in a team, were rated as important by students to be able to work successfully in a school garden. While younger students rated social competencies (Factor 2) higher, older students rated personal action competencies (Factor 1) higher. Accordingly, older students are more likely to see their own individual performance as a factor in successful school gardening. In contrast, younger students tend to focus more on joint action; perhaps the younger ones do not yet have the confidence in their own abilities.

Many studies confirm the benefits of school gardening on social skills [13,14,43], while teachers also associate work in the school garden with social learning [5,6,8,44]. The higher the items belonging to Factor 1 and Factor 2 were rated, the higher the potential for taking responsibility attributed to the individual elements in the school garden; this is plausible because taking responsibility goes hand in hand with a willingness to act socially, as well as with personal skills. Physical skills such as persistence, strength, and sportiness were rated as less important, and there are also hardly any references to this in the literature. While health-promoting effects of (school) gardening are known [45–47] and children with school garden experience move more in their everyday life in school [48], students are likely to associate sports, physical strength, and power with different activities than working in a school garden. Because students probably associate gardening more with practical action, they scored intelligence as only a moderately important attribute.

Boys rated the items included on Factor 3 (physical and cognitive attributes) for successful school gardening higher than girls did. One possible reason could be that physical activity is more important to boys and they actually move more in everyday life [49]. Three of the four items included in the third factor relate to physical attributes, and only one relates to cognitive skills; however, agreement with Factor 3 also increased with student age. Physical activity, on the other hand, decreases with age in adolescents [49]. In this respect, it is disputable whether this can be justified by individual movement behavior.

5. Limitations of the Study

As a lot of students in our study had gained their garden experience from their family garden and not a school garden, we do not know what their own gardens looked like and what kind of plants they could watch growing. A following study could ask them to specify their experience. It would be interesting to look for schools with school gardens to see if there is a difference in the answers.

We could only refer to the students' self-assessment about helping at home in the garden. It would be interesting to ask the parents at the same time, to validate the answers.

We chose the presented food plants and limited the number to 10 to make sure that the time required for the questionnaire stayed feasible during a school lesson. A following study could choose different vegetables, e.g., onions. The option "I do not know" might have helped some students to decide more quickly instead of leaving the question unanswered.

We selected the items for the school garden elements and the skills and competencies from previous studies. Maybe the students would have liked to write their own ideas for these questions.

Our schools were all from the same region in the south of Germany, the participants were mainly fifth and sixth graders from middle and grammar schools. The knowledge about and consumption of fruit and vegetables does not differ significantly between students of this age. Future studies could address a wider range of students.

6. Conclusions

For the students, fruit trees, nesting aids for birds, and vegetable patches were important elements in a school garden. Comparing the preferred elements for creating a new school garden with the already existing ones showed a congruency: the wishes of the students are taken into account in existing school gardens. Nevertheless, the study identified options for action which should be focused on in the future. For instance, the flower patches preferred by students could be created not only in school gardens but also in schoolyards. As design elements become less important according to age, differences in school garden design can be derived: School gardens for younger children could be designed with different elements than those for older ones. School gardens can provide hands-on experience for all children, especially in regions where students do not have a garden at home.

The growing of some plants is already commonly known, e.g., apple, tomato, or sweet pepper. For other plants, e.g., kohlrabi, pumpkin, or radish, gaps in knowledge were found. Many students believed that carrots and radish grow in groups underground. It is possible that this idea is caused by the sale of carrots and radish in bunches, however, the present study cannot prove this assumption. Future studies could focus on the reasons for these ideas. The knowledge about plant growth seems to be based on experiences that children acquire over the years. Because eating habits depend on the socio-economic background and family habits [31,32], it would be interesting to test a correlation between these variables and the students' knowledge.

School lessons play an important role in learning about plants. Apart from parents [50], students named school teaching as the main source of information [16]. In schools, on the other hand, textbooks are the most frequently listed medium. The focus of botanical information in textbooks is most frequently on the structure of a plant, a form of propagation (with or without seeds), and plant family characteristics. Information on the growth of food plants is given less frequently [51]. Here, a broader focus could be used to improve students' knowledge. School gardens offering meaningful hands-on experiences were the least reported source of information [16]; however, school gardens have the potential to close these knowledge gaps through hands-on working with plants from seed to seed and watching the growth process closely. This is also evident from the fact that students with previous gardening experience scored better in the knowledge test on plant growth. School gardens are therefore suitable learning environments for quality education for every child as required in the ESD. The experience with ecological gardening can be the basis of discussions about the implications of climate change on food growing, the loss of biodiversity, or ecological and social problems accompanied by the current non-sustainable use of natural resources. Students can learn for the planet and act sustainably, as postulated in the Agenda 2030.

Author Contributions: Conceptualization and methodology, F.H., D.B. and P.L.-M.; validation, F.H., D.B. and P.L.-M.; formal analysis, F.H., P.L.-M.; investigation, F.H.; writing—original draft preparation, F.H.; writing—review and editing, D.B.; visualization, F.H. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki, and approved by the Ethics Committee of Karlsruhe University of Education, Germany (15 March 2022).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Not applicable.

Acknowledgments: The authors want to thank all the teachers and students who took part in this study for their time.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Wandersee, J.H.; Schussler, E.E. Towards a Theory of Plant Blindness. *Plant Sci. Bull.* **2001**, *47*, 2–8.
2. Benkowitz, D.; Schulz, S.; Lindemann-Matthies, P. The impact of gardening experiences on children's intake of vegetables. *J. Health Environ. Educ.* **2018**, *11*, 1–5. [CrossRef]
3. Edwards, J.S.A.; Hartwell, H.H. Fruit and vegetables—Attitudes and knowledge of primary school children. *J. Hum. Nutr. Diet.* **2002**, *15*, 365–374. [CrossRef] [PubMed]
4. Somerset, S.; Markwell, K. Impact of a school-based food garden on attitudes and identification skills regarding vegetables and fruits: A 12-month intervention trial. *Public Health Nutr.* **2009**, *12*, 214–221. [CrossRef] [PubMed]
5. Burns, J. "Cheese is from Plants"—Study Reveals Child Confusion. BBC News. 2013. Available online: https://www.bbc.com/news/education-22730613 (accessed on 14 February 2022).
6. Benkowitz, D.; Köhler, K. Lernen im Schulgarten—Werden Vorhandene Potentiale genutzt? Pädagogische Hochschule Karlsruhe. 2019. Available online: http://nbn-resolving.de/urn:nbn:de:bsz:751-opus4-1855 (accessed on 16 April 2022).
7. Schilke, K.; Probst, W.; Eigenbrod, U.; Petersen, A.; Otto, B.; Strube, J. Schulgelände wohin? Situation, Defizite und Vorschläge. *Nat. und Landsch.* **2004**, *79*, 82–89.
8. Köhler, K.; Benkowitz, D. Supporting awareness of urban biodiversity: School garden, schoolyard and school surrounding. In *Human-Environmental Interactions in Cities. Challenges and Opportunities of Urban Land Use Planning and Green Infrastructure*; Kabisch, N., Larondelle, N., Reeve, A., Artmann, M., Eds.; Cambridge Scholars Publishing: Cambridge, UK, 2014; pp. 100–114.
9. Nikel, J. Making sense of education ‚responsibly': Findings from a study of student teachers' understanding(s) of education, sustainable development and education for sustainable development. *Environ. Educ. Res.* **2007**, *13*, 545–564. [CrossRef]
10. Fisher-Maltese, C. „We won't hurt you butterfly!" Second-graders become environmental stewards from experiences in a school garden. *Int. J. Early Child. Environ. Educ.* **2016**, *4*, 54–69.
11. Passy, R.; Morris, M.; Reed, F. Impact of school gardening on learning. In *Final Report Submitted to the Royal Horticultural Society*; National Foundation for Educational Research: Slough, UK, 2010.
12. Graham, H.; Beall, D.L.; Lussier, M.; McLaughlin, P.; Zidenberg-Cherr, S. Use of school gardens in academic instruction. *J. Nutr. Educ. Behav.* **2005**, *37*, 147–151. [CrossRef]
13. Block, K.; Gibbs, L.; Staiger, P.K.; Gold, L.; Johnson, B.; Macfarlane, S.; Long, C.; Townsend, M. Growing community: The impact of the Stephanie Alexander Kitchen Garden Program on the social and learning environment in primary schools. *Health Educ. Behav.* **2012**, *39*, 419–432. [CrossRef]
14. Williams, D.R.; Dixon, P.S. Impact of garden-based learning on academic outcomes in schools: Synthesis of research between 1990 and 2010. *Rev. Educ. Res.* **2013**, *83*, 211–235. [CrossRef]
15. Dirks, A.E.; Orvis, K. An evaluation of the junior master gardener program in third grade classrooms. *HortTechnology* **2005**, *15*, 443–447. [CrossRef]
16. Fritsch, E.-M.; Dreesmann, D.C. Secondary school students' and their parents' knowledge and interest in crop plants: Why should we care? *Int. J. Environ. Sci. Educ.* **2015**, *10*, 891–904.
17. Benkowitz, D. *Wirkung von Schulgartenerfahrung auf die Wahrnehmung pflanzlicher Biodiversität durch Grundschulkinder*; Schneider Verlag Hohengehren: Baltmannsweiler, Germany, 2014.
18. Pany, P. Students' interest in useful plants: A potential key to counteract plant blindness. *Plant Sci. Bull.* **2014**, *60*, 18–27.
19. Pany, P.; Heidinger, C. Nutzpflanzen als „Türöffner" für die Vermittlung botanischer Inhalte. *Erkenn. Biol.* **2014**, 25–40.
20. Strgar, J. Increasing the interest of students in plants. *J. Biol. Educ.* **2007**, *42*, 19–23. [CrossRef]
21. Lindemann-Matthies, P.; Köhler, K. Naturalized versus traditional school grounds: Which elements do students prefer and why? *Urban For. Urban Green.* **2019**, *46*, 126475. [CrossRef]
22. Almers, E.; Askerlund, P.; Samuelsson, T.; Waite, S. Children's preferences for schoolyard features and understanding of ecosystem service innovations—A study in five Swedish preschools. *J. Adventure Educ. Outdoor Learn.* **2021**, *21*, 230–246. [CrossRef]
23. Fritsch, E.-M.; Lechner-Walz, C.; Dreesmann, D.C. Hands-on crops! How long-term activities improve students' knowledge of crop species. A pretest-posttest study of the greenhouse project. *Int. J. Environ. Sci. Educ.* **2015**, *10*, 737–755. [CrossRef]
24. Fančovičová, J.; Prokop, P. Plants have a chance: Outdoor educational programmes alter students' knowledge and attitudes towards plants. *Environ. Educ. Res.* **2010**, *17*, 537–551. [CrossRef]
25. Lückmann, K.; Menzel, S. Herbs versus trees: Influence on teenagers' knowledge of plant species. *J. Biol. Educ.* **2014**, *48*, 80–90. [CrossRef]
26. Remmele, M.; Lindemann-Matthies, P. Like father, like son? On the relationship between parents' and children's familiarity with species and sources of knowledge about plants and animals. *Eurasia J. Math. Sci. Technol. Educ.* **2018**, *14*. [CrossRef]
27. Diekmann, A. *Empirische Sozialforschung: Grundlagen, Methoden, Anwendungen*, 7th ed.; Rowohlt: Hamburg, Germany, 2013.

28. Van Laerhoven, H.; van der Zaag-Loonen, H.J.; Derkx, B.H.F. A comparison of Likert scale and visual analogue scales as response options in children's questionnaires. *Acta Paediatr.* **2004**, *93*, 830–835. [CrossRef] [PubMed]
29. Bortz, J.; Döring, N. *Forschungsmethoden und Evaluation für Human- und Sozialwissenschaftler*, 4th ed.; Springer: Berlin/Heidelberg, Germany, 2006. Available online: https://link.springer.com/content/pdf/10.1007/978-3-540-33306-7.pdf (accessed on 16 April 2022).
30. Costello, A.B.; Osborn, J. Best practices in exploratory factor analysis: Four recommendations for getting the most from your analysis. *Pract. Assess. Res. Eval.* **2005**, *10*, 7. [CrossRef]
31. Borrmann, A.; Mensink, G.; KiGGs Study Group. Obst- und Gemüsekonsum von Kindern und Jugendlichen in Deutschland. Ergebnisse der KiGGS-Welle 1. *Bundesgesundheitsblatt Gesundh. Gesundh.* **2015**, *58*, 1005–1014. [CrossRef]
32. Vereecken, C.A.; Inchley, J.; Subramanian, S.V.; Hublet, A.; Maes, L. The relative influence of individual and contextual socio-economic status on consumption of fruit and soft drinks among adolescents in Europe. *Eur. J. Public Health* **2005**, *15*, 224–232. [CrossRef]
33. Morgan, P.J.; Warren, J.M.; Lubans, D.R.; Saunders, K.L.; Quick, G.I.; Collins, C.E. The impact of nutrition education with and without a school garden on knowledge, vegetable intake and preferences and quality of school life among primary-school students. *Public Health Nutr.* **2010**, *13*, 1931–1940. [CrossRef]
34. FORSA. *Repräsentative Befragung von Schülern zum Thema "Schulhof"*; FORSA: Berlin, Germany, 2014. Available online: https://www.deinschulhof.de/fileadmin/user_upload/Download/Forsa_deinSchulhof_Ergebnisse.pdf (accessed on 16 April 2022).
35. Stadler-Altmann, U.; Hilger, P. Transferring pedagogical spaces: Schoolyards as learning environments in the perspective of students and teachers. In *Transforming Education: Design, Technology, Government*; Benade, L., Jackson, M., Eds.; Spinger VS: Wiesbaden, Germany, 2018; pp. 227–244.
36. Bickel, M.; Bögeholz, S. Schülerinteressen an landwirtschaftlichen Themen. In *Biodiversität und Gesellschaft. Gesellschaftliche Dimensionen von Schutz und Nutzung biologischer Vielfalt*; Friedrich, J., Halsband, A., Minkmar, L., Eds.; Universität Göttingen: Göttingen, Germany, 2013; pp. 59–72. Available online: https://www.univerlag.uni-goettingen.de/bitstream/handle/3/isbn-978-3-86395-090-3/biodiversitaet_und_gesellschaft.pdf?sequence=1 (accessed on 16 April 2022).
37. Van den Berg, A.E.; van Winsum-Westra, M. Manicured, romantic, or wild? The relation between need for structure and preferences for garden styles. *Urban For. Urban Green.* **2010**, *9*, 179–186. [CrossRef]
38. Al-Bishawi, M.; Salaha, S.; Awad, S. Schoolyards' design and students' needs from gender perspective: The case of palestine. *Int. J. Archit. Res.* **2018**, *12*, 281–306. [CrossRef]
39. Samborski, S. Biodiverse or barren school grounds: Their effects on children. *Child. Youth Environ.* **2010**, *20*, 67–115.
40. Raith, A. Children on green schoolyards: Nature experience, preferences, and behavior. *Child. Youth Environ.* **2017**, *27*, 91–111. [CrossRef]
41. Jansson, M.; Gunnarsson, A.; Martensson, F.; Andersson, S. Children's perspectives on vegetation establishment: Implications for school ground greening. *Urban For. Urban Green.* **2014**, *13*, 166–174. [CrossRef]
42. Sarigöllü, E. A cross-country exploration of environmental attitudes. *Environ. Behav.* **2009**, *41*, 365–386. [CrossRef]
43. Robinson, C.W.; Zajicek, J.M. Growing Minds: The effects of a one-year school garden program on six constructs of life skills of elementary school children. *HortTechnology* **2005**, *15*, 453–457. [CrossRef]
44. DeMarco, L.A.W.; Relf, D.; McDaniel, A. Integrating gardening into the elementary school curriculum. *HortTechnology* **1999**, *9*, 276–281. [CrossRef]
45. Davis, J.N.; Ventura, E.E.; Cook, L.T.; Gyllenhammer, L.E.; Gatto, N.M. LA Sprouts: A gardening, nutrition, and cooking intervention for Latino Youth improves diet and reduces obesity. *J. Am. Diet. Assoc.* **2011**, *111*, 1224–1230. [CrossRef] [PubMed]
46. Retzlaff-Fürst, C. Biology education & health education: A school garden as a location of learning & well-being. *Univers. J. Educ. Res.* **2016**, *4*, 1848–1857. [CrossRef]
47. Soga, M.; Gaston, K.J.; Yamaura, Y. Gardening is beneficial for health: A meta-analysis. *Prev. Med. Rep.* **2017**, *5*, 92–99. [CrossRef]
48. Wells, N.M.; Myers, B.M.; Henderson, C.R., Jr. School gardens and physical activitiy: A randomized controlled trial of low-income elementary schools. *Prev. Med.* **2014**, *69*, 27–33. [CrossRef]
49. Nader, P.R.; Bradley, R.H.; Houts, R.M.; McRitchie, S.L.; O'Brien, M. Moderate-to-vigorous physical activity from ages 9 to15 years. *J. Am. Med. Assoc.* **2008**, *300*, 295–305. [CrossRef]
50. Gatt, S.; Tunnicliffe, S.D.; Borg, K.; Lautier, K. Young Maltese children's ideas about plants. *J. Biol. Educ.* **2007**, *41*, 117–121. [CrossRef]
51. Schussler, E.E.; Link-Pérez, M.A.; Weber, K.M.; Dollo, V.H. Exploring plant and animal content in elementary science textbooks. *J. Biol. Educ.* **2010**, *44*, 123–128. [CrossRef]