

Hands-on Crops! How Long-term Activities Improve Students' Knowledge of Crop Species. A Pretest-Posttest Study of the Greenhouse Project

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In terms of sustainability, renewable resources, nourishment and healthy diet, crops are important to the public. Thus, knowledge of crops is needed in order to enable people to participate in public discussions and take responsibility. This is in contrast to former surveys showing that students' knowledge of and interest in plants in general, crop plants and agricultural issues is moderate to little. At the same time, approaches to improving knowledge and interest in school are missing. We initiated and established the Greenhouse Project (GHP) where secondary school students (grades 5-13) get to know crops through cultivating from seed to seed. To investigate whether or not original contact with a variety of staple crops and hands-on activities positively affect students' knowledge, students of two German secondary schools were asked via questionnaires before and after the treatment. Our study was conducted in the cities of Mainz and Wiesbaden which are situated in the German Federal states of Rhineland-Palatinate and Hesse, respectively. In total, 74 students in 6/7th and 11/12th grades took part in this pretest-posttest survey; three additional 6/7th and 11/12th grade classes (i.e. 48 students) were used as control classes, and had no contact with the GHP during this time. We demonstrated that the treatment has positive effects on students' knowledge, and that girls performed better than did boys. Therefore, knowledge of crop plant species, as well as morphological knowledge, improved. A higher level of knowledge cannot only be observed objectively via test scores, but also subjectively via the students' self-assessment of knowledge. In contrast, the students' opinions about and attitudes towards agriculture and crops decreased in the posttest, both in the treatment and control classes.

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INTRODUCTION

Students' knowledge of species has been criticised for decades. Many surveys showed that students' knowledge is lacking, especially concerning plants and their recognition (Ammer & Gössinger, 2010; Bebbington, 2005, Fančovičová & Prokop, 2011; Gatt, Tunnicliffe, Borg & Lautier, 2007; Jäkel & Schaer, 2004; Tunnicliffe, 2001). Even university students recalled animal pictures better than they did those of plants (Schussler & Olzak, 2008). In addition, women were able to recall more plants than were men (Schussler & Olzak, 2008), which confirms the results of other surveys on students' knowledge of plants showing that girls have a higher level of knowledge (Gatt, Tunnicliffe, Borg & Lautier, 2007; Jäkel & Schaer, 2004). Knowledge of species and plants, respectively, increases with age (Gatt, Tunnicliffe, Borg & Lautier, 2007; Patrick & Tunnicliffe, 2011). According to Jäkel and Schaer (2004), 5th and 6th grade, respectively, students learn about one species each year.

In addition to students having little knowledge of plants, interest in plants is low compared to students' interest in animals (Löwe, 1987; Kinchin, 1999; Prokop, Tuncer & Chudá, 2007a; Strgar, 2007). Reasons for this difference include that the movement of plants is often invisible or slow in contrast to the locomotion of animals (Sula 1971; Tunnicliffe, 2001). There are usually much less options obvious for students to actively interact with plants except for watering and changing the substrate, in comparison to the opportunities to interact with animals. The lack of movement and reactions causes children to form the conclusion that plants are not living things (Sula, 1971). But still, the physiological procedures of plants are explained anthropomorphically (Barman, Stein, McNair & Barman, 2006; Tunnicliffe, 2001).

Where students get their information from has not been consistently proven. While Tunnicliffe and Reiss (2000) and Gatt, Tunnicliffe, Borg & Lautier (2007) state that school is not the main source of information concerning plants, but rather "home and direct observation", Jewell (2002) showed in a survey on primary school students (4-11 years old) that school and teachers are the predominant source of information concerning seeds to 7 to 11 year old students; 4 and 5 year old children, however, mentioned parents as source of information most often. In addition, we found in previous surveys that school is also the predominant source of information concerning crops and agriculture. The second largest source of information is parents. Irrespective of whether students get their information at home or in school, as less time is spent at home and in nature due to full-time school and new forms of media (Pergams & Zaradic, 2006; Rolff & Zimmermann, 1997; Zucchi, 2002), it is of great importance that botany is focused on in school so that students are given the chance to get to know plants. Lindemann-Matthies (2005) showed in a pre-posttest-study that the more plants students know, the more they appreciate them. Therefore, nature can be appreciated and protected, because according to Jäkel (2005), we can only appreciate what we know. Summarising those previous surveys, a lack of knowledge and interest in plants among students has been scientifically proven. And even if we are in daily contact with the fruits of crops and use them, students' interest in agriculture and crop plants is low (Bickel & Bögeholz, 2013; Holstermann & Bögeholz, 2007; Kinchin, 1999; Löwe, 1987).

Knowledge of and interest in crops have not been fully investigated. Because of this, we started surveys asking students in German secondary schools (age 10 years and older) about their knowledge of agricultural crops. As we were able to show, students' knowledge of crop plants is poor. While plants that are relevant to daily life are recognised, others, like rye or barley, were not recognised or were

recognised by only a few students (manuscript in print). At the same time, only short-term interactions and contacts with crops or agriculture are existent. For example, only one third of 479 participating students had worked on a farm. That leads to the conclusion that crop plants which are our staple food, are like wild flowers (Bebbington, 2005) or toxic plants (Fančovičová & Prokop, 2011) only marginally known. At the same time, an effective method for training and improving knowledge of species, especially plants, is less established in school contexts.

Approaches to improve students' knowledge and interest in plants

Comparing pre- and posttest results of a hands-on botany lesson, Cooper (2008) found that 4th and 5th grade students ($n = 11$) performed better and had more interest in nature after the treatment, which allowed students to interact with plants in meaningful and direct ways. Stagg and Donkin (2013) observed an equally positive effect of the three different methods ("dichotomous key, word association exercise based on a mnemonic approach and pictorial card game") on adults' knowledge. Hummel, Glück, Jürgens, Weisshaar, & Randler (2012) found that students favour working with living organisms, whether the organism is an animal or a plant. Comparing zoological and botanical treatments, the botanical treatment showed worse results in terms of interest, well-being and boredom. Nevertheless, having much contact with living organisms positively affects knowledge of species (e.g. Patrick & Tunnicliffe, 2011). In terms of teaching plants, Patrick and Tunnicliffe (2011) state that it is important to "include hands-on interactions such as planting, dissecting flowers, touching seeds, and comparing real plant parts (not plastic)." These activities can take place in school gardens. Benkowitz (2010) found that working in the school garden positively affects students' knowledge of species and their appreciation of biodiversity.

What do we mean when talking about hands-on crops? - The Greenhouse Project (GHP)

According to Haury and Rillero (1994), hands-on activities "actively involve[s] people in manipulating objects to gain knowledge or understanding". Hands-on activities, or "learning by experience" (Holstermann, Grube & Bögeholz, 2010), seem to have a positive effect on students' knowledge (Bigler & Hanegan, 2011; Holstermann, Grube & Bögeholz, 2010), and on their knowledge of specific species (Randler & Bogner, 2006). As well as real experiences, they are included in Germany's curricula and in the curricula of other countries around the world. In our survey, hands-on crops means practical work allowing contact with crops during cultivation. As Brämer (2006) found that children are alienated from nature, and many studies showed that hands-on experiences are favoured by students and may lead to increased knowledge and interest, it is important to give students the chance through hands-on experiences to "learn about their environment through exploration and play" (Jakobson, McDuff & Monroe, 2006, p.133). In order to keep the enthusiasm alive in long-term projects, such as our Greenhouse Project (GHP), it is of great importance to "build some excitement about the upcoming activity by displaying a picture or object related to the hands-on activity" (Jakobson, McDuff, & Monroe, 2006, p. 135).

In the GHP, students explore the cultivation of crops under constant and controllable conditions. They sow them, care for them and harvest them. In addition, an experiment concerning drought and its effect on plant growth, plant development and harvest is run. The GHP was initiated in 2011 for German secondary schools (starting at grade 5) and deals with crops that are cultivated by the students on the schoolyard. The project supplies hands-on experience with crop plants and provides

various opportunities for addressing crop-related subjects such as plant breeding, agriculture, renewable resources and abiotic growth factors in a grade-independent and interdisciplinary way.

Growing plants and crop plants in particular, is usually not integrated in scholarly lessons, except for in short assays concerning germination. Practical experience and contact with plants is therefore either missing or resulting from activities at home or in earlier periods of the students' education. We developed a procedure for growing common standard crop plants under experimental conditions while exploring the impact of the abiotic environmental factors, such as temperature, humidity and water, on the growth, development and yield of the crop plants. The project is integrated into regular biology classes, so that each student takes part in it by working in groups. Each group is responsible for one species. Crops are seeded in pots and positioned at different sites: a small greenhouse, which can be bought in common garden centres, and the adjacent outside area located on the schoolyard. Within the greenhouse, two assays are run in parallel with different watering techniques, so that the effect of drought on crops can be investigated. The students work in teams and are responsible for a specific set of plants growing under three different conditions: outside vs. inside the greenhouse and watered in a regular way, and inside the greenhouse and watered significantly less, respectively. Thus, students can develop an understanding of a scientific investigation by establishing and testing hypotheses concerning the impact of different climates on crop physiology and yield. By learning methods of plant research, students may improve their practical expertise while coordinating and performing a long-term experiment. Discussions of everyday subjects concerning crops, like the production of food, can be included, linking the project to the personal background of the students. The growth and development of the plants are measured and documented. Climate data are collected and can be linked to the crops' development and yield. The project lasts for a period of 3–5 months, depending on the crops being investigated. It starts in April after the Easter holiday and ends by harvesting the mature fruits.

The GHP intends to create and improve students' knowledge of crop plants and agriculture, as well as on working scientifically with crops in a social context. Its hands-on crop plants approach combines diverse practical scientific methods which are preceded by a thorough theoretical classroom introduction. The project deals with plant cultivation in an experimental setup on the school yard. Therefore it refers to elements that are part of well-established educational concepts like experiential learning (Kolb, 1984, for a recent review see Burch et al, 2014) and outdoor learning (see Behrendt & Franklin, 2014). Within the GHP, students gain first-hand experience and are instructed to use their senses for observation and analysis of the plant objects. In small groups, they are in charge of crop plants which trains personal responsibility as well as communication skills. Within scientific learning, reflecting results of plant experiments may contribute to students' scientific literacy, too (Anderson, 2007).

Study Purpose

In consequence of the energy revolution, images of plants as renewable resources, bio-petrol, and food shortage crops are present in the media and in the daily lives of the students that participated in our study. Moreover, climate change and global warming are well-known via the media. However, we found that German secondary school students (grades 5-13) have little knowledge of crop plants (manuscript in print). As hands-on activities are favoured by students (Nott & Wellington, 1999), it is tempting to investigate the effect of hands-on experiences on

students' knowledge of crop plants. Hence, the general research questions for our study were:

- Does the GHP, with its hands-on activities, including real experiences via sowing, taking care and harvesting, positively affect students' crop plant knowledge?
- Is there any difference between boys and girls concerning the effectiveness of the GHP on their knowledge?

METHOD

Data generation tool

This study utilized a pretest-posttest design. Students were assessed before their first contact with the Greenhouse Project and again after the treatment with an identical questionnaire.

The questionnaire included open and closed questions about:

1. Personal aspects (sex, age, grade, contact to crops and agriculture out of school)
2. Knowledge (Table 1: S1–S6)

Identifying and recognising, in terms of knowledge, are used similarly in this manuscript and mean that images and seeds are known by the students. Similar to our previous surveys, small glass containers with wheat, corn, rape, millet and oat seeds were supplied for the pre- and posttest (Table 1; S2). Students were to assign them to one of eight given plant names or choose the answer-option "don't know". Less emphasis was placed on students' interest. However, two closed questions on students' interest in agriculture and crops were asked in the questionnaire (Table 1: S7, S8). In addition, at the end of the treatment, feedback sheets were given to the students asking for further information on their opinion on the GHP. Feedback question was: Which issue of the project did you like and not like, respectively? Pros and cons were collected and ranked according to their frequency of nomination.

As closed questions can lead to educated guessing (Nadeau & Niemi, 1995), several classes were asked to minimise that guessing-bias. Still a possible bias cannot be eliminated.

Table 1. Evaluated questions of the students' questionnaire (S), excluding personal questions

S1	What plant is illustrated in images 1 (wheat), image 2 (corn), image 3 (barley), image 4 (rye), image 5 (oat)? <input type="checkbox"/> millet <input type="checkbox"/> rice <input type="checkbox"/> oat <input type="checkbox"/> wheat <input type="checkbox"/> corn <input type="checkbox"/> rape <input type="checkbox"/> rye <input type="checkbox"/> barley <input type="checkbox"/> don't know
S2	What seed do you see in tube 1 (millet), tube 2 (corn), tube 3 (rape), tube 4 (wheat), tube 5 (oat)? <input type="checkbox"/> millet <input type="checkbox"/> rice <input type="checkbox"/> oat <input type="checkbox"/> wheat <input type="checkbox"/> corn <input type="checkbox"/> rape <input type="checkbox"/> rye <input type="checkbox"/> barley <input type="checkbox"/> don't know
S3	What is a) white bread b) popcorn c) cornflakes d) malt beer made of? <input type="checkbox"/> millet <input type="checkbox"/> rice <input type="checkbox"/> oat <input type="checkbox"/> spelt <input type="checkbox"/> wheat <input type="checkbox"/> corn <input type="checkbox"/> rye <input type="checkbox"/> barley <input type="checkbox"/> don't know
S4	Labelling the image (wheat plant) (open question; five structures were to label; spica - node- stem - root - leaf)
S5	Labelling the image (rape plant) (open question; five structures were to label; blossom - pod - stem - leaf - root)
S6	Freelist plants used as raw materials (e.g. building material, cloths).
S7	Are you interested in "agriculture/crops"? <input type="checkbox"/> yes <input type="checkbox"/> no <input type="checkbox"/> don't know
S8	Would you like to discuss crops in class? <input type="checkbox"/> yes <input type="checkbox"/> no <input type="checkbox"/> don't know
S9	How do you rank your knowledge about agriculture? <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> low high don't know
S10	How do you rank your knowledge about crops? <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/> low high don't know

Collecting data

Before the tests were conducted, the study purpose was explained and students were asked whether or not they were willing to participate. If they were not, no questionnaire was given to them. Data analysis was anonymous. Only students participating in the pre- and posttest were part of the sample.

Sample

Two German secondary schools (starting with grade 5, age 10 years and older) in the cities of Mainz and Wiesbaden participated in the Greenhouse Project from March 2013 until November 2013. In total, four classes took part in this project; three additional randomly selected classes, both of equal grade as the respective treatment class and of the same school, were used as control classes, and had no contact with the GHP during this time. Altogether, 74 students, aged 11, 12, 16, 17, and 18 years, took part in the project (63.5 % female; 36.5 % male). In addition, 48 students, aged 11 to 18 (except 15) filled in the questionnaire for the control (58 % female; 40 % male; no sex information was given by one student (2 %)). 6/7th grade students were ages 11 to 12, and upper grade students (11/12th grade) were ages 16 to 18.

Data analysis

T-tests were performed in SPSS whenever possible and reasonable. Within sums, missing data and false answers were rated "0", right answers were rated "1", as only the right answers were interesting within the sums.

Different sets of data are presented: relative and rounded frequencies comparing pre- and posttest and averaged scores concerning recognising images or seed.

RESULTS

Hands-on crops and the influence on students' knowledge

The results show that treatment classes performed significantly better for each question concerning knowledge after the treatment (Figure 1). Depending on test items, the results within the control classes were both improving and declining, while improvements were not significant (Figure 1).

Looking at the subcategories or sub-questions, 14 items occur:

1. Recognising images of wheat, corn, barley, rye and oat;
2. Recognising seed of millet, corn, rape, wheat and oat and
3. Assigning crops to white bread, popcorn, cornflakes and malt beer.

Therefore, it can be seen that in the pretest, as well as in the posttest, corn and wheat were best known, with a percentage of correct answers of more than 50 % of all participants, each. Oat was identified correctly by 20 % more of the treatment class than in the pretest, and concerning rye and barley, the increase was marginal (Figure 2a).

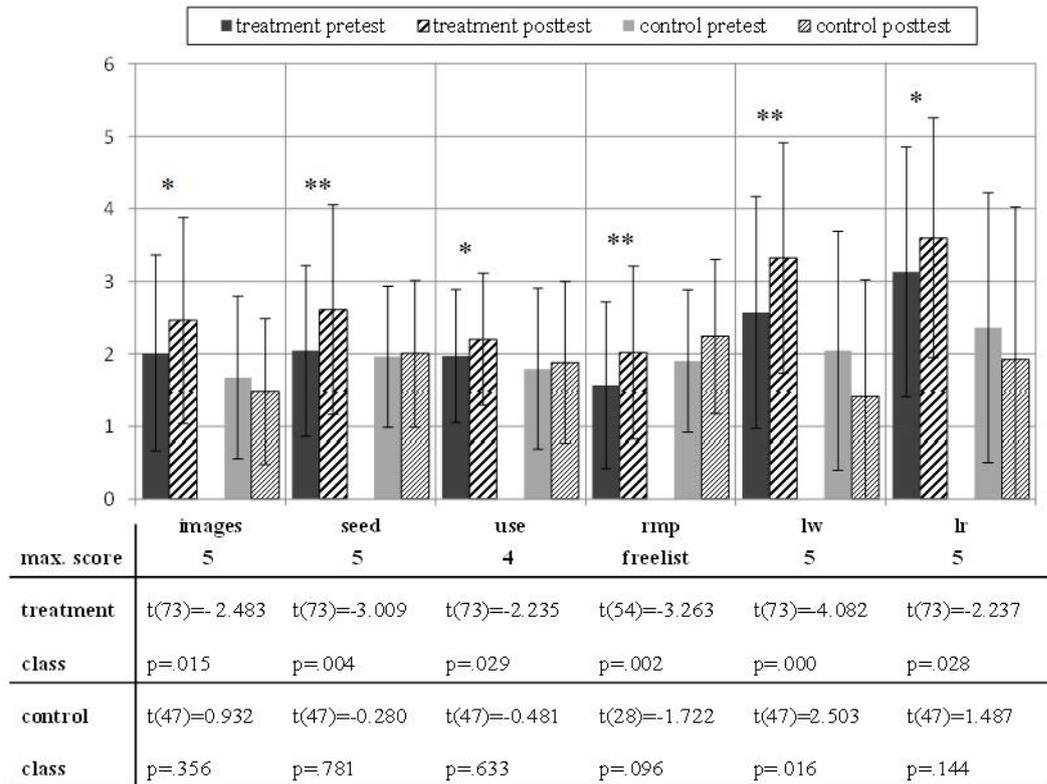
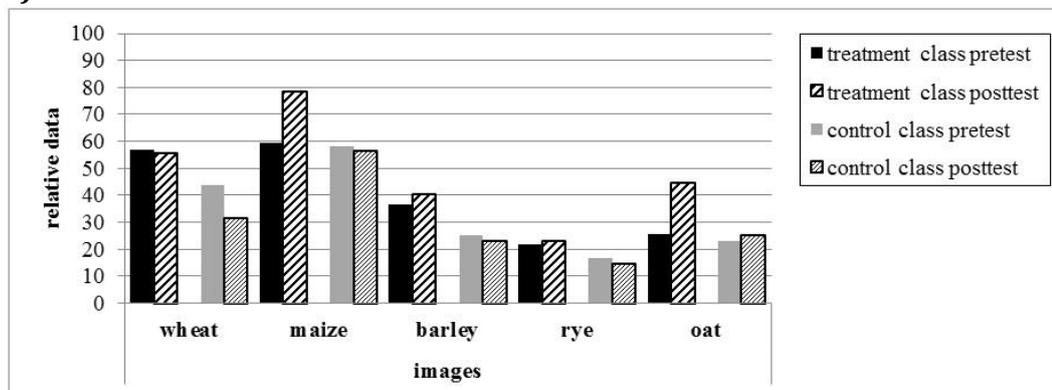
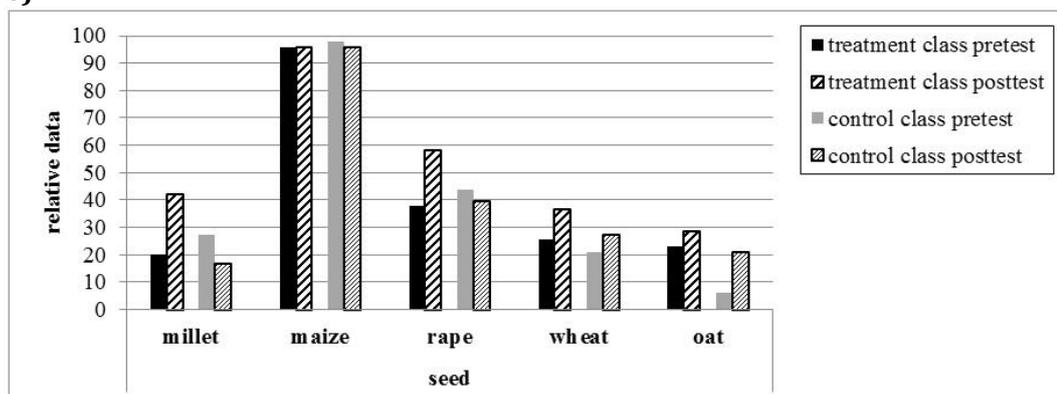


Figure 1. Average, standard deviation, t-test of treatment and control class concerning achieved sums; for raw material plants, data are related to correctly given raw material plants; *significant $p < .05$; **highly significant $p < .01$; treatment class $N = 74$ except raw material plants ($N = 55$); control class $N = 48$ except raw material plants ($N = 29$); rmp = raw material plants, lw = labelling wheat, lr = labelling rape; sd below abscise not shown

a)



b)



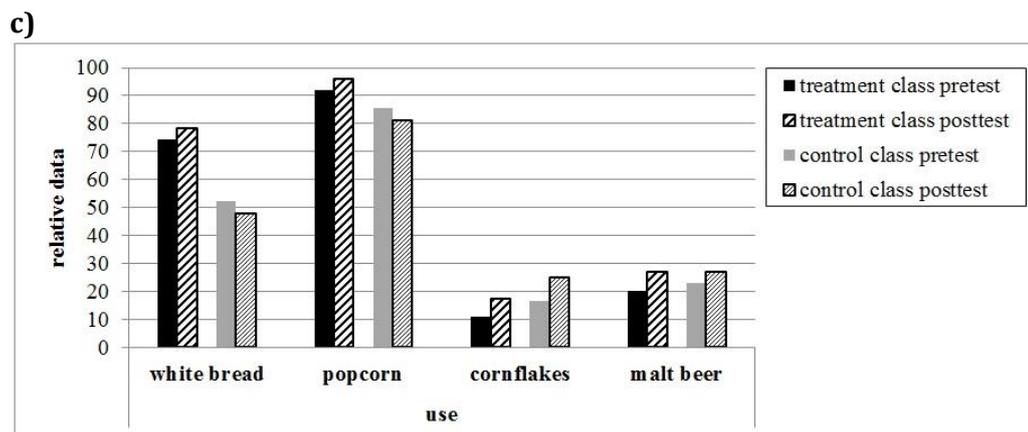


Figure 2. Recognised a) images and b) seed and c) assigning plants to certain food; relative frequency of correct answers in pre- and posttest; treatment class N = 74; control class N = 48

Students taking part in the GHP recognised images, except wheat (-2 %), better after the treatment than they did before, so they performed better in four out of five image-items (Figure 2a). The discrepancy concerning the wheat image is low. Only one student less labelled it correctly in the posttest. The seeds, presented in glass containers, were better recognised in four out of five cases (Figure 2b). There were no changes with corn. In terms of food production, an improvement in all items was observed (Figure 2c), so that on the whole, treatment students performed in 12 out of 14 items better after the treatment. Concerning images and seed, corn was best known, followed by wheat (in terms of images) and rape (in terms of seed). Rape and millet seed showed the highest improvements, with about 21 %. The control classes performed worse on four out of five images and three out of five seeds in the posttest. While the treatment classes were able to assign the correct crops to food in the posttest concerning all items, control classes improved in two out of the four use-items. The ingredients for white bread and popcorn were less known in the posttest (Figure 2c). On the whole, the control students improved in 5 out of 14 items. In terms of crops being the basis for food production, the improvement of the treatment classes was low, at about 7 % for each item. Therefore, treatment and control classes showed the same ranking. The basis for popcorn was best known, followed by white bread, malt beer and cornflakes.

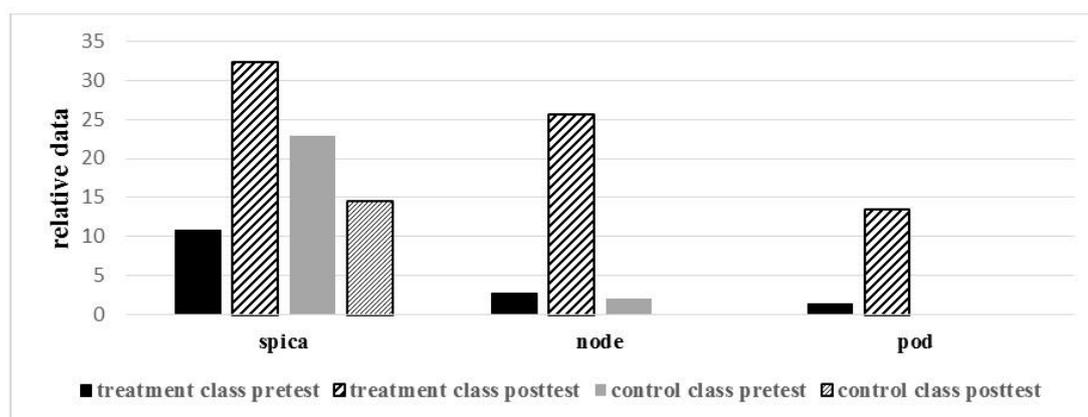


Figure 3. Results of labelling plant structures with their correct morphological names; root, shoot and leaf are not listed as they are known to almost every student; treatment class N = 74, control class N = 48

Beside improvement in recognising images and seed, students taking part in the project achieved better results concerning labelling images of wheat and rape with

morphological terms. Therefore, it has to be mentioned that basic plant organs (root, shoot, leaf) were known by almost every student in the pretest. But still, an improvement concerning non-basic plant organs (Spica, node, pod) was determined (Figure 3). While the treatment class showed the highest improvement concerning node (+23 %) followed by spica (+22 %) and pod (+12 %), students without hands-on experience in the Greenhouse Project showed no improvement, but rather impairments (Figure 3). These data show that having contact with crop plants and cultivating them positively effects morphological knowledge.

Concerning treatment classes, it has to be considered that every group of students sowed, cared for and harvested their own species. The number of students is therefore low in each group. The term “spica” was more known after the treatment in every group except for those students caring for pea and millet. The term node was better known after treatment in every group except for those groups caring for pea, sugar beet and corn. Only 5 out of 10 groups demonstrated increased knowledge regarding the term “pod”. Exceptions include the groups caring for wheat, pea, sugar beet, corn and millet. The group caring for peas showed no correct answers in the pre- and the posttest, while the group measuring data improved in terms of all three morphological structures. Students caring for sugar beet showed a better result only concerning the spica. Still, the number of correct answers was low in each group, with less than 50 % of students knowing the answer.

Girls vs. boys: Do hands-on experiences affect the sexes differently?

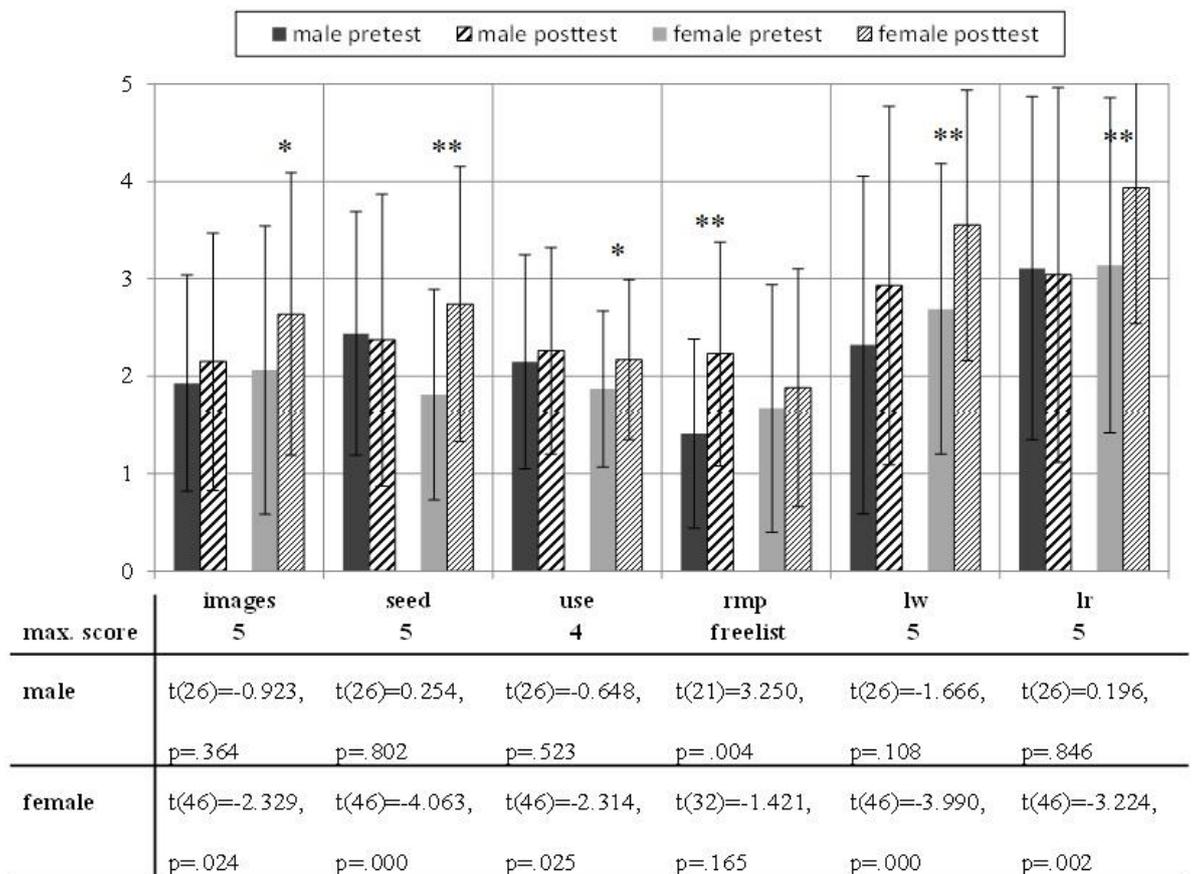


Figure 4. Mean achievements of participating girls and boys before and after the treatment; concerning raw material plants, only correctly listed plants are considered; rmp = raw material plants, lw = labelling wheat, lr = labelling rape; girls N = 47 (except rmp N = 33), boys N = 27 (except rmp N=22); sd above 5 not shown; ** highly significant, * significant

Comparing boys' and girls' performances of the treatment class in the pretest, our data show that the girls performed better than did the boys in terms of recognising images, raw material plants and labelling wheat. Boys showed better results than did girls concerning seed and use in the pretest. Concerning labelling, the rape plant results were almost even. Taking a look at the posttest, girls achieved better results than did boys in terms of recognising images, recognising seed, labelling wheat and rape plants. In terms of use and raw material plants, they performed worse than the boys. Nevertheless it can be observed that the boys improved in four out of six items (Figure 4), but only one item showed significant improvement (raw material plants ($t(21) = 3.250, p = .004$). In terms of recognising seeds ($t(26) = .254, p = .802$) and labelling the rape plant ($t(26) = .196, p = .846$), the boys' achievements were lower in the posttest than in the pretest, but not significantly. Girls, on the other hand, improved in all items, with significant improvement in five out of six items (Figure 4). No significant improvement was observed concerning listing raw material plants ($t(32) = -1.421, p = .165$).

Taking a look at single questions concerning recognising images and seed and assigning crops to certain food, it is shown that boys performed better in four out of five image-items, with wheat being the exception (-30 %). Wheat was correctly identified less often after the treatment (33 %) than it was in the pretest (63 %). Girls showed higher achievements after the treatment in three out of five image-items (wheat +15 %, corn +21 %, oat +21 %), with an impairment found concerning barley (-6 %). In terms of rye, the results of the pre- and posttest were even (28 %). Regarding seed-recognition, girls performed better concerning all five seeds. On the other hand, boys achieved lower results in three out of five cases (corn -7 %, wheat -7 %, oat -11 %). There was an improvement regarding rape, and millet was the same in the pre- and posttest. In the task of assigning crop plants to certain food items, girls improved for each item, while boys improved concerning the origin of popcorn (+4 %) and malt beer (+4 %). The boys showed impairments concerning the origin of cornflakes (-4 %). Concerning the production of white bread, the results were even in the pre- and posttest (74 %). To summarise, it was found that girls performed better concerning 12 out of 14 sub-items (except barley image -6 %; rye image, same result (28 %)), while boys performed better in four out of five images (exception wheat -30 %), one out of five seeds (rape +19 %; millet same result (37 %)) and three out of four uses (exception cornflakes -4 %; wheat same result (74 %)).

Self-assessment of students' knowledge

Students participating in the hands-on project did not only experience an objective, measurable improvement concerning knowledge. The treatment students also ranked their own knowledge concerning agriculture ($t(66) = 2.418, p = .018$) and crops ($t(61) = 3.802, p = .000$) significantly higher after the treatment. However, the control classes rated their knowledge about agriculture ($t(33) = 2.024, p = .051$) and crops ($t(33) = 1.071, p = .292$) lower, which goes along with an objective measured decrease of knowledge (Figure 5).

The difference concerning control students' own estimation of knowledge is not significant, but shows a certain tendency. The average of treatment and control classes in the pretest, as well as in the posttest, ranges from 3.5 to 4. That means that students ranked their knowledge as "satisfying" or "adequate", speaking in the language of school grades. The subjective ranking of their own knowledge before and after the treatment shows that both sexes ranked their knowledge as being higher after the treatment (Figure 6). The difference between the pre- and posttest is significant for girls (agriculture $t(43) = 22.712, p = .010$; crops $t(38) = 4.382, p = .000$) and insignificant for boys (agriculture $t(22) = 0.463, p = .648$; crops $t(22) =$

0.848, $p = .406$). Both sexes range in the middle of the 1-to-5 Likert-scale concerning their own ranked knowledge (min. 3.19; max. 4.29). Nevertheless, girls ranked their knowledge higher than did the boys in the pretest and the posttest. That could indicate participants of the treatment realising an increased knowledge, which was already objectively observed above.

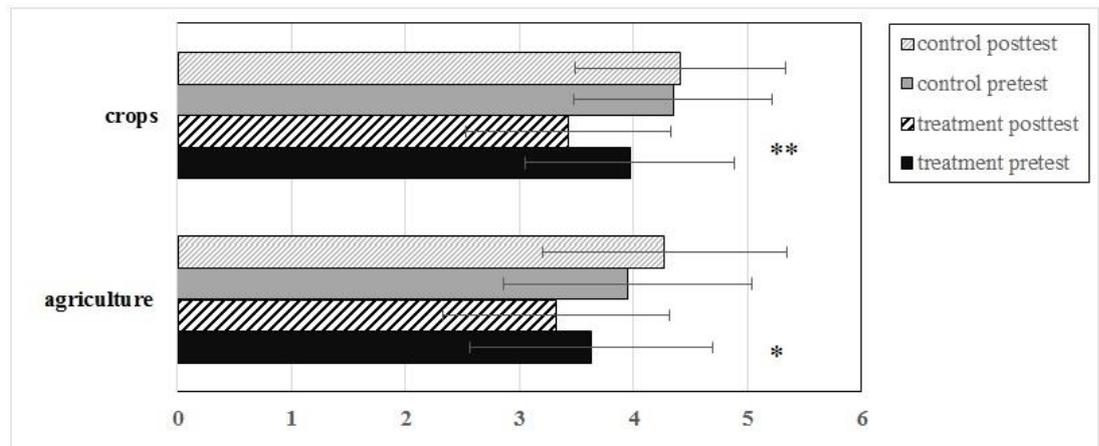


Figure 5. Overview of students' own knowledge-rating in treatment and non-treatment classes; Likert-scale from 1 to 5; Average, standard deviation given concerning pre- and posttest; *significant $p < .05$; **highly significant $p < .01$

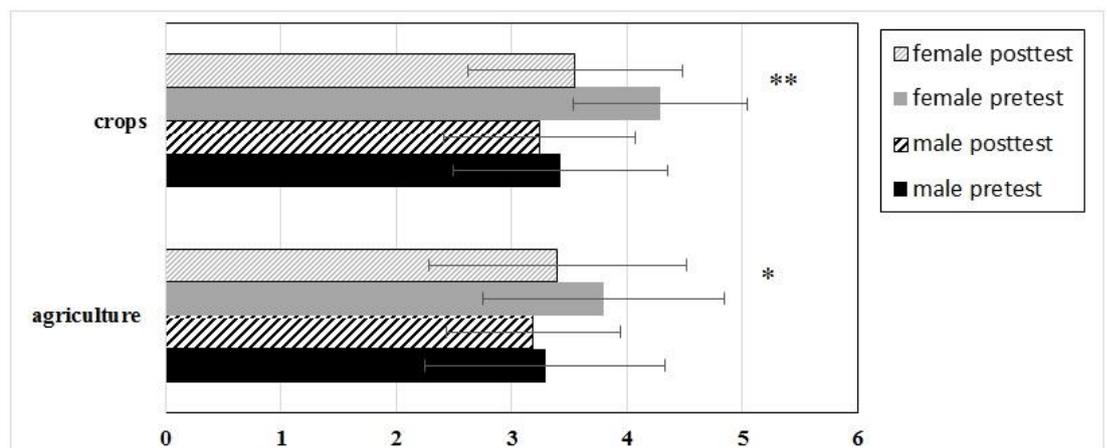


Figure 6. Overview of students' own knowledge-rating in treatment and control classes according to sex; Likert-scale from 1 to 5; Average, standard deviation concerning pre- and posttest; *significant $p < .05$; **highly significant $p < .01$

Students' opinion on agriculture/crops and the GHP

The effect of the Greenhouse Project on students' attitude towards agriculture and crops was tested in the current survey via non-standardised, closed questions in order to get a first impression on the students' opinion (see S7 and S8 in Table 1). While about 50 % of the treatment students choose the answer-option "yes" concerning the question "Are you interested in crops/agriculture?" and 46 % wanted to discuss crops in class before the treatment, about 35 % of the treatment-students were interested and 19 % wished to get more information about crops after having participated in the GHP. This negative development was not only observed within the treatment classes. The control students' interest declined as well between the pre- and posttest. About 31 % stated that they were interested at the time of the pretest, while about 17 % were interested when completing the

posttest. At the same time about 27 % of the control students wished to learn more about crops in class in the pretest, whereas about 13 % wished to in the posttest.

The students' opinion about the Greenhouse Project itself was investigated by analysing the comments treatment students gave when asked to write down pros and cons after having participated in the project (Table 2).

First of all, students enjoyed being outside the classroom and having personal contact with plants. The observation of plant development was especially mentioned as a positive aspect of the GHP. Moreover, students expressed themselves positively about self-determined and practical work during the project. Looking at Table 2, students most often criticised the fact that the management of the plants took too long during class.

Table 2. Top 5 of the given pros and cons of the Greenhouse Project via feedback sheets; 2013

Pros	Cons
Being outside the classroom	Took too much time
Observing plant growth and development	Easy/trivial/monotone
Harvest/evaluation	Boring/not interesting
Learning new things/learning about crops	Watering
Practical and self-determined work	Too much writing

DISCUSSION

The effect of own cultivation on students' crop knowledge

That students' knowledge of different groups of plants is poor (e.g. Bebbington, 2005; Cooper, 2008; Hesse, 2002; Jäkel & Schaer, 2004), was shown in several surveys. Results on crop knowledge are not consistent, if those results exist at all (Burrows, 2012; Cooper, 2008; Patrick & Tunnicliffe, 2011; Wagner, 2008). German students in previous surveys did not recognise common crop plants or their seeds. That is also obvious in the pretest of this survey.

The current study shows that cultivating crop plants, including sowing, managing and harvesting, positively affects students' knowledge. Throughout the treatment, knowledge of crops increased objectively (i.e. test scores, see Figure 1–3) and subjectively (i.e. self-evaluation, see Figure 5–6). Students showed better scores after the treatment and realised an increased knowledge on their own. According to the gender-based analysis of the treatment classes, girls performed better than did boys in the pretest and the posttest. Girls' higher achievements are not only measured objectively (looking at their own estimation of knowledge), girls showed significant differences in terms of their estimated knowledge about agriculture and crops before and after the treatment. However, boys did not significantly assign themselves better knowledge in the posttest, so their own estimation confirms the results shown via the categories.

The fact that practical work positively affects students' knowledge was already shown by Atkinson & White (1981) in a chemistry class. Demonstrations were less effective than were hands-on experiments. In addition, Randler and Bogner (2006) showed that hands-on activities improve students' identification skills regarding birds, which can be replicated here with crop plants. Therefore, we, like Randler and Bogner (2006), chose a low number of crop species in the GHP, so that students

would not be overextended and instead, learn about a selection of crops cultivated in Germany at the same time. The differences between the pre- and posttest in our study are significant. However, despite real contact with crops and their seeds, not all of the types of plants and seeds that had been cultivated in the GHP were recognised by the class. A reason for that could be the organisation of the project. Each group of students cared for one species. Therefore, contact with other crops is not necessarily a given, unless students focused on other plants on their own, or the teacher facilitated contact with other crop species and their seeds during class. But even if not all of the crop plants are known after the treatment, it seems that those having a strong connection to daily life and have a cultural importance are often already known in the pretest, which affirms Cooper's (2008) results. These species are still best known in the posttest (corn, wheat). The fact that corn and rapeseeds were best known could arise from the fact that the corn seeds are used in their original form as a staple food, and could therefore have connection to daily life. In terms of rapeseed, the special look could make it so that students recognise it better than they do other seeds. Tunnicliffe (2001) showed that students recognise plants with special characteristics better than they do other plants. Possibly, special characteristics play an important role concerning seeds, too. That would also explain why similar seed, like rye and barley, and also wheat and oat, are often interchanged. Further surveys could focus on the effect and importance of special characteristics on the knowledge of species using, e.g., the seeds of sugar beet with their eye-catching star-like shape.

Knowledge of crop plants as food

Teaching students the origin of food components is important as food safety scandals and discussions on genetically modified crops and food are present in the media. Previous surveys showed lacking knowledge in this area (Brämer, 2006; Hess & Trexler, 2011). Similar to our earlier studies, corn and wheat are the best-known crop plants due to their use in popcorn and white bread production. The origins of malt beer and cornflakes are less known. For English speakers, this might be surprising since the English word "cornflakes" contains a syllable referring to the origin plant. However, the German similar-sounding word "Korn" (kernel/grain) does not mean the same as the American word corn (maize). This semantic difference, in combination with similar sounds, may cause confusion and wrong assumptions. The reason for the observation could be the products' value in daily life. White bread is quite popular in Germany and students may be familiar with popcorn by producing it at home or consuming it at the cinema. Therefore, the origin of this product will be familiar via personal experience. Malt beer, on the other hand, is less frequently used in daily life, and the word malt, unlike oat flakes or "cornflakes", does not give a hint to the original plant. At the same time, cereals are less often eaten by children than recommended by experts, and therefore, show up less frequently in their daily lives (Kersting, Alexy, Kroke & Lentze, 2004; Mensink, Kleiser & Richter, 2007). Students participating in the GHP improved in all items concerning processing, but the improvement was very low, at less than 10 %. To achieve higher improvement concerning the production of crops, in the GHP usage of the cultivated plants could be integrated into the project by including the harvest in order to produce bread, popcorn, oil and so on.

Knowledge of morphology

Already in the pretest, basic plant organs (root, shoot, and leaf) were known by almost every student, affirming the results of our earlier surveys, as well as those by Barman, Stein, McNair & Barman (2006). They found that, especially stem, leaves,

the green colour and the fact that plants grow in the soil, are characteristics associated with plants. Whereas more specific plants structures were not known before the treatments, the terminology for basic plant organs was known and could be transferred to different objects. A reason for this could be that early in one's education, often at the beginning of secondary school, the physiological and cellular level is the focus of class discussions on plants. Morphology is often only intensively discussed for basic organs; frequently, this takes place in primary school. After the treatment, more specific organs were better known. Node, pod and spica were used more often to label crop plant structures. Still, the number of correct answers was low, at less than 50 %, while basic organs were known by about 90 % of the participating students. Concerning treatment classes, it has to be considered that every group of students sowed, cared for and harvested its own species. If there was no discussion of other groups' plants (e.g. in the class) or no examination of other crop plants took place by choice or by given tasks in class, students caring for corn had no contact with rape, and therefore, were not or were hardly stimulated to learn the term "pod". A similar situation is given for those students caring for rape concerning the habitus of corn and the terms "spica" and "node". The term "spica" was better known after the treatment in every group, except for those students caring for pea and millet, which both have no spica. The term "node" was better known after the treatment in every group except for those groups caring for pea, sugar beet and corn. Pea and sugar beet do not have such nodes. Five out of 10 groups better knew the term "pod" in the posttest. Similarly to the terms mentioned before, the groups caring for plants without having a pod (except for pea), i.e. wheat, pea, sugar beet, corn and millet, did not improve. Moreover, as the picture that should be labelled in the questionnaire showed the rape plant and not the pea plant, these results show that there has possibly been no transfer from one plant to another, i.e. from pea to rape. To increase students' morphological knowledge, purposeful and personal contact with crop plants and plants in general should be intensified. It can be supported by means of adapted specialty literature concerning the development of plants and their organs.

Students' attitude towards agriculture, crops and the GHP

As surveys of Lineberger & Zajicek (2000) and Holstermann, Grube & Bögeholz (2010) may indicate, practical work with plants has a positive influence on the attitude (cultivating fruit and vegetable with 3rd and 5th grade students) and is liked by students (experiments with plants, microscopy). However, interest of students in crops and agriculture is low (Holstermann & Bögeholz, 2007). This could be confirmed in our study where we made a first attempt to measure the effect of practical work with crops in the GHP on students' interest and attitude. We are aware of the fact that these data are of preliminary character. However we think that they may contribute to round the evaluation of the project at the present time. By asking two closed, non-standardized questions, we found that the amount of interested students was low before the treatment and could not be kept up or improved throughout the GHP. Moreover, it seemed to decline. A reduction of the students' interest in agriculture and crops could be observed after the project period both in the treatment and the control group to a similar extent. Interest in those topics decreased by 14-15 percentage points between pre- and posttest in both groups. Regarding the wish to further discuss crops in class, the treatment class' value declined more strongly than the control. Thus, treatment students may have had the impression that working with crops and discussing the project may have fulfilled their requirement for information about crops so that they did not see any need to further go through the subject in class. At the time of posttest, the amount of

treatment students interested in discussing crops in class was comparable to, however slightly higher than the control (19 vs. 13 %).

According to Berck & Graf (2010), long-lasting activity with animals has positive effects on knowledge and interest of students. Those results cannot be easily transferred to plants and the GHP, though knowledge can be improved during the treatment, while attitude and interest seem to decline, or at least not to be maintained or improved. Reasons for a missing positive effect on students' opinions can be varied and may be ascertained via feedback-sheets given to students after the treatment (Table 2).

While short-term treatment (field trip) seems to have positive effects on students' attitudes towards biology (Prokop, Tuncer & Kvasničák, 2007b), a long-term project with crops did not seem to improve students' interest and attitude in our study where the overall project period may have led to the statement of "too long" in a written feedback of the students. Thus, a project period of three to five months, which requires a certain effort of the teacher in terms of organisation as well as endurance of the learners, appears to not be favoured by students in this survey.

In a project like our GHP that includes the cultivation and management of plants from sowing to harvesting, repeating work like watering and measuring cannot be avoided. This was often called "monotonous" or "boring" by students. Writing down abiotic data and plant development was also a point of complaint at times. That is consistent with the findings of Ballantyne & Packer (2002), which stated that students are less enthusiastic about those activities. Such tasks do not seem to positively affect environmental learning, contrary to having personal contact and interaction with the environment. The GHP combines both writing down data and having personal contact. Writing down data could have such negative influences that it abolishes the positive effects of practical work and personal contact. The extent of measurements and documentation, as well as watering techniques, might thus be adapted to the respective students' classes. However, with respect to the scientific methods that are included in the continuous management of the plants, it should be remembered that repeating tasks, like measuring growth and soil humidity before watering, belong to and illustrate scientific work and support the acquisition of competencies. In terms of long-lasting projects, Jakobson, McDuff, & Monroe (2006) advises highlights to keep the project fun and motivating, and therefore keep the interest up and even improve motivation. With respect to the GHP, improving the variety of subjects and methods, as well as introducing "highlights," could be addressed in the future by working with apps, analysing data via Excel, using infrared cameras to illustrate leaf temperature, and so on. The use and profit of crop plants is important to students. Hence, crops should be processed after the harvest. However, the cultivation in flowerpots would not be sufficient to produce high quantities, so commercial seed should be provided additionally in order to allow students to process their own crops' fruits into food.

Educational demand

Getting to know crops during a lesson and caring for cultivated crops is necessary in a time when contact with nature and agriculture is rare, and there is little knowledge regarding crops. Especially as recreation time is often spent with modern media rather than in nature (e.g. Pergams & Zaradic, 2006), intensified personal contact with crop plants that produce staple food is required. The GHP, which allows the cultivation and analysis of crop plants, shows positive effects on students' knowledge. As students should not only learn about one crop, a purposeful use of extra teaching material should counteract single-plant-contact. Those materials could include interaction with other crops, such as drawings to learn about the

crops' morphology, dissecting fruit and inflorescence and looking at the variety of seeds. At the same time, school subjects should be combined (e.g. plastic and glue could be made out of starch in chemistry and genetic engineering, world hunger and climate change could be discussed in social studies), so that students' own cultivation can be connected to daily life and the actual topics presented in the media. Combining instruction regarding crops with other school subjects could be highlighted within the treatment.

Especially concerning (sweet) grasses, a focused, purposeful and manifold teaching methodology is needed, as those plants which are important in our lives since they represent important crop plants, are often not or are less perceived because of their uniform green colour and inconspicuous blossoms. Besides a didactical connection, good organisation within the school is needed. The communication within the school must be established before the project, so that not only treatment classes get to know the crops, but also the other students do as well. Therefore, the students can realise and be amazed that "there is only grass growing in [our] plants pot".

On the whole, concerning school, there should be more space given for long-term projects, with respect to both financial and organizational aspects.

Methodological demand

The positive effect of practical work on the knowledge of species is shown in our survey. More research is needed that focuses on how interest and opinion can be positively influenced during cultivation. Hence, a more detailed recording of students' interest should take place. An effect on long-term interest of the respective subjects of the project should be investigated in further studies. To analyse the development of the students' interest throughout the treatment, frequent questionnaires regarding interest should be conducted in upcoming years.

As short-term interventions lasting one day with 11–12-year-old Slovakian students had positive effects on students' knowledge and "attitudes towards biology, natural environment outside and future career in biology" (Prokop, Tuncer & Kvasničák, 2007b), those regularly occurring questionnaires could identify favoured and unpopular activities during the treatment. Possible measurement methods may include the QCM (Questionnaire of Current Motivation) (Freund, Kuhn & Holling, 2011; Rheinberg, Vollmeyer & Burns, 2001), allowing for the measurement of the motivation at different points in time over the course of the treatment.

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