International Journal of Environmental & Science Education, 2015, **10**(6), 891-904

Secondary School Students' and Their Parents' Knowledge and Interest in Crop Plants: Why Should We Care?

Eva-Maria Fritsch
Johannes Gutenberg-Universität Mainz, GERMANY
Daniel C. Dreesmann
Johannes Gutenberg-Universität Mainz, GERMANY

•*Received 27 March 2015* •*Revised 17 July 2015*•*Accepted 27 July 2015*

While there is increasing world-wide discussion of the importance of renewable biological resources and a bio-based economy, science educators around the world have become aware of a declining general interest in plants and agriculture and of little knowledge of plants among the public. Recently, there have been few systematic investigations on the knowledge of crops. To address this observation, we initiated a questionnaire survey with secondary school students based on the assumption that students should acquire a fundamental knowledge of agriculture and crop-plant biology during compulsory education. As home is a source of information, parents were also questioned. On the whole, 926 German secondary school students aged nine to 18 years and 314 parents participated in our questionnaire survey. The data suggest an unsatisfactory level of knowledge about crop plants among students. Girls have greater knowledge and claim to be interested in crops more often than do boys. While knowledge of species was independent of grade and age, knowledge of crop use did increase with increased years of schooling. Parents showed an overall better performance than the students' on items involving plant recognition and their use.

Keywords: knowledge of crops, staple foods, crop plant recognition, interest in crop plants

INTRODUCTION

Crops have been cultivated for about 10,000 years. Among those that are still essential for society are corn, wheat, rye, barley, oat, millet and rape. We are in daily contact with crop plants in terms of e.g., food, clothes, furniture and cosmetics. Crops are in connection to agriculture, which is an important economic factor. The importance of agriculture in many people's lives has decreased with mechanization (Bickel & Bögeholz, 2013). People are able to buy their staple food in the supermarket without having any contact with the original plants. Thus, it is not surprising that the knowledge of product processing is low (Brämer, 2006). Even though personal contact with crop plants and agriculture has decreased, the

Correspondence: Daniel C. Dreesmann,
Department of Biology Education, Faculty of Biology, Johannes Gutenberg-Universität, D-55099 Mainz, GERMANY
E-mail: daniel.dreesmann@uni-mainz.de
doi: 10.12973/ijese.2015.282a

ISSN: 1306-3065

economic and scientific importance of such topics is apparent.

The discussion on renewable resources and their use for food or petrol production and the idea of a "bio-based economy" as coined by the OECD (2009), has become an important issue for public attention. The federal government of Germany also mentions the topic in its National Research Strategy BioEconomy 2030 (BMBF, 2010). An appropriate knowledge of crop plants is necessary in order to take part in public discussions on the food security through plant breeding and the industrial use of renewable resources.

Current state of research on the knowledge of and interest in crop plants

Many surveys on students' knowledge of plants have been conducted to date. Crop plants were either not or only marginally included. However, it is shown that girls have a higher knowledge of species than boys (Gatt, Tunnicliffe, Borg & Lautier, 2007; Jäkel & Schaer, 2004). Still, students' knowledge of botanical species like early bloomers, trees, wild flowers, plants growing on the way side and toxic plants is lacking (Ammer & Gössinger, 2010; Bebbington, 2005; Fančovičová & Prokop, 2011; Gatt, Tunnicliffe, Borg & Lautier, 2007; Hesse, 2002; Jäkel & Schaer, 2004). Even adults do not know the leaves of common trees (Hesse & Lumer, 2000).

Results on knowledge of culturally important plants and crops are rare and not consistent. According to Cooper (2008) and Wagner (2008) culturally important plants such as trees, cotton, potatoes, roses, strawberries and bamboo are better recognized than others, while crops – which are definitely culturally important – are rarely known by agriculture students at the beginning of their study, even though 80 % have an agricultural background (Burrows, 2012).

Contrary to the findings of Jewell (2002), school seems not to be a relevant source of information for knowledge and recognition of species according to Tunnicliffe and Reiss (2000) and Fančovičová and Prokop (2011). Instead, daily life (Patrick & Tunnicliffe, 2011), daily use and sociocultural value (Natarajan, Chunawala, Apte & Ramadas, 2002), as well as parents (Gatt, Tunnicliffe, Borg & Lautier, 2007; Tunnicliffe & Reiss, 2000), seem to influence knowledge of plants. Those results are consistent with Hesse's (2000) survey on adults showing that names of plants and animals were learned less within the school than in family. At the same time, adults would like to have gained more knowledge of plants and animals within their school time.

Besides little knowledge, a lower interest in plants as compared to interest in animals can be observed (e.g., Berck & Klee, 1992; Holstermann & Bögeholz, 2007; Hummel, Glück, Jürgens, Weisshaar & Randler, 2012; Kinchin, 1999; Löwe, 1987; Prokop, Tuncer & Chudá, 2007). Moreover, adults were more interested in animals than in plants retrospectively when asked about their time in school (Hesse, 2000). Interest in crops and agriculture has been investigated less. Holstermann and Bögeholz (2007) and Bickel and Bögeholz (2013) found that students are less interested in agriculture and plants than they are in technical, human biological or zoological issues and that cultivation is less interesting than the keeping of animals. Thus, students prefer animals and have higher knowledge of them (Ammer & Gössinger, 2010; Schussler & Olzak, 2008). Moreover, animals are far more linked to the terms "farm" and "agriculture" according to Hamann (2004).

Wandersee and Schussler (1999) coined the term "plant blindness", meaning the underestimation of the importance of plants apparent in e.g. (1) the inability to realize plants in their environment, (2) the inability to notice the value of plants and giving them a lower value than animals and (3) the inability to appreciate plants concerning aesthetics and biology. Both authors assume that we can only recognize

what we know and that plants without special characteristics are not realized. This is consistent with Tunnicliffe (2001) and Zucchi (2007) who state that special plant characteristics are perceived.

Lindemann-Matthies (2005) showed that the more plants are known the more they are appreciated. Along with other authors, Lindemann-Matthies also showed the importance of knowledge about species for the protection of nature and biodiversity and that biodiversity is appealing to people (Lindemann-Matthies, Briegel, Schüpbach, & Junge, 2010; Lindemann-Matthies, Junge, & Matthies, 2010; Lindemann-Matthies, & Marty, 2013). Unfortunately, children are alienated from nature (Brämer, 2006) and not interested in the knowledge of species (Bebbington, 2005), which is regrettable as a good knowledge of species promotes a pro-environmental behavior (Zubke & Mayer, 2003) and is the basis for understanding biodiversity (Killermann, Hiering & Starosta, 2009). It is necessary to experience and appreciate nature, to notice its changes and to protect it. Moreover, it is the prerequisite for scientific examination, and knowledge of plant species, in particular, is the basis of social and political issues, such as cultivation of genetically modified crops, organic farming, renewable raw materials, climate change and world hunger. Furthermore, knowledge is a basis for interest (Berck & Graf, 2010) – meaning without knowledge students' low interest, especially in plants, cannot be counteracted.

However, as about 300,000 higher plants have been taxonomically described, each plant cannot be known. Thus, it is important to select examples that should be discussed in school and should belong to general education. As students are interested in the use and processing of plants (e.g., Bickel & Bögeholz, 2013), crop plants may be suited for teaching knowledge of species, health education (e.g., a balanced diet) and several other biological topics (e.g., morphology, ecology).

Study purpose

Knowledge of and interest in crop plants of German secondary school students has not been systematically investigated so far. Thus, it is of importance to find out at first:

- What do students know about crops and are they interested in them?
- Moreover, do parents have a greater knowledge than their children?
- Where do they get their information?

Knowledge of species in our survey has been defined as the recognition of and ability to label plant inflorescence images and seeds, as provided in small glass containers, as well as assigning crops to certain foods and enumerating raw material plants. Recognizing is used similarly to identification in this survey. A school in this survey means an institution including lessons, media, teachers and so on.

METHODOLOGY

Sample

In total, 926 students of 44 classes from six secondary schools (in Germany 5th to 13th grade) between the ages of nine and 18 years participated (46 % female; 52 % male; no sex information was given by 2 % of the questioned students). Fifth grade students had an average age of 11; upper grade students (11th – 13th grade) were generally ages 16 to 19.

To examine whether parents had a greater knowledge than their children, whether they had a stronger direct contact with crops in school or whether there were differences in interest, all students taking part in the survey were given a

questionnaire including an envelope for one of their parents. Students were able to bring the filled-in questionnaire back to school and put it in a box placed in the secretary's office. Thus, parental participation was anonymous and optional. Altogether, 314 parents participated in the questionnaire (235 female: 75 %; 76 male: 24 %; three parents did not give information about their sex: 1 %).

Data generation tools

To determine the knowledge and interest students and parents ascribe to themselves concerning the topics "crops" and "agriculture" in general, we started a questionnaire survey in German secondary schools (5th to 13th grade) in the cities of Mainz and Bingen from June 2012 until December 2012. All questionnaires included open and closed questions. The students' questionnaire included questions about:

1. Personal aspects (sex, age, grade);
2. Knowledge (Table 1: S1–S4 – seeds were presented in small glass tubes; monochrome images were taken from current schoolbooks)
3. Experiences in school concerning crops (Table 1: S5–S10)
4. Students' interest in agriculture and crops (Table 1: S11–S12).

The parents' questionnaire was shorter, but seven questions were identical to the students' questionnaire, allowing a comparison of generations (see Table 1).

Table 1. Evaluated questions of the students' questionnaire (S) and teachers' questionnaire (T) excluding personal questions; mc = multiple choice; # similar questions in parental questionnaire

S1#	**What plant is illustrated in image 1 (wheat), image 2 (corn), image 3 (barley), image 4 (rye), image 5 (oat)?** □ millet □ rice □ oat □ wheat □ corn □ rape □ rye □ barley □ 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)?** □ millet □ rice □ oat □ wheat □ corn □ rape □ rye □ barley □ don´t know
S3#	**What is a) white bread b) popcorn c) cornflakes d) malt beer made of?** □ millet □ rice □ oat □ spelt □ wheat □ corn □ rye □ barley □ don´t know
S4#	**Freelist plants used as raw materials (e.g., building material, clothes).**
S5	**Does your school have a school garden?** □ yes □ no □ don´t know
S6	**Where do you get your information about crops and their use? (mc)** Answer options see Figure 3a
S7	**What media are used in your biology class? (mc)** Answer options see Figure 3b
S8#	**Have you discussed "crops" in school?** □ yes □ no □ don´t know
S9#	**Have you discussed "agriculture" in school?** □ yes □ no □ don´t know
S10#	**Have you a) cultivated b) identified c) touched d) processed crops in school?** □ yes □ no □ don´t know
12	**Are you interested in "agriculture/crops"?** □ yes □ no □ don´t know

Data collection and analysis

For inquiry, we visited the classes so that questions could be answered and the execution was observed. If students were not willing to participate, no questionnaire was given to them.

Different sets of data are given: relative and rounded frequencies as well as average scores and standard deviations. Cross-tables, χ^2- and t-tests were performed in SPSS. Within sums, missing data and wrong answers were rated "0," and right answers were rated "1" as only the right answers were interesting within the sums. As closed questions can lead to educated guessing (Nadeau & Niemi, 1995), a large sample was selected to minimize the guessing-bias. Still, a possible bias could not be eliminated. To be suited for lower and upper grade students, questions concerning interest were binary scaled ("yes–no") with the additional option "don't know." Previous studies conducted by our group showed that lower-grade students were especially compromised by Likert scaled questions, and tended to choose the center level. Furthermore, the general attitude – are students interested or not – and not the level of interest was the focus in this study.

RESULTS

Knowledge of crops plants

Identifying plant images revealed that corn was the best-known crop species (60 %), followed by wheat (51 %), oat (33 %), rye (30 %) and barley (20 %). Seed recognition showed that corn was selected correctly by 92 % (N = 912) of the students. The seed of rape was identified by 32 %, wheat was identified by 25 %, millet-seed by 24 % and oat was correctly recognized by 17 % of the students. Moreover, seeds were often interchanged. The use of corn to produce popcorn was known by 91 % of the students. That white bread is made of wheat was known by 67 %. 18 % knew that cornflakes are made of corn and 39 % that malt beer is made of barley (Note: The word "cornflakes" is used in German as well; there is no translation to an equivalent in the German language). A mean of two out of five correct image (M = 1.94, SD = 1.419) and seed (M = 1.9, SD = 1.141) answers and two out of four correct use (M = 2.14, SD = 1.037) answers was achieved. The open question, which asked to list raw material plants, showed that, on average, one example was given. Cotton was mentioned most often with more than 500 nominations followed by tree/wood (151), cannabis/*cannabis sativa* (98), rape (49), bamboo (37) and caoutchouc (33). Silk, a non-botanical material, was ranked in 8th place with 19 nominations.

According to sex, a highly significant difference was examined concerning the sums achieved in identifying images as well as concerning sums achieved in recognizing seeds and the use of plants for food production. Thereby, girls performed better than boys (*images*: male M = 1.78, SD = 1.366; female M = 2.14, SD = 1.448; t(902) = -3.845, p = .000; *seed:* male M = 1.81, SD = 1.158; female M = 2.01, SD = 1.116; t(888) = -2.676, p = .008; *use*: male M = 2.04, SD = 1.105; female M = 2.26, SD = 0.935; t(900.021) = -3.269, p = .001).

No significant changes occurred from one school grade level to the next concerning the recognition of images and the recognition of seeds (*images:* t(924) = -0.996, p = .319; one image difference; *seed:* t(910) = -0.318, p = .751; one seed difference). In terms of the enumeration of raw material plants (t(277.281) = -7.954, p = .000) and the use of crops (t(350.028) = -6.913, p = .000), a highly significant difference was found. While students between the 5th and the 10th grade assigned two products with the correct crops, students of upper grades were able to correctly

name up to three basic materials for food production. Among the 12th grade students, 46 % were able to assign the correct basic crops to all four staples.

Interest in crop plants and agriculture

Two closed questions concerning interest in and desirability of crops in class showed a balanced opinion with a negative tendency. Answer options "no interest" and "crops not welcome in class" were selected more often than the options "interest" and "crops welcome in class." While 37 % said that they were interested, 45 % said they were not. At the same time, 26 % wished to discuss agriculture and crops in class, while 37 % did not. About 20 % chose "don't know." Girls selected "interest" (χ^2 (2, N = 887) = 18.438, p = .000) and "crops welcome in class" (χ^2 (2, N = 768) = 20.557, p = .000) significantly more often than did boys (Figure 1).

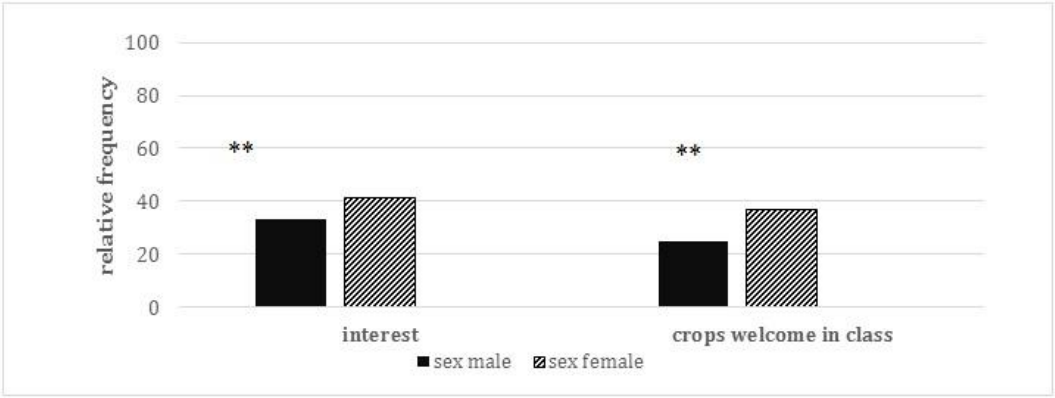


Figure 1. Results of "interest" (S11) and "crops welcome in class" (S12) according to sex and according to agricultural holding in families; N = 926, relative data given; * significant ** highly significant according to χ^2-Test

In terms of grade, 5th grade students declared themselves interested most often, interest decreased until the 10th grade and increased again in the upper grades. Similar results were found concerning desirability in class (Figure 2).

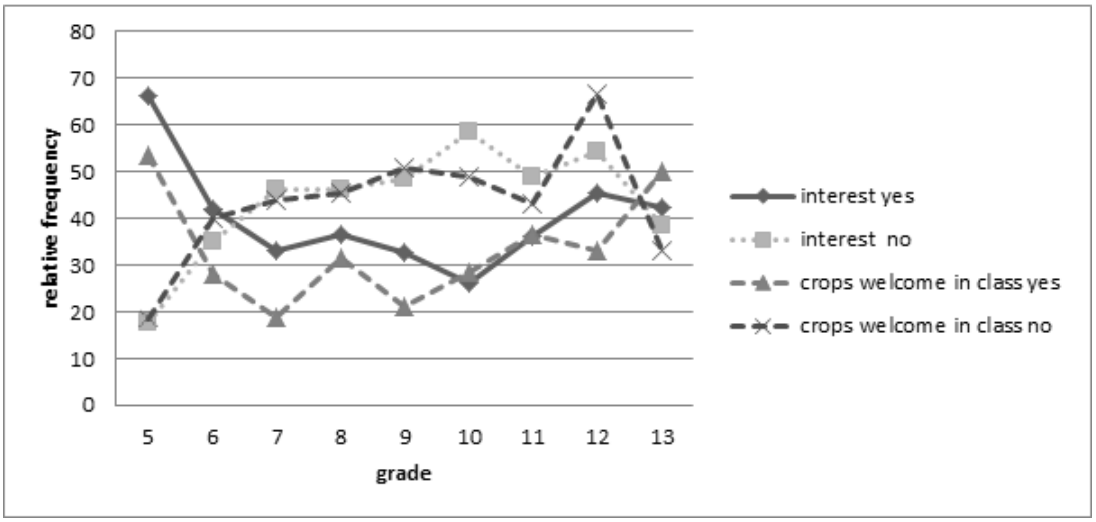
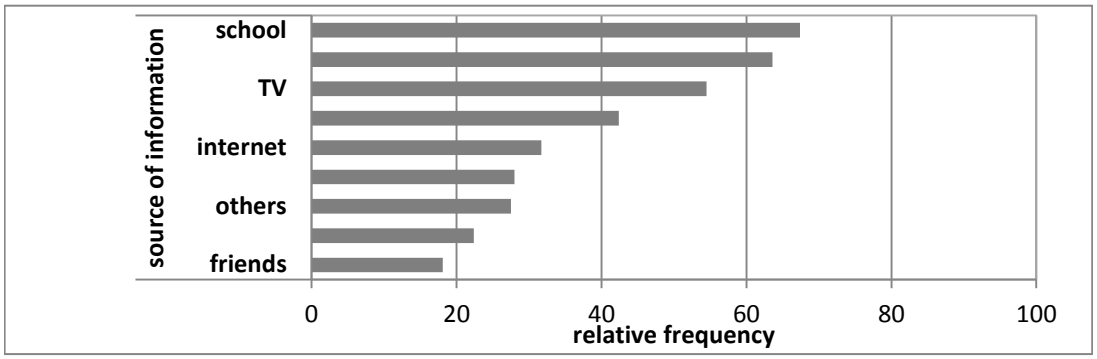


Figure 2. Results of "interest" (S11) and "crops welcome in class" (S12) during school

Sources of information on crop-related issues

School and parents were the predominant sources for students concerning crops; holidays and friends ranked in the bottom positions (Figure 3a). Within school, textbooks were the most common media, followed by film and model-reconstructions. Therefore, secondary media – offering no hands-on experiences – were used most often. School gardens, a primary media allowing real contact and hands-on experience, were in the bottom position (Figure 3b). At the same time, 510 of 926 students confirmed that their school indeed had a school garden.

(a)



(b)

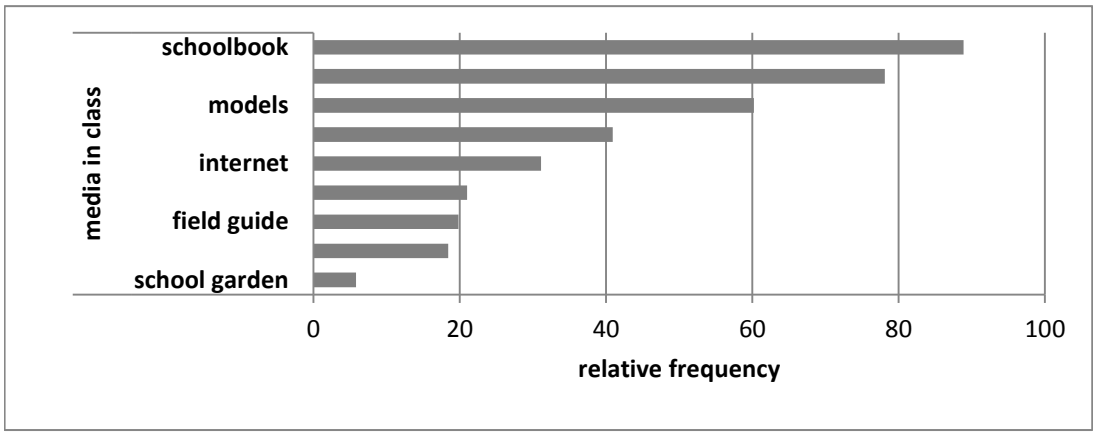


Figure 3. Ranking of students' sources of knowledge (a) and of media used in biology class (b); N = 926, multiple choice question (S6-S7), relative data given)

Parents' knowledge and interest

Parents performed significantly better on all questions of knowledge, including recognizing plant images ($t(1238) = 12.822$, $p = .000$), listing raw material plants ($t(376.151) = 15.291$, $p = .000$) and assigning plants to certain foods ($t(708.525) = 19.692$, $p = .000$). While students named on average two out of five images and two out of four origins for food production correctly, parents knew three out of five images and three out of four origins for food production. In addition, parents were able to freelist about three raw material plants, while students listed one. According to their own statements, a higher number of parents said they were interested in agriculture and crops and that both topics were discussed in school (*interest:* χ^2 (2, N = 1210) = 62.558, $p = .000$); *school:* crops χ^2 (2, N = 1222) = 62.027, $p = .000$; agriculture χ^2 (2, N = 1221) = 17.635, $p = .000$). While 38 % of the students said that

crops were discussed in school and 55 % stated that agriculture was discussed, 59 % of the parents said that crops and 64 % said that agriculture was discussed. Current students said that they had cultivated and touched or used plants in school more often (*crop plants cultivated*: χ^2 (2, N = 1223) = 21.668, p = .000; *crop plants touched*: χ^2 (2, N = 1207) = 1.445, p = .486; *crop plants used*: χ^2 (2, N = 1205) = 1.751, p = .417). However more parents selected "identification of plants in school" than did students (χ^2 (2, N = 1213) = 3.654, p = .161)..

DISCUSSION

This study, to our knowledge, provides the largest empirical analysis of students' and their parents' knowledge of crop plants and interest in crop-related issues. Its findings are comparable to other countries with similar living conditions and educational systems like in Germany.

More than wheat and corn?

According to FAO, wheat and corn are commonly cultivated in Europe and all around the world and are the most common crops in daily life e.g., in staple products (bread, noodles) or sweets (popcorn, pastries). Our results show that only plants with a strong connection to daily life (i. e. wheat and corn) are well-known with regard to image recognition, seed identification and – with some limitations – assignment of use. In other words students could only recognize two out of five crop images and seeds. Both crop species have special characteristics in their appearance, such as the female flower of corn or the beardless head of wheat, and are often printed on food packaging. A focus on special characteristics is indicated by Tunnicliffe (2001) and Zucchi (2007). Thus, it is not surprising that such plants images and seeds are well recognized. Barley, rye and oat are less well known. The confusion between rye and barley could arise from the black and white images which were presented in the questionnaires and their similar habitus displaying a spica with beard. While differences between the two species are easy to observe in the field, limited knowledge about major differences such as beard length impedes proper identification on photographs or line drawings. Moreover, the rather greyish than green color of rye kernels could not be observed in the black and white drawings. So by bringing stalks into the classroom, rye and barley should be discussed in class purposefully and examined accurately to avoid confusion. The results confirm a survey on German primary students (Hamann, 2004). She found that corn and wheat are named more often than rye, oat and barley when students are asked to list cultivated plants. As in several other surveys, girls (e.g., Gatt, Tunnicliffe, Borg & Lautier, 2007; Jäkel & Schaer, 2004), performed better in recognizing plant images, seeds and the use of crops. Moreover, daily life seems to influence children´s knowledge (Natarajan et al., 2002; Patrick & Tunnicliffe, 2011). Children remember plants encountered outside of school (Patrick & Tunnicliffe, 2011) or plants that possess a daily and sociocultural relevance (Natarajan et al., 2002). These facts can explain the high enumeration of cotton and tree/wood concerning raw material plants, which are present in daily life e.g., in clothes and furniture. Still, this enumeration is not necessarily equivalent to recognizing and knowing the plant species.

Does school really matter?

While Tunnicliffe and Reiss (2000) claimed that school was a less important source of plant knowledge for students, school was most often chosen as a source of knowledge concerning crops by our participating students. According to information

given by the students, lower and upper grades said that they were interested more often than students of 8th to 10th grade. This could indicate that either students are more interested during grades in which agriculture and crops are discussed or this could indicate that teachers adjust their classes to students' interests. At the same time, German curricula may be adjusted to students' interests as in 8th, 9th and 10th grade botanical issues are less mentioned while human biological or ecological topics are focused on (e.g. Ministerium für Bildung, Wissenschaft, Jugend und Kultur, 2014).

Even though no longitudinal study was conducted, it seems that, in terms of recognizing images and seeds, no improvement throughout school years occurs. Even the discussion of agriculture and crops did not significantly affect students' performance (except for use of crops). Only concerning the use of crops and the enumeration of raw material plants did students from upper grades perform significantly better. This could be traced back either to experiences in their daily life or to school.

The non-significant difference between lower and upper grades concerning recognizing images and seeds could indicate, that crops and their recognition are either not or are only marginally discussed in class and cannot be transmitted to long-term memory. Crops are, rather, discussed in relation to geography (agriculture, cultivation), nutrition and crop use, not in terms of their systematics or morphological or botanical characteristics. This would explain the significant difference between lower and upper grades concerning the naming of raw material plants and the use of crops for food.

Thus, our study affirms results from Tunnicliffe and Reiss (2000) and Fančovičová and Prokop (2011). Rather than school, daily life (Patrick & Tunnicliffe, 2011) and the daily use and sociocultural value of crops (Natarajan et al., 2002) seem to influence students' knowledge of plants.

As less time is spent at home due to full-time schooling and less time is spent in nature, it is of great importance that knowledge of crops and agriculture is transferred to students in school. (see e.g. Bigler & Hanegan, 2011; Holstermann, Grube & Bögeholz, 2010; Lineberger & Zajicek, 2000). Unfortunately, an analysis of 42 German school books showed that original contact and hands-on contact with crops, as well as an entire discussion of plants from seedlings to processing, are not or only marginally included (Fritsch & Dreesmann, 2014). All in all, school was the predominant source of information according to students' statements, but whether crops and agriculture were discussed in class did not affect their knowledge significantly.

Are crop plants and agricultural issues interesting at all?

Our results show, that more students declared themselves not to be interested in crop-related topics. Only 40 % of the surveyed students were interested, and only 30 % would like to discuss those topics in class. This affirms results of Holstermann and Bögeholz (2007) and Bickel and Bögeholz (2013) showing that agriculture, plants and cultivation are least interesting. Thereby, girls scored higher than boys concerning cultivation (Bickel & Bögeholz, 2013). Other surveys on students' interest in plants showed that girls were significantly more interested than boys (Kinchin, 1999; Löwe, 1987, 1992), which is consistent with our results. However, a difference can be discovered in students' grade levels. While there was a maximum in selecting "yes" in the 5th grade, the frequency of assigning interest decreased in the following grades. From 11th grade on, an increase was detected (Figure 2). Those results are consistent with Löwe (1987) and Strgar (2007). Löwe (1987) suggested a 5th grade effect. Strgar (2007) found that 5th grade students had the highest "interest" scores concerning a selection of eight given plants.

Parents vs. students – how to close the knowledge gap?

Adults in our survey performed better than students concerning recognizing images, assigning use and enumerating raw material plants. Reasons for these results can only be supposed. Knowledge increases with experience through the passing of time. This fact could explain these differences, and adults have far more life experiences than students have. Furthermore, most of the adult participants were female. Surveys showed that females have a better knowledge concerning plants (Gatt, Tunnicliffe, Borg & Lautier, 2007; Jäkel & Schaer, 2004) and that they are also more interested in them (Kinchin, 1999; Löwe, 1987). In addition, women still cook at home more often than do men (Australian Bureau of Statistics, 2009; Bianchi, Milkie, Sayer & Robinson, 2000; Meusch, 2013), which would make them more familiar with the ingredients of food. Additionally, adults selected significantly more often that crops and agriculture were discussed in class when they were students.

As plants gained much attention in former curricula and recognition skills were part of the curriculum – in contrast to the current situation (Berck, 2009) – it is plausible that more adults affirm those topics to have been discussed in school. Accordingly, their better performance could be explained through: (1) higher personal contact in the parents' childhood, e.g., helping in the field, (2) life experience or (3) discussion in school, which was less based on hands-on activities but was transmitted to long-term-memory.

Educational and methodological demand

As stated above, crops and agriculture are important issues these days. For students, school is the main source of information concerning these topics. However, there is no difference between lower and upper grade students, indicating that there may not be an increase in students' performance during school concerning recognizing plant species. Moreover, with a mean of two out of five plants or seeds, a shortcoming can be identified, which needs to be corrected. Accordingly, agriculture and crops should be discussed in school purposefully. To achieve this, both topics should be mentioned in science curricula and specific didactic material should be prepared that allows personal experience so that students feel addressed.

As a consequence, science curricula must include knowledge of species. Today, knowledge of species is implicitly mentioned but not listed in curricula (American Association for the Advancement of Science, 2009; Berck, 2009).However, students should learn and practice scientific methods connected with the scientific identification of species (monitoring, writing a register of characteristics). As learning in contexts has a positive influence on students' knowledge, motivation and interest (e.g., Goller, 2001), it is evident that not only crops but also crop-related issues should be taught in class (e.g., agriculture, climate change, plant breeding) combined with other disciplines. Hands-on experience should be included as students like such personal activities (Murphy, 1991; Nott & Wellington 1999), and hands-on experiences "increase student content knowledge" (Bigler & Hanegan, 2011).

One effort to meet the educational demands listed above is a project called the "Greenhouse Project," which is an educational research project initiated by our group in 2011. Secondary school students of different grades cultivate and examine crop plants grown inside and outside of a small greenhouse so hands-on experiences are included. Additionally, effects of drought stress and climate change are discussed. Topics from different subjects such as physics, chemistry and history are also raised within the project (Fritsch, Lechner-Walz & Dreesmann; 2015).

CONCLUSIONS

German students' knowledge of crop plants is poor. In addition, no significant difference between grades or age, respectively, can be observed. Only concerning knowledge of crop use did upper grade students show higher results than lower grade students. At the same time, many students are not interested in crops and agriculture. According to Wandersee's and Schusslers' (1999) conception of plant blindness, German students are crop-blind. Students lack knowledge of almost every plant group: herbs (Hesse, 2002; Jäkel & Schaer, 2004), wild flowers (Bebbington, 2005), toxic plants (Fančovičová & Prokop, 2011) and trees (Ammer & Gössinger, 2010). This even includes those plants they eat. And if culturally important plants are better recognized than others (Cooper, 2008), the knowledge of non-crop plant must be even worse. Our results strongly support the need for new and better teaching materials and methods to increase students' knowledge of and interest in plants.

ACKNOWLEDGEMENTS

The authors are grateful for the participation of the students, parents and teachers in our study. The authors wish to thank Dr. Cornelia Lechner-Walz for her feedback on earlier drafts of this manuscript. We are indebted to three anonymous reviewers for valuable comments and suggestions which helped to improve the manuscript.

REFERENCES

American Association for the Advancement of Science (2009). Benchmarks online: 5. The Living Environment. Retrieved from http://www.project2061.org/publications/bsl/online/index.php?chapter=5

Ammer, U., & Gössinger, L. (2010). Was wissen bayerische Schulkinder über den Wald? [What do Bavarian pupils know about the forest?] *Waldpädagogik. Unser Wald, 1*, 10–12.

Australian Bureau of Statistics (2009). Trends in household work. Retrieved from http://www.ausstats.abs.gov.au/ausstats/subscriber.nsf/LookupAttach/4102.0Publication 25.03.095/$File/41020_Householdwork.pdf

Bebbington, A. (2005). The ability of A-level students to name plants. *Journal of Biological Education, 39*(2), 63–67. Doi 10.1080/00219266.2005.9655963

Berck, K. H. (2009). Artenkenntnis wozu – Naturbegegnung was ist das? Ein Abgesang für den Biologieunterricht? [Why knowledge of species? – What does encounter with nature mean?]. *MNU, 62*(2), 68–71.

Berck, K. H., & Graf, D. (2010). *Biologiedidaktik: Grundlagen und Methoden* [Didactics of biology: Basics and methods]. Wiebelsheim, Germany: Quelle&Meyer Verlag.

Berck, K. H., & Klee, R. (1992). *Interesse an Tier- und Pflanzenarten und Handeln im Natur-Umweltschutz. Eine empirische Untersuchung an Erwachsenen und ihre Konsequenzen für die Umweltbildung* [Interest in animal and plant species and action in environmental protection. An empirical survey on adults and its consequences for environmental education]. Frankfurt am Main, Germany: Peter Lang Verlag.

Bianchi, S. M., Milkie, M. A., Sayer, L. C., & Robinson, J. P. (2000). Is anyone doing the household? Trends in the gender division of household labor. *Social Forces, 79*(1), 191–228.

Bickel, M., & Bögeholz, S. (2013). Schülerinteressen an landwirtschaftlichen Themen [Students´ interest in agricultural topics]. In J. Friedrich, A. Halsband, & L. Minkmar (Eds.). *Biodiversität und Gesellschaft. Gesellschaftliche Dımension von Schutz und Nutzung biologischer Vielfalt. Beiträge der Fachtagung, Göttingen* [Biodiversity and society. Societal dimensions of the conservation and utilisation of biological diversity.

Conference proceedings]. (pp. 59-72). Göttingen, Germany: Goettingen University Press.

Bigler, A. M., & Hanegan, N. L. (2011). Student content knowledge increases after participation in a hands-on biotechnology intervention. *Journal of Science Education Technology*, *20*, 246–257. DOI: 10.1007/s10956-010-9250-7

BMBF. (2010). *Nationale Forschungsstrategie BioÖkonomie 2030. Unser Weg zu einer bio-basierten Wirtschaft* [National research strategies BioEconomy 2030. Our way to a biobased economy]. Berlin, Germany.

Brämer, R. (2006). *Natur obskur. Wie Jugendliche heute Natur erfahren* [Obscure nature. How teenagers experience nature today].Munich, Germany: Oekom Verlag.

Burrows, G. E. (2012). Recognising differences in weed and crop species: Recognition skills of agriculture students. *Bioscience Education, 19*.

Cooper, C. L. (2008). Botanical knowledge of a group of South Carolina elementary school students. *Ethnobotany Research & Applications, 6*, 121–127.

Fančovičová, J., & Prokop, P. (2011). Children's ability to recognise toxic and non-toxic fruits. *Eurasia Journal of Mathematics, Science & Technology Education, 7*(2), 115–120.

FAO-Stat. (n. d.). Retrieved from http://faostat.fao.org/site/339/default.aspx

Hands-on Crops! How Long-term Activities Improve Students´ Knowledge of Crop Species. A Pretest-Posttest Study of the Greenhouse Project. *International Journal of Environmental & Science Education, 10*(5), 737-755.

Fritsch, E.-M., & Dreesmann, D. C. (2014). Nutzpflanzen und Landwirtschaft in Schulbüchern. Eine Untersuchung zur Alltagsrelevanz von Biologieunterricht [Crops plants and agriculture in high school biology textbooks. An analysis of textbook contents and their relevance to everyday life]. *Journal für die Didaktik der Biologie (F), 5*, 58–71.

Gatt, S., Tunnicliffe, S. D., Borg, K., & Lautier, K. (2007). Young Maltese children's ideas about plants. *Journal of Biological Education, 41*(3), 117–122. DOI: 10.1080/00219266.2007.9656080

Goller, H. (2001). *Kontextabhängiger Erwerb von Arten- und Formenkenntnissen im Biologieunterricht des Gymnasiums* [Context-based acquisition of knowledge of species in biology lessons of secondary schools] (Doctoral dissertation). University of Regensburg, Germany.

Hamann, S. (2004). *Schülervorstellungen zur Landwirtschaft im Kontext einer Bildung für nachhaltige Entwicklung* [Students' conceptions on agriculture concerning an education of sustainable development] (Doctoral dissertation). University of Education Ludwigsburg, Germany.

Hesse, M. (2000). Erinnerungen an die Schulzeit – Ein Rückblick auf den erlebten Biologieunterricht junger Erwachsener [Memories of young adults on school time – A review on experienced biology lessons]. *Zeitschrift für Didaktik der Naturwissenschaften, 6*, 187–201.

Hesse, M. (2002). Eine neue Methode zur Überprüfung von Artenkenntnissen bei Schülern. Frühblüher: Benennen – Selbsteinschätzen – Wiedererkennen [A new method to test students' knowledge of species. Early bloomers: Naming – self-assessment – recognizing]. *Zeitschrift für Didaktik der Naturwissenschaften, 8*, 53–67.

Hesse, M., & Lumer, J. (2000). Was bleibt von der Schule? Basiskenntnisse aus dem Biologieunterricht bei Erwachsenen [What remains of school? Adults´ basic knowledge gained in biology class]. *Berichte des Instituts für Didaktik der Biologie der Westfälischen Wilhelms-Universität Münster, 9*, 27–40.

Holstermann, N., & Bögeholz, S. (2007). Interesse von Jungen und Mädchen an naturwissenschaftlichen Themen am Ende der Sekundarstufe I [Boys' and girls' interest in science at the end of middle school]. *Zeitschrift für Didaktik der Naturwissenschaften,* 13, 71–86.

Holstermann, N., Grube, D., & Bögeholz, S. (2010). Hands-on activities and their influence on students' interest. *Research in Science Education, 40*, 743–757.

Hummel, E., Glück, M., Jürgens, R., Weisshaar, J., & Randler, C. (2012). Interesse, Wohlbefinden und Langeweile im naturwissenschaftlichen Unterricht mit lebenden Organismen [Interest, wellbeing and boredom in science class with living organisms]. *Zeitschrift für Didaktik der Naturwissenschaften,*18, 99-116.

Jäkel, L., & Schaer, A. (2004). Sind Namen nur Schall und Rauch? Wie sicher sind Pflanzenkenntnisse von Schülerinnen und Schülern? [Are names hollow words? How

certain is students' knowledge of plants?]. *Berichte des Instituts für Didaktik der Biologie der Westfälischen Wilhelms-Universität Münster, 13,* 1–24.

Jewell, N. (2002). Examining children's models of seed. *Journal of Biological Education, 36*(3), 116–122.

Killermann, W., Hiering, P., & Starosta, B. (2009). *Biologieunterricht heute. Eine moderne Fachdidaktik* [Biology class today. A modern didactic]. Donauwörth, Germany: Auer Verlag.

Kinchin, I. M. (1999). Investigating secondary-school girls' preferences for animals or plants: A simple 'head-to-head' comparison using two unfamiliar organisms. *Journal of Biological Education, 33*(2), 95–99.

Lindemann-Matthies, P. (2005). 'Loveable' mammals and 'lifeless' plants: How children's interest in common local organisms can be enhanced through observation of nature. *International Journal of Science Education*, *27*(6), 655–677.

Lindemann-Matthies, P., Briegel, R., Schüpbach, B., & Junge, X. (2010). Aesthetic preference for a Swiss alpine landscape: The impact of different agricultural land-use with different biodiversity. *Landscape and Urban Planning*, *98*(2), 99–109.

Lindemann-Matthies, P., Junge, X., & Matthies, D. (2010). The influence of plant diversity on people's perception and aesthetic appreciation of grassland vegetation. *Biological Conservation*, *143*(1), 195–202.

Lindemann-Matthies, P., & Marty, T. (2013). Does ecological gardening increase species richness and aesthetic quality of a garden?. *Biological Conservation*, *159*, 37–44.

Lineberger, S. E., & Zajicek, J. M. (2000). School gardens: Can a hands-on teaching tool affect students' attitudes and behavior regarding fruit and vegetables?. *Hort Technology, 10*(3), 593–597.

Löwe, B. (1987). Interessenverfall im Biologieunterricht [Loss of interest in biology class].*Unterricht Biologie, 124*(11), 62–65.

Löwe, B. (1992). *Biologieunterricht und Schülerinteresse an Biologie* [Biology class and students' interest in biology]. Weinheim, Germany: Deutscher Studien Verlag.

Meusch, D. (2013). *Iss was, Deutschland? – TK-Studie zum Ernährungsverhalten der Menschen in Deutschland* [Eat something, Germany? TK-survey on peoples´ nutritional behavior in Germany]. Hamburg, Germany. https://www.tk.de/centaurus/servlet/contentblob/498464/Datei/64173/TK_Studienband_zur_Ernaehrungsumfrage.pdf

Ministerium für Bildung, Wissenschaft, Jugend und Kultur (2014). *Lehrpläne für die naturwissenschaftlichen Fächer für die weiterführenden Schulen in Rheinland-Pfalz. Biologie Chemie Physik. Klassenstufen 7 bis 9/10* [Science curriculum for secondary school in Rheinland-Pfalz. Biology – Chemistry – Physics. 7th–9/10th grade]. Mainz, Germany.

Murphy, P. (1991). Gender differences in students' reaction to practical work. In R. Levinson (Ed.). *Teaching science* (pp. 131–144). London, UK: Routledge.

Nadeau, R., & Niemi, R. G. (1995). Educated guess: The process of answering factual knowledge questions in surveys. *The Public Opinion Quarterly, 59*(3), 323–346.

Natarajan, C., Chunawala, S., Apte, S., & Ramadas, J. (2002). Lessons for teaching botany: What middle school students know about plants. http://www.modelab.ufes.br/xioste/papers/xioste_paper010.pdf

Nott, M., & Wellington J. (1999). The state we're in: Issues in key stage 3 and 4 science. *School Science Review, 81*(294), 13–18.

OECD. (2009). *The bioeconomy to 2030: Designing a policy agenda*. Paris, France: OECD Publishing.

Patrick, P., & Tunnicliffe, S. D. (2011). What plants and animals do early childhood and primary students' name? Where do they see them*?. Journal of Science Education Technology, 20*(5), 630–642. DOI: 10.1007/s10956-011-9290-7

Prokop, P., Tuncer, G., & Chudá, J. (2007). Slovakian student' attitudes towards biology. *Eurasia Journal of Mathematics, Science & Technology Education, 3*(4), 287–295.

Schussler, E. E., & Olzak, L. A. (2008). It's not easy being green: Student recall of plant and animal images. *Journal of Biological Education, 42*(3), 112–119.

Strgar, J. (2007). Increasing the interest of students in plants. *Journal of Biological Education, 42*(1), 19–23.

Tunnicliffe, S. D. (2001). Talking about plants: Comments of primary school groups looking at plant exhibits in a botanical garden. *Journal of Biological Education, 36*(1), 27–34. DOI:10.1080/002/00219266.2001.9655792

Tunnicliffe, S. D., & Reiss, M. J. (2000). Building a model of the environment: How do children see plants? *Journal of Biological Education, 34*(4), 172–177.

Wagner, G. E. (2008). Botanical knowledge of a group of college students in South Carolina, U.S.A. *Ethnobotany Research & Application, 6*, 443–458.

Wandersee, J. H., & Schussler, E. E. (1999). Preventing plant blindness. *The American Biology Teacher, 61*(2), 82, 84, 86.

Zubke, G., & Mayer, J. (2003). Ökologisches Verständnis und Umwelthandeln im schulischen und außerschulischen Kontext [Ecological Understanding and environmental action in school and out of school contexts]. In A. Bauer et al. (Eds.). *Entwicklung von Wissen und Kompetenzen im Biologieunterricht. Internationale Tagung der Sektion Biologiedidaktik im VDBiol 14.09. – 19.09.2003.* [Development of knowledge and competences in biology class. Conference proceedings]. (pp.67-70). Berlin, IPN.

Zucchi, H. (2007). Zur Bedeutung und zum Erwerb von Artenkenntnissen [Meaning and acquisition of knowledge of species].*Unterricht Biologie, 324*, 44–45.