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The effect of age on students' conceptions of agriculture

Agricultural literacy is increasingly regarded as an important issue in sustainability education, yet little survey data regarding children and adolescents are available. We therefore surveyed two different age groups, fifth and sixth graders (n=122) and tenth graders (n=158) of German schools, about their conceptions of farmers' duties, thereby identifying seven distinct conceptions. The conception most frequently mentioned by the younger students was animals (85.7 per cent) followed by processing (68.7 per cent), whereas the older students named the conception plants (76.0 per cent) most often, followed by animals (65.2 per cent). We found discrepancies in the sub-conceptions of animals between the two age groups, but none in plants. Ecology-related aspects (5.1 per cent) were only mentioned by the older students. We then examined the effect of a student having an agricultural family background on the conceptions named. Only 25 per cent of the younger students and none of the older students reported a past contact with farms through visits or guided tours. We found that regardless of having an agricultural family background, most students lack an understanding of the impact of agriculture on the environment. Consequently, we conclude that agricultural education in German schools does not adequately teach modern agricultural practices or the importance of modern agricultural challenges.

Keywords: agriculture literacy, alternative conceptions, school education, context-related learning

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Introduction

Even before any educational interventions, children and adolescents have scientifically correct, less correct or even incorrect conceptions, originating from individual everyday experience (Tanner and Allen, 2005). Within the literature, there are many different terms for non-scientific conceptions, like *preconceptions* (Novak, 1977), *misconceptions* (Helm, 1980) or *everyday conceptions* (Lewis and Kattmann, 2004). In the following, we will use *alternative conceptions* (Driver and Easley, 1978) for non-scientific conceptions as a neutral term. Conceptions are very stable and firmly held (Duit and Treagust, 2003a; Treagust and Duit, 2008), even when students later learn about the correct scientific conceptions. During learning processes that consider the discrepancy between the alternative and the scientific conceptions, confusion on the students' side may arise and impede the learning process (Vosniadou *et al*., 2001, Poehnl and Bogner, forthcoming). The conceptual change theory describes the methodology and principles of how mostly nonscientific conceptions can potentially be modified into scientific ones (Posner *et al.*, 1982). Such a change or even a total replacement of students' alternative conceptions is not a linear process and is generally very difficult to achieve (Duit and Treagust, 2003b). For a conceptual change process to take place, teachers and educators must first gather information about any alternative conceptions the students may have and then confront the students' alternative conceptions by presenting the scientific ones. The students' dissatisfaction with their alternative conceptions combined with the discrepancy between the conceptions themselves should start a process to modify the existing conceptions. The theory has subsequently been revised based on studies showing that there are still more or less big fragments of the alternative conceptions kept in the students' minds. Such studies have addressed how hybrid conceptions arise (Gilbert *et al.*, 1982); the development of the synthetic model (Vosniadou and Brewer, 1992); and peripheral conceptual change (Chinn and Brewer, 1993). Nevertheless, regarding the state of research on the efficiency of conceptual change approaches, 'there appears to be ample evidence in various studies that these approaches are more efficient than traditional approaches dominated by transmissive views of teaching and learning' (Duit *et al*, 2008, p.636).

In our present study, we identified the conceptions which students held before and at the end of secondary school regarding the field of agriculture as well as farmers' duties. To the best of our knowledge, there are currently no published studies about students' conceptions of this topic. In the field of agriculture and alternative conceptions, there are only a few studies: Trexler *et al*. (2000) analysed fifth graders' understanding of livestock and meat production; Heleski and Zanella (2006) asked animal science students about their conceptions concerning general husbandry practices; Meischen and Trexler (2003) mentioned a few studies about the agricultural literacy of elementary school students; and Trexler (2000) found that elementary school students did not show much understanding of modern agriculture, its place within society and its effects on the environment.

Our research focused on general farmers' duties. This may at first seem to be a very simple task, but it is an important first step in identifying students' conceptions and ideas about agriculture. In the agricultural field, owing to the fact that the students learn mostly through secondary and tertiary sources, stereotypes are developed and kept in a student's imagination (Wright *et al.*, 1994).

The need to overcome the previously described knowledge gap was first highlighted when agricultural literacy was defined in the 1990s (Frick *et al.*, 1991). Agricultural literacy defines and explains the principles and conceptions which every citizen should know about agriculture: the societal and global importance of agriculture; agricultural policy; agriculture's relationship with the environment and natural resources; plant and animal science; the processing, marketing and distribution of agricultural products.

However, why is knowledge about the agricultural industry and production practices important? Why is there a need for agricultural literacy? In the light of the recent food scandals (e.g., mad cow disease, *E. coli* outbreaks, antibiotics in meat and dioxin in eggs), the increasing environmental problems are to a vast extent thought to be caused by modern

agricultural practices (Leising *et al.*, 1998), and there is an ongoing debate about adequate food prices in politics and the media. Consequently, it is important for the next generation to have enough agricultural literacy to be in a position to form well-founded opinions about the future development of the agricultural industry and food production (Hubert *et al.*, 2000). The US National Research Council has already stated in 1988 that 'all students should receive at least some systematic instruction about agriculture' sometime over the course of their schooling (Meunier *et al.*, 2003, p.23).

In Bayern, Germany, where our study took place, such advice is not as common, but the awareness of the importance of agriculture education is increasing as shown by the requirement that every elementary student visits a farm and the government's financial support of these visits. Agriculture has a long tradition in Bayern and still is of importance in the nowadays modern industrial state. One third of the agricultural farms in Germany are situated in Bayern, which comprises a fifth of the size of Germany. The average size of a farm in Bayern is about 32 ha and nearly half of them are farmed as a sideline and as a family business. In 2011 the utilised agricultural area was about 44.6 per cent of the land coverage, which was a decline of 9 per cent in comparison to 1970 (Bayerisches Staatsministerium für Ernährung, Landwirtschaft und Forsten, 2012). Nevertheless, agriculture still dominates the countryside, but fewer and fewer people are in close contact with agricultural practice.

As an added benefit, interdisciplinary agricultural involvement substantially improves students' scientific thinking and awareness of complex ecological conceptions (Ivanitskaya *et al*., 2002; Knobloch, 2008). Integrating agriculture and agricultural topics within the curricula of scientific subjects could beneficially increase interests of individual people in science by connecting real-world applications with everyday lives (Lynch, 2000). In a pilot study at a secondary school, agriculture was integrated in science lessons during a complete school year: based on the higher student achievement levels he found, Balschweid (2001) showed this to be a more effective way of teaching science compared to teaching the usual content.

The low priority that has been assigned to agricultural education in schools' curricula in, for instance the United States (Trexler and Suvedi, 1998; Terry *et al.*, 1992), as well as in Germany (Bischopink and Brandes, 2002; Busch, 2003) could have diverse reasons:

- The potential of agriculture as a science subject (including mathematical, chemical, biological and physical aspects) which relates to the everyday lives of students has not yet been realised by many teachers (Knobloch, 2008).
- Most teachers have little knowledge about agriculture. They therefore do not feel very competent concerning the issue nor consider agriculture as the important topic it is today (Ball *et al.*, 2003).
- A typical syllabus for teaching agriculture often includes a field trip to a farm or food-processing plant. Due to time-management problems or other reasons, these field trips are mostly cancelled (Prokop *et al.*, 2007).

To get a first impression about previous experience and knowledge, we asked students a simple question about what duties they consider typical for farmers. We expected a pattern association about the diverse fields of agriculture with the exception of the global trade markets. Based on these theoretical considerations our research objectives included answering two major questions: (1) What conceptions of farmers' duties do students have at the beginning and at the end of secondary school? and (2) Are there any differences between the conceptions of students with or without an agricultural family background?

Methodology

We selected fifth and sixth graders as subjects (87 fifth graders, 25 sixth graders; 50 boys, 62 girls; age: $M = 11.7$, $SD = 0.64$) as well as tenth graders (73 male adolescents, 85 female adolescents; age: $M = 16.0$, $SD = 0.81$); all the subjects were selected from 14 different classes from five different cities in the state of Bayern in Germany. The communities have populations of 13,000 to 73,000 inhabitants and the students came either directly from each city or from the rural surroundings. None of the schools had implemented agricultural education programmes or projects.

We chose age groups at the beginning and at the end of secondary school. All the subjects were surveyed about their conceptions of farmers' typical duties. They were asked to provide the first two conceptions that came to mind. The responses were iteratively categorised by following the method of inductive category development, a very common method in qualitative analyses (Figure 1, Mayring, 2000). In the first step, all the student answers were categorised according to the research question into 12 categories. An inter-rater reliability analysis using the Cohen's Kappa statistic was performed to determine the consistency among raters. Based on 10 per cent of the participants, all randomly selected, we calculated Cohen's coefficient Kappa for inter-rater consistency: $\kappa = .73$. According to Mayring (2000), this can be considered as sufficient.

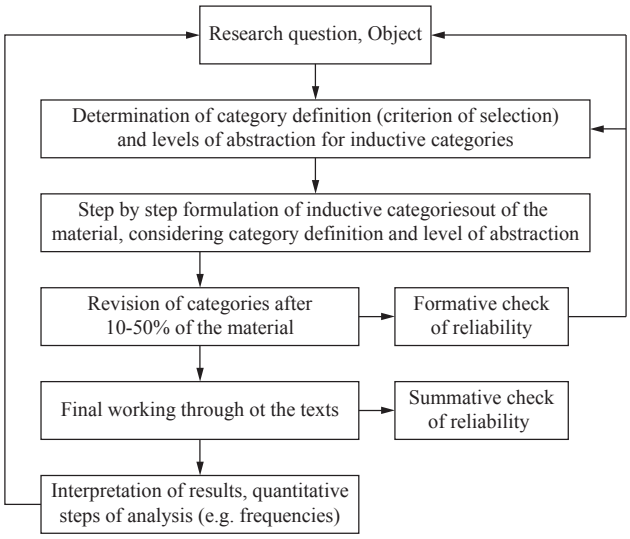

Figure 1: Step model of inductive category development (according to Mayring, 2002).

In the following steps, the categories were revised (feedback loops), and we extracted seven main categories out of the 12 preliminary ones and classified the answers according to these categories. Additionally, the two most frequent categories, *animals* and *plants*, were analysed in more detail to gain further insight into the students' conceptions of these categories. We also examined whether the students had an agricultural family background as well as the frequency and reason for individual farm visits.

Results

We selected seven different main conceptions (see Table 1) out of the total conception data body. The most popular association pairs derived from the younger students' responses were *animal – processing* (40.5 per cent), followed by *processing – animal* (31.0 per cent) and *animal – animal* (9.5 per cent). In comparison, the older students' responses were mostly *plant – animal* (40.6 per cent), *animal – plant* (27.1 per cent) and *plant – plant* (16.7 per cent).

Figure 2 shows the frequency as a percentage of all the participating fifth and sixth graders in comparison to tenth graders. The biggest difference between the two student groups is the naming of a plant-related conception: 76.0 per cent of the tenth graders named this type of conception in comparison to 8.9 per cent of the fifth and sixth graders. *Animals* is the conception most often reported by the younger students (85.7 per cent), whereby 65.2 per cent of the tenth graders named *animals* as the second most common conception. Also the fifth and sixth graders named *processing* more often than the tenth graders (68.8 and 29.8 per cent respectively). Ecological aspects, however, were only associated by the tenth graders (5.1 per cent).

For a more detailed analysis, we compared the sub conceptions of *animals* and *plants* from the two sample groups. In each of these categories, we identified eight sub conceptions named by the younger students and six named by the older students. Regarding the animal-related duties, the percentage of students who named *milking* is the biggest difference between the subsamples (fifth/sixth graders: 40.9 per cent; tenth graders: 1.6 per cent). Other notable differences include the naming of *feeding* (fifth/sixth graders: 12.5 per cent; tenth graders: 4.4 per cent) and animals such as *cows* (0.5 per cent) and *chickens* (0.5 per cent) were specifically named only by the younger students (Figure 3).

Comparing the individual answers with respect to plant-related aspects, we found no significant differences between the subsamples (Table 2).

Table 1: The seven main categories of Bavarian students' conceptions about the duties of farmers in 2011 (two answers per student).

Item	Main categories
What are the most important duties of farmers?	Activities related to… - Animals, e.g. feeding, breeding - Plants, e.g. field work, sowing - Ecology, e.g. land management - Processing, e.g. food production - Technology, e.g. tractor driving - Marketing, e.g. selling of products - Others, e.g. doing agriculture

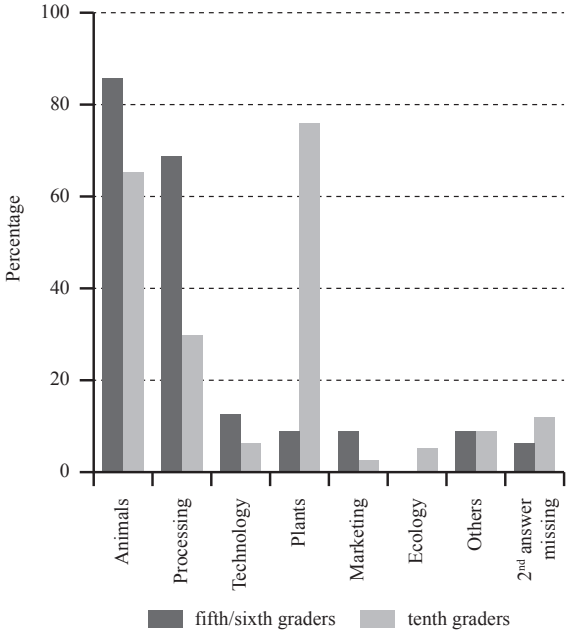

Figure 2: Percentage of the main categories of farmers' duties generated from the conceptions named by Bavarian fifth/sixth grade and tenth grade students concerning the duties of farmers in 2011.

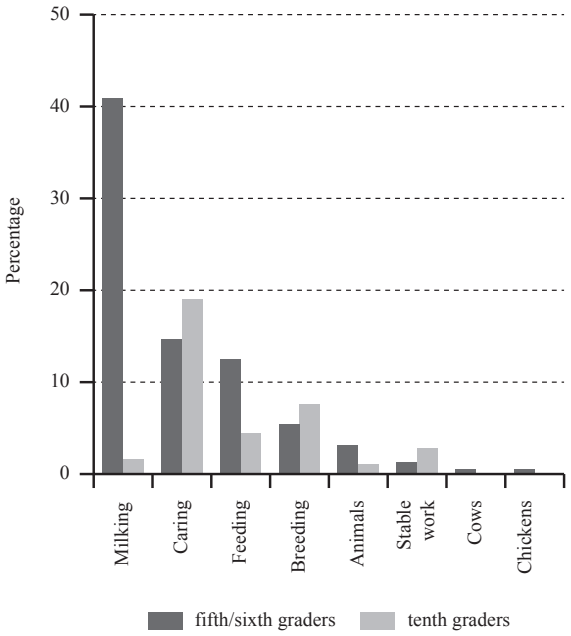

Figure 3: Comparison of the sub conceptions of animal-related duties of farmers named by Bavarian fifth/sixth grade and tenth grade students (percentage of all answers) in 2011.

Table 2: Comparison of the sub conceptions regarding farmers' plant-related duties between Bavarian fifth/sixth graders and tenth graders in 2011 (percentage of all answers).

Duty	Fifth/Sixth graders (%)	Tenth graders (%)
Agricultural land use	17.4	18.4
Harvesting	7.6	9.5
Crop	5.8	3.2
Cultivation	4.5	8.2
Sowing	2.2	2.5
Vegetables	1.8	3.2
Plant breeding	0.9	-
Manuring	0.9	-

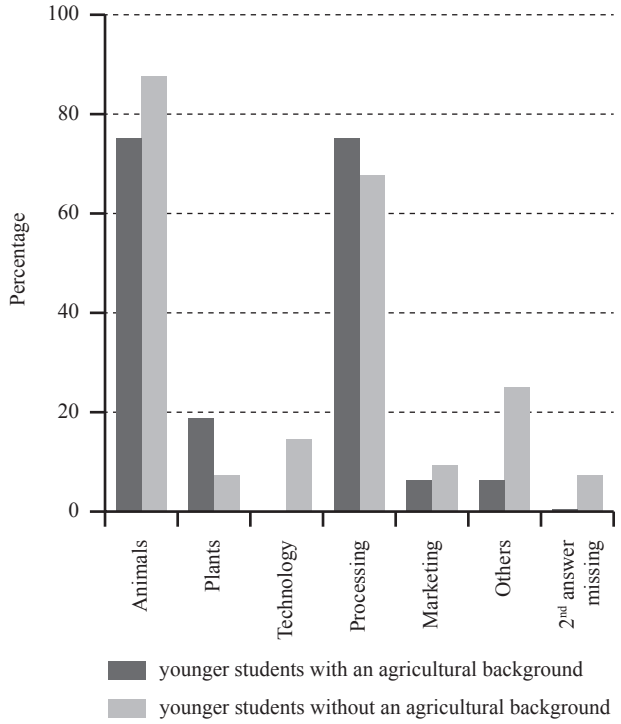

Figure 4: Comparison of the conceptions concerning the duties of farmers as named by Bavarian fifth and sixth grade students with (n=16) and without (n=96) an agricultural family background in 2011.

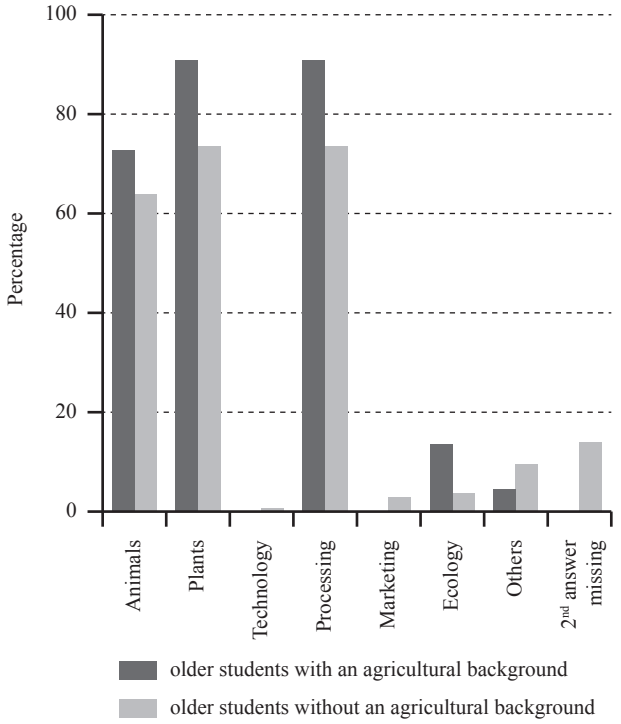

Figure 5: Comparison of the conceptions concerning the duties of farmers as named by Bavarian tenth grade students with (n=22) and without (n=136) an agricultural family background in 2011.

Dividing the group of fifth and sixth graders into groups of students with (n=16) and without (n=96) an agricultural family background, we found further differences in the answers concerning the duties of farmers (Figure 4). Students with no agricultural family background named the category *animals* most often (87.5 per cent) followed by *processing* (67.7 per cent). Students with an agricultural family background, however, named these two categories with similar frequency (*processing*, *animals*: 75.0 per cent). Interestingly, the category *plant* was named twice as often by students with an agricultural family background compared to those without (18.8 per cent c.f. 7.3 per cent). The answer spectrum for these students was also greater (*others*: 25.0 per cent c.f. 6.3 per cent). Of the students without an agricultural family background, 7.3 per cent had problems identifying a second duty.

We also examined the answers provided by tenth graders with (n=22) and without (n=136) an agricultural family background and found interesting results This comparison of naming divided in the existence of an agricultural family background is also very interesting for the older students (Figure 5). All the students without an agricultural family background named *animals* (72.7 per cent), *plants* (90.9 per cent) and *ecology* (13.6 per cent) more often than the other group (64.0, 73.5 and 3.7 per cent respectively). Furthermore, 14.0 per cent of the students without an agricultural family background could not name a second duty.

To gather additional information, we asked the students how often they visit a farm on average. Independent of age, most of the students reported having visited a farm several times in the past (fifth/sixth graders 53.6 per cent; tenth graders 44.3 per cent). In the younger student sample group, except for those students who visited a farm infrequently (fewer than several times), visiting friends and family was the most often stated reason. Just four of the fifth and sixth graders and two of the tenth graders named either a kindergarten or school field trip as a reason for a visit. Also comparable between the two subsamples is the percentage of students who never visited a farm: 4.5 per cent and 4.4 per cent (Table 3).

Table 3: Frequency and most reported reasons for farm visits of the sample groups of Bavarian students.

Frequency	fifth/sixth graders (%) (n= 112)	Most reported reason	tenth graders (%) (n= 158)	Most reported reason
Every day	2.7	Family home (100%)	3.8	Friends/Family (83.3%)
Several times a week	14.3	Friends/Family (50.0%)	9.5	Friends/Family (53.3%)
Several times	53.6	Friends/Family (36.7%)	44.3	Friends/Family (64.3%)
Infrequently	25.0	Visits/Guided tour (64.3%)	38.0	Friends/Family (50.0%)
Never	4.5	-	4.4	-

Discussion

The main focus of our study is the quantitative and qualitative analysis of students' conceptions about farmers' duties at the beginning and at the end of secondary school. Most of the students' conceptions, independently of age, include very simple conceptions of farmers' duties. Some of the associations do not include activities as required, but instead function as substantial umbrella terms such as for example *animals* and *plants*. Considering these answers, we may conclude that these students do not have detailed conceptions about the duties of farmers. The production of food, generally mentioned as the main duty of farmers, was defined as *processing*. Most of the students named either specific animal- or plant-based products such as milk or vegetables without merging them to one higher-level category, for example food production. Interestingly, none of the conceptions of modern agricultural practices, such as bioenergy, soil conservation and efficient management, were stated: Therefore, either the students do not know about these practices or they may not consider them as important duties of farmers. Our results indicate that students seem to have a very old-fashioned image of farmers and use stereotypic associations concerning the related duties. The students often focus on the manual labour of farmers and nearly completely miss the chemical, physical, economic or ICT-related tasks and/or competencies involved. This result is in line with Ruth *et al*. (2005) who analysed this issue in the mass media by specifically pointing to an underrepresentation of modern and authentic agriculture on television (Searls *et al.*, 1985).

The older students naming plant-related aspects much more often than the younger ones might be due to individual cognitive development: 11- to 13-year-olds see animals as very important, whereas plants are of no interest (Kellert, 1985, Morgan, 1992). This is in line with our results where the older students (15- to 17-year olds) named plant conceptions nearly as often as animal conceptions. Students of this age group apparently see the farmers' duties as nearly equally divided between animal and plant related duties. In conclusion, our results suggest that the students either have the conception of a farm with animal- as well as plant-production or they see plant-based production as the focus of agricultural production.

This can be clearly seen when the conceptions are analysed in more detail. With regard to the number of animal-related duties named in relation to the total number of conceptions, the fifth graders named *milking* most often (40.9 per cent), while the tenth graders seldom named this aspect (1.6 per cent). For the younger students, milk seems to be far more important than it is for the older ones in this context. Milk production and cows seem to be for many of them the embodiment of agriculture.

As the results another study also indicate (Poudel *et al.*, 2005), our students were not likely aware of the importance of the agriculture-environment link. However, we can say that the tenth graders may be more aware than the fifth and sixth graders of the relation between agriculture and environment since at least 5 per cent of the duties that they name are ecology-related duties. This suggests that either the students may not know the impact of agriculture on the environment or they do not consider the environmental aspects of agriculture to be very important. Regardless of the reason, the students seem to lack knowledge about the close interrelation of agriculture and ecology. Considering the severe environmental problems caused by agriculture, students as the future generation should know about the relationship between agriculture and ecology as they have to face these problems in the future.

Yet when we compared the answers between students with and without an agricultural family background, we found that ecology-related duties were named more often by students with an agricultural family background. This corroborates on the one hand the importance of farmers' ecology-related duties and on the other hand the knowledge gap regarding these duties experienced by students with less contact to agriculture.

Matthews and Falvey (1999) showed that non-metropolitan tenth graders have a more negative view of the impacts of agriculture on the environment than metropolitan students. Our results show that the tenth graders with an agricultural family background mentioned ecological aspects more often than the students with no agricultural background. However, our students might have mentioned ecological duties more often, an indication of the duties' perceived importance, because they know about the negative impact of agriculture on the environment. As the younger students did not mention ecological duties at all, we recommend teachers and educators to focus on this important aspect when educating younger students.

Summarising our findings, we find no relevant differences in the answers from both age groups except in the case of plant-related aspects. Therefore we assume that the agricultural education in secondary schools in Bayern, Germany are not providing students with deep knowledge of agricultural practices nor focusing on the preliminary challenges and tasks of modern agriculture. Of course, the main duty of farmers is producing food, but most of the students could not think of anything else. There may be a reason for that which involves the frequency of the students' farm visits: only the younger students reported infrequent visits to a farm through guided tours, which may have been organised by schools; the most common reasons for both age groups to visit a farm were friends or family. To what extent they got to know background knowledge when visiting friends or grandparents is questionable. For this reason, it is school education that must ensure students attain agricultural literacy. To change the conceptions of the students to reflect a more in-depth understanding of farmers' duties, we suggest interventions or programmes where the students could get an opportunity to get more in contact with agriculture and actual farmers. The most efficient way would be to get the students actively involved with a farmer's work, possibly arranged as farm-stays on a modern farm with large-scale production facilities. If that is for some reason not possible, the teachers should at least show scientific documentaries since these also have effects on students' awareness and learning (Barbas *et al.*, 2009). The students on educational farms often are only exposed to very simple images and basic ideas of agriculture. Most of the farms offering pedagogical programmes are very different from modern farms, for example, with respect to

the size, amount of animals and farming techniques. Therefore, it is not only important for the students to have real experiences on such farms, where it is easier to implement students as workers, an authentic life experience at modern industrialised farms is also important.

Another reason for the lack of agricultural literacy could be, as already mentioned, teachers' lack of knowledge about modern agricultural practices. Anderson *et al*. (2010) conducted a study with teachers at different educational levels (pre-kindergarten through secondary school) about their conceptions of agriculture. The teachers' conceptions mainly consisted of those in animal and plant production, as in our study with the students. It is therefore important not only to educate the students but also the teachers in agriculture literacy. The teacher training should also be done on farms to give the teachers the opportunity to gain a deeper understanding of agriculture by talking to farmers and experts. Additionally, the idea of agriculture as a science subject seems to be an innovative method of teaching and should be fostered in schools.

In conclusion, we find that it is absolutely essential to apply interventions that teach modern agriculture practices or to restructure the curricula in such a way that the students learn the required knowledge.

Potential limitations of the study

To achieve this, we used the paper-pencil-method to get quantitative data. A more qualitative analysis, however, would be very interesting to obtain more in-depth information about the students' images of agricultural practices. According to the students' answers in our study, students may form their conceptions based on picture booklets or personal experience on small farms. For future research on agricultural conceptions, we suggest interviews or focus groups to gain more in-depth knowledge about agricultural literacy in different age groups. As there appears to be a lack of knowledge regarding the impact of agriculture on the environment, this should also be a focus of future investigations.

Although the teacher's knowledge is regarded an important factor as well (Frick *et al.*, 1995; Knobloch, 2008; Anderson *et al.*, 2010), we were not able to collect such data due to administrative restrictions. However, to the best of our knowledge, this is the first study to collect the conceptions of Western European (in our case, German students) students about agriculture. In the United States, the awareness of the importance of agricultural education was established about 20 years ago. Yet in Europe, this realisation of the importance of agricultural education is just at the beginning, and the research in this educational field has just started.

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