Professional Competence of Student Teachers to Implement Species Identification in Schools – A Case Study from Germany

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This study investigates how well prepared student teachers are to implement species identification in school. Data were collected with the help of a questionnaire and a PowerPoint presentation in which local plant and animal species were presented. Participants (n = 357) correctly identified, on average, 23% of the plants and 44% of the animals. They identified plants mainly by flower characteristics and leaves, and animals mainly by shape and colour. Family and school were key sources of participants' knowledge of species. The self-estimated competence of participants to identify species was positively correlated with their taxonomic knowledge and the amount of time they had spent on species identification during their own schooldays. The number of correctly identified plant and animal species increased with interest in identifying species and participation in species identification courses. Participants considered learner-centred education and experience-based learning, and the use of living organisms to be most important when identifying species in school.

Keywords: biodiversity; species identification; student teachers; curriculum

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Strokovne kompetence bodočih učiteljev za implementacijo prepoznavanja vrst v šoli – študija primera iz Nemčije

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Ta raziskava preučuje, kako dobro so bodoči učitelji pripravljeni na implementiranje prepoznavanja živalskih in rastlinskih vrst v šoli. Podatki so bili zbrani s pomočjo vprašalnika in predstavitve v PowerPointu, v kateri so bile predstavljene lokalne rastlinske in živalske vrste. Udeleženci (N = 357) so v povprečju pravilno prepoznali 23 odstotkov rastlin in 44 odstotkov živali. V večini primerov so rastline prepoznali glede na značilnosti cvetov in listov ter živali glede na obliko in barvo. Glavna vira znanja udeležencev o vrstah sta bila družina in šola. Samoocena kompetenc udeležencev za prepoznavanje vrst je bila pozitivno povezana z njihovim taksonomskim znanjem in s količino časa, ki so jo v šoli namenili prepoznavanju vrst. Število pravilno prepoznanih rastlinskih in živalskih vrst se je povečalo z njihovim zanimanjem za prepoznavanje vrst in s sodelovanjem pri predmetih, pri katerih se ukvarjajo s prepoznavanjem vrst. Udeleženci so opredelili, da so za prepoznavanje vrst v šoli najpomembnejši na učenca osredinjeno poučevanje in izkustveno učenje ter uporaba živih organizmov pri pouku.

Ključne besede: biotska pestrost, prepoznavanje vrst, bodoči učitelji, kurikulum

Introduction

Biodiversity has been recognised as an educational priority at all levels of formal education (UNESCO, 2005) and it has been proposed that pupils should be empowered to act in ways that protect and conserve biodiversity (Gayford, 2000; Lindemann-Matthies et al., 2011; Menzel & Bögeholz, 2009; Van Weelie & Wals, 2002). However, pupils might not care about species which they do not know and cannot name (Pilgrim, Cullen, Smith & Pretty, 2008; Weilbacher, 1993). Familiarising pupils with local plants and animals should thus be a fundamental part of biodiversity education in school (Barker, Slingsby & Tilling, 2002; Leather & Quicke, 2010; Lindemann-Matthies, 2005, 2006; Scott et al., 2012). However, teachers might not be well-prepared for this task.

Systematic biology has been drastically reduced in recent decades at European universities (Bilton, 2014; Leather & Quicke, 2009; Swiss Academy of Sciences, 2006), leading to a generation of academics, teachers included, who can barely identify organisms or know their functions (Leather & Quicke, 2009; 2010; Stagg & Donkin, 2013). In a British study, for instance, only a few (student) teachers were able to identify more than three common local wildflowers, which were shown to them as colour illustrations (Bebbington, 2005). Moreover, among biology undergraduates in the UK, a conspicuous decline in both botanical and zoological knowledge has been observed (Leather & Quicke, 2010). The authors concluded that most biology students today have virtually no training or experience in identifying organisms and that the drive towards ever more molecular courses is exacerbating the situation. The 'taxonomic impediment' in higher education (Bilton, 2014) is reinforced by the fact that in industrialised, high-income countries, which are now largely independent of local environmental goods and services, knowledge about species and their functions is no longer needed to sustain people's livelihoods (Pilgrim et al., 2008).

Decreasing knowledge of local biodiversity in highly developed countries (e.g. Balmford, Clegg, Coulson & Taylor, 2002; Bebbington, 2005; Lindemann-Matthies, 2002a, b) is not only due to decreasing educational opportunities, or less dependence on natural surroundings for food or other resources, but also due to a reduction of independent outdoor experiences for children. With increasing urbanisation, 'wild' habitats that children prefer for outdoor play and nature investigations are lost (Louv, 2006), and parental anxiety regarding social and traffic dangers increasingly keeps children indoors (Hüttenmoser, 1995; Prezza, Alparone, Cristallo & Luigi, 2005; Valentine & McKendrick, 1997). Electronic/video games and television also keep children indoors, thus contributing to a reduction of their autonomous outdoor experiences and knowledge of local organisms (McKendrick et al., 2000). When, for instance, in Switzerland more than 6000 young people between the age of eight and 18 were asked about organisms in their immediate environment, on average five plants and six animals were named and unspecified taxa, such as 'flowers' and 'birds', were among the most commonly listed in all age-groups (Lindemann-Matthies, 2002a).

Familiarising pupils with local plants and animals through relevant experiences in school requires competent teachers. In this paper, we present results from a German case study on the professional competence of primary and secondary school student teachers to implement species identification in school. Our study took place in the federal state of Baden-Württemberg. The state's education plans for both primary and secondary school requiring pupils to be sensitised to the diversity of local plants and animals, and for species conservation. However, the education plans do not provide teachers with a canon of species or a list of groups of organisms, which pupils should know. They also do not refer to certain identification strategies or approaches for species identification. This means that the number and identity of plants and animals pupils will become familiar with, and the ways that species are introduced in school, depend on the individual teacher, and thus on his or her own knowledge of species, identification approaches and commitment to species-identification activities.

The overall goal of the present study was to investigate how well-prepared student teachers are to implement species identification in school. The results contribute to international studies on people's ability to identify species (e.g. Balmford, Clegg, Coulson & Taylor, 2002; Bebbington, 2005; Lindemann-Matthies, 2002a; Lückmann & Menzel, 2014; Palmberg et al., 2015; Randler, 2008), on features used when identifying organisms (e.g. Kos & Jerman, 2015; Tunnicliffe & Reiss, 1999, 2000) and on suitable approaches for species identification in school (e.g. Lindemann-Matthies, 2006; Palmberg et al., 2015; Randler & Bogner, 2002; Scott et al., 2012). The main questions explored in this study were:

(Q1) How familiar are student teachers with local plants and animals and which specific features do they use to identify species?

(Q2) How interested are they in identifying species and from where do they obtain their knowledge (initial teacher education, other sources)?

(Q3) How satisfied are they with their teacher preparation, and how competent do they feel they are to identify species?

(Q4) Which approaches and methods do they consider most suitable when investigating species at school?

Methods

Data collection

The present study took place at one university in the federal state of Baden-Württemberg, which places much emphasis on biodiversity education. Data were collected with the help of a PowerPoint presentation and a questionnaire. All data collection exercises took place during normal lesson hours of biology courses and required approximately 45 minutes. Lecturers were contacted in advance and asked for their support. Student teachers were not informed in advance about the study. At the start of each data collection exercise, a short introduction about the PowerPoint presentation and the questionnaire was provided, always by the same person and in a similar way. At the end, all participants received some sweets to thank them for their participation. Participation was voluntary and anonymity guaranteed to the participants. A pilot test was made with student teachers enrolled in an ecology course, who did not participate in the present study. No changes to the questionnaire were needed.

PowerPoint presentation and questionnaire

Overall, 18 plant species and 18 animal species were presented to the study participants (Table 1). The species were included in two separate PowerPoint presentations, i.e. one presentation for plants and one for animals. Each presentation was shown to about 180 student teachers and the subsequent questionnaire items referred either to plants or to animals. All species were shown as photographs, in colour and at high resolution. Typical features of the species were clearly visible. Each species was presented for 30 seconds. After all species had been shown, the presentation started again.

Species selection followed a range of criteria. Species had to be (1) typical for Germany, (2) presented in species-identification courses at the target university, (3) characterised by typical features, (4) already been used in other species identification tests, and (5) from different taxonomic orders and functional groups (e.g. trees and herbs; mammals and insects).

Table 1. *Plant and animal species student teachers had to identify in a PowerPoint presentation. Brackets indicate that names at the genus or species level were accepted as correct.*

Plant species		Animal species	
Common name	**Scientific name**	**Common name**	**Scientific name**
Silver birch	*Betula pendula*	(European) badger	*Meles meles*
Large-leaved lime	*Tilia platyphyllos*	(Red) fox	*Vulpes vulpes*
Creeping buttercup	*Ranunculus repens*	Fat dormouse	*Glis glis*
Shepherd's-purse	*Capsella bursa-pastoris*	Barn swallow	*Hirundo rustica*
White campion	*Silene latifolia*	Great tit	*Parus major*
Greater plantain	*Plantago major*	Laughing gull	*Larus ridibundus*
Wild strawberry	*Fragaria vesca*	Great spotted woodpecker	*Dendrocopus major*
Meadow geranium	*Geranium pratense*	Brown trout	*Salmo trutta f. fario*
Common poppy	*Papaver rhoeas*	(Northern) pike	*Esox lucius*
Red dead-nettle	*Lamium purpureum*	Common viper	*Vipera berus*
White clover	*Trifolium repens*	Slow worm	*Anguis fragilis*
Red Clover	*Trifolium pratense*	Fire salamander	*Salamandra salamandra*
Cornflower	*Centaurea cyanus*	Common toad	*Bufo bufo*
Wild chamomile	*Matricaria chamomilla*	European cockchafer	*Melolontha melolontha*
Canada thistle	*Cirsium arvense*	Colorado beetle	*Leptinotarsa decemlineata*
(Common) yarrow	*Achillea millefolium*	Red wood ant	*Formica rufa*
(Common) dandelion	*Taraxacum officinale*	Peacock butterfly	*Inachis io*
Orchard grass	*Dactylis glomerata*	Brown-lipped snail	*Cepaea nemoralis*

The questionnaire consisted of four parts (covering research questions Q1-Q4). The first part investigated participants' familiarity with the species presented, and features used to identify plants or animals (see Q1). Participants were asked to write down, as precisely as possible, the names of the plants/animals presented. An answer was considered correct if the common name of a species, or its scientific name, was provided (see Table 1). In a multiple-choice question, participants were also asked to indicate the three most important features they had used when identifying the plant/animal species presented. In a similar way, they were asked which features they would use when identifying species in nature (list of features in Table 2).

The second part of the questionnaire investigated participants' taxonomic interest and sources of knowledge about species (see Q2). Participants were asked to indicate their interest in identifying plants/animals on five-step scales, ranging from 1: very low to 5: very high. They were then asked to indicate their sources of knowledge about plants/animals (see answer options in Table 3). If participants had indicated the university as a source, they were asked to specify their answer by ticking one or more of the following options: lecturer, teaching material, excursions, indoor courses, and to explain their choices. Because experiences in school and knowledge of local organisms were found to be predictors for student teachers' readiness to implement species investigations later in school (Brewer, 2002; Lindemann-Matthies et al., 2011), participants were also asked to indicate how often they had identified plants/animals during their own schooldays (on five-step scales, ranging from 1: very rarely to 5: very often), and where they had done so (primary school, lower or upper secondary school).

The third part of the questionnaire investigated participants' satisfaction with their teacher preparation and self-estimated competence to identify species (see Q3). Participants were asked whether they had attended courses in plant/animal identification. They were then asked how satisfied they felt with the amount of information provided (on five-step scales, ranging from 1: very unsatisfied to 5: very satisfied). They were also asked whether they felt sufficiently prepared to implement species identification activities in school and, if not, to write down ideas for improvement. Because perceived competence is a significant determinant of a person's intrinsic motivation and actual competence to carry out future tasks (Bandura & Schunk, 1981; Losier & Vallerand, 1994), participants were further asked to estimate their competence in identifying plants/animals on five-step scales, ranging from 1: very incompetent to 5: very competent.

The fourth part of the questionnaire investigated which approaches and methods participants considered important when investigating species at school (see Q4). For both indoor and outdoor investigations, participants had to choose the three most suitable approaches (see Table 4) to rank-order them by priority and to explain their first priority. Participants were also asked to indicate the three most suitable teaching materials when identifying species in class (living plants/living animals, dried plants/stuffed animals, drawings, pictures, photographs, books, magazines, CD/DVDs, internet) and to rank-order them by priority.

Participants and data analysis

Overall, 357 student teachers participated in the study. They either filled-in the questionnaire about plants (183 persons) or the one about animals (174 persons). About 60% of participants were in primary and 40% in secondary teacher training, and 88% were women. This reflects the typical ratio at the target university. Participants were, on average, in their third year of study (mean number of terms = 4.8, SD = 2.0).

General linear models (Type II SS) were used to test for influences on participants' taxonomic knowledge (number of plant/animal species correctly identified). As this type of analysis does not allow strong correlations between explanatory variables, Pearson correlations between the explanatory variables were tested first. Self-estimated competence to identify plants/animals was strongly correlated with interest in identifying plants/animals (all $p < 0.001$). Moreover, the probability that participants had already taken species identification courses strongly increased with their length of study ($p < 0.001$). The following factors and variables were initially included in the models: sex (0: male, 1: female), amount of time spent on species identification during schooldays (scale from 1–5), study orientation (0: primary school, 1: secondary school), participation in species identification courses during teacher training (0: no, 1: yes), satisfaction with the courses offered on species identification (scale from 1–5), interest in identifying plants/animals (scale from 1–5). The final minimum adequate models were obtained by backward elimination of non-significant variables (Crawley, 2005). All analyses were carried out with IBM SPSS Statistics for Windows, version 22.

Results

(Q1) Knowledge of local plants and animals, and features used to identify species

On average, participants could correctly identify 23% of the plant species and 44% of the animal species shown to them in the PowerPoint presentation (meanplants = 4.1 ± 0.21 and meananimals = 8.0 ± 0.26 out of 18, respectively). Common dandelion (Taraxacum officinale), common poppy (Papaver rhoeas) and wild strawberry (Fragaria vesca) were the best-known plant species (Figure 1a), while red fox (Vulpes vulpes), European badger (Meles meles) and European cockchafer (Melolontha melolontha) were the best-known animal species (Figure 1b).

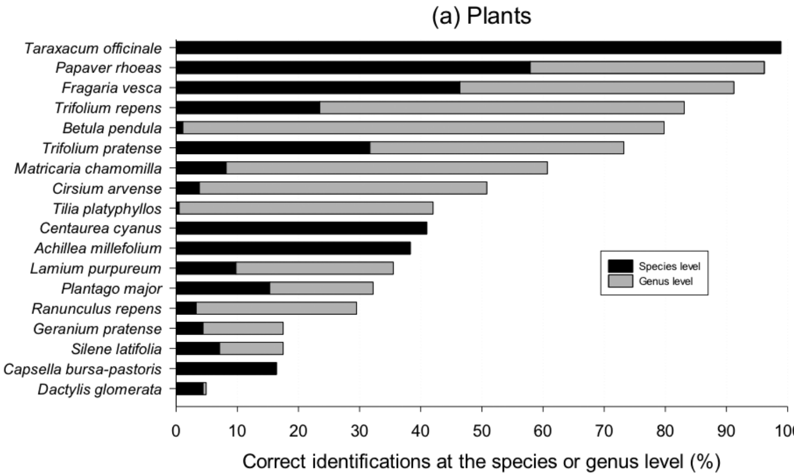

Figure 1a. Proportion of student teachers (n = 183) who correctly identified plants at the species or genus level. The species were shown in a PowerPoint presentation.

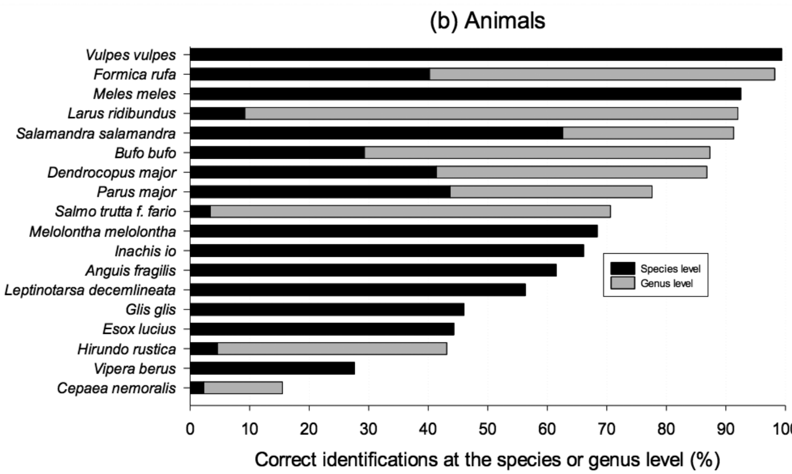

Figure 1b. Proportion of student teachers (n = 174) who could correctly identify animals at the species or genus level. The species were shown in a PowerPoint presentation.

About 49% of participants had already taken courses in species identification. Participants, who had taken such courses, identified more species correctly than those who had not (plants: 5.6 ± 0.27 vs. 2.8 ± 0.27, respectively, $F_{1,181} = 54.14$, $p < 0.001$; animals: 9.4 ± 0.33 vs. 6.7 ± 0.32, respectively, $F_{1,169} = 35.84$, $p < 0.001$).

In the PowerPoint presentation, participants identified plants mainly by their flowers, whereas they stated that in nature, they would identify plants mainly by leaves (Table 2a). With regard to animals, participants identified (or would identify) them largely by shape and colour (Table 2b).

(Q2) Interest in identifying species and sources of knowledge

Participants were only moderately interested in identifying plants (mean score of 3.0 ± 0.07 on the five-step scale), but they were rather interested in identifying animals (mean score of 3.7 ± 0.05). Whether they had already attended courses in species identification did not influence the results (both $p > 0.210$).

Family and school were major sources of participants' knowledge of species (Table 3). If their knowledge of plants was primarily due to university education, it was mainly acquired through excursions and species identification courses (indicated by 37% of participants each), lecturers (30%) and teaching material (24%). Similarly, knowledge of animals was mainly acquired through excursions and teaching material (indicated by 32% of participants each). Lecturers (23%) and species identification courses (13%) were indicated less often.

Table 2. *Features used when identifying (a) plant species and (b) animal species in a PowerPointpresentation and in nature. In a multiple-choice question, student teachers were asked to indicate the three features they considered to be most important. For each feature, the proportion of student teachers who indicated it as one of their three choices is given in the table.*

(a) Plant species		
Feature	PowerPoint (n=160)	Nature (n=148)
	Response (%)	Response (%)
Flower	93.1	62.8
Leaves	70.0	90.5
Colour	64.4	14.9
Shape	50.6	0.0
Size	11.2	44.6
Habitat	5.6	66.2
Seeds	2.5	6.1
Smell	not asked	10.8
Taste	not asked	0.7

(b) Animal species		
Feature	PowerPoint (n=156)	Nature (n=154)
	Response (%)	Response (%)
Colour	95.5	71.4
Shape	91.7	86.4
Size	67.9	49.4
Habitat	39.7	51.9
Sound	not asked	25.3
Movement	not asked	12.3
Smell	not asked	0.6
Touch	not asked	1.3

Table 3. *Sources of knowledge about (a) plants and (b) animals. In a multiple-choice question, student teachers were asked to indicate those three sources they considered to be most important. For each source, the proportion of student teachers who indicated it as one of their three choices is given in the table.*

Source	(a) Plants (n=129)	(b) Animals (n=143)
	Response (%)	Response (%)
Family	80.6	69.1
School	72.9	68.5
University	68.2	57.3
Media	49.6	65.7
Hobby	19.4	27.3
Friends	9.3	8.4

Participants stated that they had rarely identified plants or animals during their own schooldays (plants: mean score of 1.7 ± 0.06 on the five-step scale; animals: mean score of 1.9 ± 0.07). If they had identified species, this took place in primary school (indicated by 44% of participants for plants and by 48% for animals) as well as in lower (50% and 51%) and upper secondary school (12% and 15%).

(Q3) Satisfaction with teacher preparation and competence to identify species

Participants were moderately satisfied with the number of courses offered (plants: mean score of 3.3 ± 0.06 on the five-step scale; animals: mean score of 3.1 ± 0.07, respectively). About 54% of participants felt that they needed more knowledge and skills to identify plants later in school, and 64% felt so for animals. In both cases, ideas for improvement were more time, practical work, and excursions.

Participants who had already attended courses in species identification felt more satisfied with the courses offered than those who had not (plants: mean scores of 3.5 vs. 3.0 on the 5-step scale, $F_{1,143} = 17.67$, $p < 0.001$; animals: mean scores of 2.9 vs. 3.2, $F_{1,138} = 5.35$, $p = 0.022$).

Participants felt barely competent to identify species (plants: mean score of 2.4 ± 0.07 on the 5-step scale; animals: mean score of 2.8 ± 0.07). However, there was a clear positive correlation between the number of species participants could correctly identify in the PowerPoint presentation and their perceived competence (plants: $r = 0.55$, $n = 177$, $p < 0.001$; animals: $r = 0.45$, $n = 166$, $p < 0.001$). Moreover, the more often participants had identified organisms during their own schooldays, the more competent they felt (plants: $r = 0.19$, $n = 177$, $p = 0.015$; animals: $r = 0.24$, $n = 166$, $p = 0.002$).

The number of correctly identified plants increased with interest in identifying plants (GLM, $F_{1,131} = 8.22$, $p = 0.005$) and participation in species identification courses ($F_{1,131} = 42.11$, $p < 0.001$). Likewise, the number of correctly identified animals increased with interest in identifying animals ($F_{1,129} = 13.91$, $p < 0.001$) and participation in species identification courses ($F_{1,129} = 30.15$, $p < 0.001$).

(Q4) Successful approaches and methods for species investigations

Participants considered learner-centred education and experience-based learning to be most important when identifying plants and animals in school (Table 4). This was the case for both indoor and outdoor education. According to the participants, a learner-centred approach has a strong positive effect on learning, fosters interest and motivation, and allows pupils to be active and creative. There was hardly any difference in participants' reasoning with regard to plants or animals. Participants argued, for instance, that 'learner-centred education follows a constructivist approach, in which the learner, and not the teacher, decides what and how to learn'. Other participants felt that 'people learn most by self-guided learning' and that 'typical features of organisms will be memorised best with learner-centred approaches'. One participant pointed out that a learner-centred approach 'is fun and allows pupils to detect and develop their own skills'.

With regard to experience-based learning, participants argued, for instance, that 'pupils have to experience organisms with all senses; otherwise, they will not remember them' and that 'with their own experiences, pupils will remember organisms best'.

Living plants and animals were considered most important when identifying organisms at school (chosen by 94.8% and 75.7% of participants, respectively, as their first priority). Dried plants were chosen by 2.6% and stuffed animals by 10.5% of participants as their first priority. Photographs were prioritised by 0.6% of participants for plants, and by 7.9% for animals. Books, magazines or CD/DVDs were prioritised by 2.0% for plants and by 5.9% for animals.

Table 4. *Approaches used when investigating (a) plant species and (b) animal species in the classroom and outdoors. In a multiple-choice question, student teachers were asked to indicate the three approaches they considered most suitable. For each approach, the proportion of student teachers who indicated it as one of their three choices is given in the table.*

Approach	(a) Plant species		(b) Animal species	
	Indoor (n=150)	Outdoor (n=140)	Indoor (n=144)	Outdoor (n=136)
	Response (%)	Response (%)	Response (%)	Response (%)
Student-centred	89.3	95.0	86.8	94.1
Experience-based	52.7	67.1	49.3	65.4
Project work	43.3	44.3	45.8	44.1
Cooperative learning	37.3	28.6	39.6	27.9
Experiments	34.7	28.6	36.1	29.4
Teacher-centred	22.7	17.1	20.1	16.9
Problem-based	10.7	10.7	14.6	14.0
Group work	9.3	8.6	7.6	8.1

Discussion

Without special training at university, student teachers could only correctly identify three out of 18 plants and seven out of 18 animals that were shown to them in a PowerPoint presentation. After university training, participants could identify two more plant and three more animal species. University training thus had a positive effect on participants' taxonomic knowledge, which has also been found in other studies (Taraban, McKenney, Peffley & Applegarth, 2004; Wyner & Berkov, 2012). However, the small effect of university training indicates a strong need to improve the training of biology undergraduates so that they can start training the coming generations (see also Leather & Quicke 2009).

Participants identified more animal than plant species correctly, most likely due to their greater interest in identifying animals. This reflects the general tendency that children and adults are more interested in animals than plants (Flannery, 1991; Palmberg et al., 2015; Wandersee, 1986; Wandersee & Schussler, 1999) and are also more informed about animals (Hershey, 1996; Lindemann-Matthies, 2002a). Charismatic mammals, such as red fox and European badger, were correctly identified by almost all participants (as in Eschenhagen, 1982). Common and colourful plants, such as dandelion and poppy, were the best-known plant species, which was also the case when pupils were asked to name wildflowers of Germany (Hesse, 1984) and Switzerland (Lindemann-Matthies, 2002a). Inconspicuous plant species such as shepherd's-purse and greater plantain, in contrast, were among the least identified species, although the previous was shown with its characteristic fruits. Similar results were found in children, adolescents and teachers when pictures of these plants were presented (Lückmann & Menzel, 2014; Scherf, 1988). During a field course in the UK, hardly one in 20 biology students recognised a plantain as such (Leather & Quicke, 2010).

Study participants identified animals mainly by shape and colour. This was also the case in a Nordic-Baltic research project, in which almost 90% of student teachers used shape and colour when identifying animals (Palmberg et al., 2015). That colour is an important animal determination criterion, and that colour picture keys may be more effective than mere language ones has been confirmed (Randler, 2008). Striking features such as colour, shape and size were also found to be important when children classified animals (Tunnicliffe & Reiss, 1999). As in the present study, the habitat in which an organism occurs was of only minor interest, indicating that organisms are recognised more as isolated entities than as integral parts of an environment (Tunnicliffe & Reiss, 1999, 2000; Palmberg et al., 2015). When identifying plants, participants focused primarily on flower characteristics, i.e. the primary feature for identifying whole plant families (Eberbach & Crowley, 2009). In nature, however, participants would clearly prioritise leaves, most likely due to their realisation that flowers are simply not present over long periods of the year or, as in many tree species, too high-up. In contrast to other studies with children and student teachers (Kos & Jerman, 2015; Palmberg et al., 2015), the colour of a flower was only a minor identification criterion for our participants, especially when identifying organisms in nature. This is an interesting result as many easy-to-handle field guides use flower colour as a first identification step.

The family was the most important source of knowledge about plants and animals (as in Scherf, 1988; Tunnicliffe & Reiss, 1999, 2000). In contrast to other studies (Palmberg et al., 2015; Patrick & Tunnicliffe, 2011; Patrick et al., 2013), school education was almost equally important, although participants had rarely identified plants or animals during their own primary or secondary education. However, the more often participants had practiced species identification at school, the more competent they felt in this regard (as in Lindemann-Matthies et al., 2011). Such activities in schools have become rare. Therefore, teacher education has to compensate for the lack of taxonomic experience, if we want teachers who can support their pupils in developing an empathetic perspective towards biodiversity. Our study shows that experiences with species identification during teacher education indeed contributed to student teachers' competence and thus to intrinsic motivation to engage their future pupils in such activities (see Bandura & Schunk, 1981).

Species-identification activities in school, which allow pupils to be active and gather practical skills, were clearly prioritised over teacher-centred ones. Moreover, the use of living organisms was clearly preferred over other methods (as in Palmberg et al., 2015). Living organisms in species identification courses and the active involvement of learners were found to be rather effective (e.g. Scott et al., 2012; Taraban et al., 2004). University students learned more when exposed to living instead of web-based material (Taraban et al., 2004) and were also better able to sort, group and describe living organisms which they had collected themselves (Scott et al., 2012). Among secondary pupils, hands-on, group-based and learner-centred work lead to higher post-test retention rates than teacher-centred education does (Randler & Bogner, 2002).

Caution should be exercised in generalising the results of this study, as our data are based on a survey of only about 350 student teachers from one university. Moreover, two-dimensional pictures of plants and animals, although some close-up pictures of identifiable features were integrated in the presentation, may not be as good for identification purposes as their three-dimensional originals are. A comparison with findings from other studies, where living plants or animals were presented, should thus be taken with care.

Conclusions

Species identification is not an end in itself, but central for understanding ecological concepts, nature and our place in it (Bebbington, 2005; Bilton, 2014; Leather & Quicke, 2009). Moreover, species identification is at the very foundation of biodiversity conservation (Pfeiffer, Scheiter, Kühl & Gemballa, 2011; Randler, 2008; Scott et al., 2012). Nowadays, species identification can be done in rather enjoyable ways, contradicting the perception of boring 'flower-pressing or bug-collecting' activities (Leather & Quicke, 2010). Videos and apps for mobile devices (e.g. Kumar et al., 2012; Pfeiffer et al., 2011) or so-called BioBlitz activities, i.e. the 24-hour intensive cataloguing of diversity at one site might trigger the interest of pupils (Pollock et al., 2015).

The present results demonstrate the crucial role of the initial teacher preparation system in familiarising graduate students with local organisms, and with suitable approaches on how to carry out species identification later on in school. In times of decreasing taxonomic knowledge, but ever increasing loss of biodiversity, this is especially important. We should not end-up with teachers who are no longer able to familiarise their pupils with species, i.e. a core content of biology education in school. Qualified teachers should at least be familiar with common wild plants and animals in their neighbourhood, in order to understand and teach the very nature of biodiversity. This requires a stronger emphasis on biodiversity and taxonomy in the teacher-training curriculum.

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