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CEPS Journal 7 (2017) 4, S. 125-146

Primary School Student Teachers' Perceived and Actual Knowledge in Biology

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Individuals' perceptions of their knowledge can have an important role in shaping their cognition and influencing their behaviour. However, there has been a scarcity of studies in biology on how perceived knowledge relates to actual knowledge. The focus of this article is on quantitative results analysing and interpreting student teachers' perceived knowledge of biological content in relation to their actual animal and species name knowledge linked to the ecosystem in which they live. K-means cluster analysis and ANOVA were used. The results show a high- and low-level perceived knowledge cluster group among the participants. They further indicate that the difference in actual animal and species name knowledge between these cluster groups remained the same during the five years of the study. The student teachers with a higher level of perceived knowledge tended to have better actual animal and species name knowledge than those in the low-level group. The actual animal name knowledge in these cluster groups was similar with regard to the local Finnish ecosystems but differed concerning the exotic species by year. The year that the participants enrolled in the study programme had an impact on their actual animal and species name knowledge. Strategies for coping with work-related demands and maintaining engagement in one's career would be important additions to the teacher education curriculum.

Keywords: actual knowledge, biology education, perceived knowledge, student teachers

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Predstava bodočih učiteljev razrednega pouka o njihovem znanju biologije in njihovo dejansko znanje biologije

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Predstava posameznika o svojem znanju ima lahko pomembno vlogo pri oblikovanju novega znanja in vpliva na vedenje, vendar na področju biologije ni veliko študij, ki bi preučevale povezanost predstave o znanju z dejanskim znanjem. Prispevek se osredinja na kvantitativne rezultate, tako da analizira in interpretira predstave o znanju študentov razrednega pouka na področju biologije v povezavi z njihovim dejanskim znanjem o imenih živalskih vrst v povezavi z ekosistemom, v katerem živijo. Pri analizi sta bili uporabljeni klastrska analiza (K-povprečja) in ANOVA. Na osnovi rezultatov analize so bili sodelujoči razdeljeni v dve skupini – skupino z višjo ravnjo predstave o znanju in skupino z nižjo ravnjo predstave o znanju. Rezultati kažejo, da so razlike v dejanskem znanju o imenih živalskih vrst med tema skupinama ostale na isti ravni vseh pet let študija. Bodoči učitelji z višjo ravnjo predstave o znanju so nagnjeni k temu, da imajo boljše dejansko znanje o imenih živali kot tisti, ki so bili razvrščeni v skupino z nižjo ravnjo predstave o znanju. Dejansko znanje o imenih živali v teh skupinah je bilo podobno, ko je bil govor o lokalnem finskem ekosistemu. Razlike pa so se z leti pokazale pri bolj eksotičnih živalskih vrstah. Leto, ko so se udeleženci vpisali v študijski program, je imelo vpliv na njihovo dejansko znanje o imenih živalskih vrst. Strategije spopadanja z zahtevami, povezanimi z delom, in ohranjanjem angažiranosti v individualni karieri bi lahko predstavljale pomembna dopolnila kurikuluma izobraževanja učiteljev.

Ključne besede: dejansko znanje, biološko izobraževanje, predstava o znanju, bodoči učitelji

Introduction

Species and ecosystems should be sustained not only for their utilitarian service to humans, but also because of humanity's moral obligations (Taylor, 2011). When building sustainability, the professional competence of teachers is a key factor. According to Kunter, Klusmann, Baumert, Richter, Voss and Hachfeld (2013), teachers' professional competence includes, among other things, cognitive aspects (e.g., professional knowledge) and beliefs related to learning. Subject content knowledge (CK) and pedagogical content knowledge (PCK) form an important part of teachers' professional knowledge (Appleton, 2010; Shulman, 1986, 1987). PCK represents the blending of content and pedagogy into an understanding of how particular aspects of the subject matter are organised, adapted and represented for instruction. The success of teaching, studying and learning processes depends, on the one hand, on CK and PCK (Appleton, 2010; Shulman, 1986, 1987) and, on the other hand, on actual and perceived knowledge (Ziegler & Montplaisir, 2014).

Teachers' and students' perceptions of their own knowledge have an important role in shaping their cognitions. The greater one's feeling of knowing an issue, the more time one wants to spend working on that issue (Johnson, 1994). Perceived knowledge also has implications for behaviour. Attitudes are more predictive for behaviour when they are associated with high rather than low levels of perceived knowledge of a topic (Davidson, Yantis, Norwood, & Monano, 1985).

According Abell and Smith (1994), a significant number of primary school teachers lack sufficient CK and PCK to teach essential scientific ideas in their classrooms. In biology, teachers' subject content knowledge (BCK) includes, for instance, species identification and ecology knowledge. Student teachers' (STs) knowledge of species has decreased during the last twenty years (Braun, Buyer, & Randler, 2010; Lindemann-Matthies & Bose, 2008; Randler, 2008). Furthermore, STs' ability to name animals in different ecosystems is limited, with mammals and birds being best known (Yli-Panula & Matikainen, 2014). The knowledge of species in relation to ecosystems is important in understanding the biodiversity and sustainable development of ecosystems.

In Finnish primary schools, species identification and animal knowledge in relation to biodiversity and sustainable development are part of biology (The Finnish National Board of Education, 2004, 2014). At the heart of PCK is the manner in which subject matter is transformed for teaching. This occurs when the teacher interprets the subject matter and finds different ways to represent it and make it accessible to learners. In Finnish teacher education, PCK studies therefore include discussions about and practice of teaching methods

through which student teachers can acquire and create ideas on how to teach species identification and animal knowledge in relation to biodiversity and sustainable development (Faculty of Education, the University of Turku, 2014).

The issues outlined above demonstrate why species knowledge is an important topic in primary education, as well. To our knowledge, no studies of animal species knowledge other than Yli-Panula and Matikainen (2014) have been conducted until now. In the present article, we describe primary school student teachers' (PSSTs) perceived and actual knowledge regarding biological themes such as animal and species name knowledge.

Research questions

The purpose of this study is to interpret and describe (Eskola & Suoranta, 2014) how PSSTs evaluate their perceived knowledge in relation to their actual knowledge. Based on the results, the biology curriculum and instruction in elementary teacher education will be developed. The research questions are as follows:

1. What is the PSSTs' level of actual knowledge concerning animal and species names, as measured by the number of animals and species named in four different ecosystems?
2. What is the yearly variation in perceived knowledge in the *high-level group* and the *low-level group* concerning a) animal name knowledge, and b) species name knowledge in four ecosystems?
3. What is the PSSTs' perceived knowledge in biological themes with respect to their actual a) animal name knowledge, and b) species name knowledge?

Theoretical framework

The Earth's assemblages of life forms, whether described as biodiversity in general or as species or ecosystems in particular, should be sustained not only for their utilitarian service to humans, but also because of humanity's moral obligations (Taylor, 2011). Greater understanding is needed of how biological systems work, how to stem the continued loss of habitats, and how ecosystems can be restored and managed.

Studies Concerning Student Teachers' Biological Content Knowledge

Knowledge of species identification is weak among STs in Nordic and Baltic countries (Palmberg et al., 2008; Palmberg et al., 2015; Palmberg, Jonsson,

Jeronen, & Yli-Panula, 2016). Although most STs are interested in nature, their knowledge of the connection between species identification and biodiversity and/or sustainable development is unclear (Yli-Panula & Pollari, 2013). According to Yli-Panula and Matikainen (2014), marked variation exists between Finnish STs concerning their awareness of the names of the animals living in different ecosystems. The animals of the spruce-dominated coniferous forest were the best known, while the animals of the indigenous Nordic fen were the least known, as evidenced by the low number of names and the high number of falsely named animals. Even though invertebrates are an essential part of biodiversity, and of several food chains and webs, only few STs named these animals as part of these indigenous ecosystems, as well as of savannahs and rainforests.

In Nordic studies of knowledge concerning ecological concepts and processes (such as ecosystem, rainforest, desert, biosphere, succession, and the environmental problems of fish farming), STs provided correct answers in 20–65% of the questions. The least known facts were that the rainforest forms a kind of a belt around the equator and that the biosphere is connected to ecosystems (Palmberg et al., 2011; Palmberg et al., 2016). Concerning the question "What is a seed?", only 20% of STs could provide a correct explanation, and 27% of the explanations were nonsense. The majority (55–95%) of the participants thought that the ecological issues listed above belong to basic knowledge that teachers should manage while teaching primary students. Issues such as blood circulation and the function of the liver, brain and organs of equilibrium were seen as basic knowledge by the majority of the Danish, Finnish and Swedish STs; however, only 60–75% of them provided correct answers, depending on the theme (Palmberg et al., 2016).

Perceived Knowledge, Actual Knowledge and Academic Achievement

Perceived knowledge means the amount of persuasive information in a particular orientation one believes one has about a target issue (Tormala & Petty, 2007). Actual knowledge is a direct and clear awareness of something, e.g., facts and conditions. Perceived knowledge is therefore in the metacognitive domain and actual knowledge in the cognitive domain (Dori & Avargil, 2015). In the fields of language education and chemistry education, there are studies of how perceived knowledge relates to actual knowledge (e.g., Dori & Avargil, 2015). Concerning biology concepts, Ziegler and Montplaisir (2014) found significant differences in university students' perceived and actual knowledge, both at the beginning and at the end of the course. At the end of the course,

female students' perceived and actual knowledge were more accurate than that of male students.

Although in the field of biology education, there are many international studies concerning recall and factors affecting the recall and memory of animal names and knowledge (e.g., Evans, Dixon, & Heslop, 2006; Lindemann-Matthies & Bose, 2008; Randler, 2008; Patrick & Tunnicliffe, 2011; Patrick, et al., 2013), the perspectives of these studies are different from that of the present article. To the best the authors' knowledge, no studies have been published from this perspective in Finland until now.

The professional competence of teachers has an effect on the success or failure of education. A teacher should possess a wide range of qualifications, which can be nurtured and developed through initial education and continuous training. These include the teacher's attitudes and beliefs regarding teaching, learning and his/her role, all of which affect the way (s)he comprehends, evaluates and chooses the knowledge acquired. These attitudes and beliefs also affect the way the teacher benefits from this knowledge in practice (PCK) (Liakopoulou, 2011). The basic components of professional knowledge include subject knowledge and knowledge of learners, teaching methods and the curriculum (Shulman, 1987). In addition, the teacher needs general pedagogical knowledge that relates to pooling resources, learning and pedagogical theories, the organisation of the classroom, and motivating students and retaining their attention. Shulman also referred to knowledge of contexts and knowledge of self (1987). In conclusion, the professional competence of the teacher includes his/her PCK, enthusiasm for teaching and self-regulatory skills in instructional quality, which in turn affect students' academic achievement (Kunter et al., 2013).

In addition to the professional competence of teachers, students' academic achievement is also affected by other factors, such as the availability of textbooks, laboratory equipment and other learning resources, students' attitudes, and parents' education and occupation (Ali, Toriman, & Gasim, 2014), as well as learning difficulties concerning concepts in biology (Achor & Agbidye, 2014; Södervik, Mikkilä-Erdmann, & Vilppu, 2014).

Ziegler and Montplaisir (2014) state that students struggling with the learning processes can lack metacognitive skills. Metacognition consists of both metacognitive knowledge and metacognitive experiences or regulation. Metacognitive knowledge refers to acquired knowledge about cognitive processes. In order to be effective learners, students should therefore recognise what they know and what they do not know; they need to possess the ability to assess and regulate their knowledge.

Biology as Part of the Finnish School System and Teacher Education

In the Finnish primary school, biology belongs to environmental studies. The main purpose of these studies is to support students to perceive the nature of science and to learn new scientific concepts and principles in order to develop skills in experimental work. Students are guided to make observations on interactive relationships between mankind and nature, to emphasise man's responsibility for protecting natural diversity, and to focus on and understand natural phenomena (FNBE, 2004, 2014). Certain biological themes are introduced, including the tree of life, systems of organisms, species identification and species knowledge, biodiversity, sustainable development, and values related to biology content or to special issues, such as sustainable education in biology (FNBE, 2004, 2014). Biology is taught along with other subjects in primary school (grades 1–6) by primary school teachers (class teachers), while subject teachers teach biology at lower secondary school level (grades 7–9).

Class teachers are educated at universities in Finland and become qualified teachers after finishing a master's degree. The main components of the primary school teacher education programme are class teachers' studies in a major in education, supervised teaching practices, and pedagogical studies in 11 different subjects taught in primary school (Niemi & Jakku-Sihvonen, 2006). Pedagogical studies in biology include two ECTS units (European Credit Transfer System). The goal is to collaboratively study teaching in workshops, learning methods, assessment tools, skills, and other matters typical of biology education in primary school. In addition, PSSTs must choose one subject for extended studies to complete a master's degree.

Methods

Participants

The respondents were PSSTs (n = 439) from one Finnish university. Most of them (95%) were 19–22 years old, and 20.5% were males. This percentage of male PSSTs is normal in Finland; in 2013, for instance, 25.7% of the Finnish primary teachers were males (Kumpulainen, 2014). The animal and species name knowledge was based on the information the PSSTs had obtained in their free time, and on their learning in Finnish basic education and upper secondary schools (FNBE, 1994, 2003). The PSSTs had completed their first year of pedagogical studies to become qualified class teachers (in the grades 1–6) at primary

school. The study was carried out in Southwest Finland over a period of five years, and is part of a larger research project aimed at investigating the biological knowledge of both school students and STs (Yli-Panula & Matikainen, 2014).

Instruments

In this study, both numerical methods and exploratory approaches (mixed method approach, Tashakkori & Teddlie, 1998) have been used. In the present article, we interpret and describe the quantitative results.

Perceived Knowledge

Perceived knowledge in this study means the PSSTs' perceptions of their own biological core content knowledge in the seven different biological themes that they are going to teach as primary school teachers. Perceived knowledge was measured using the PSSTs' self-evaluation estimations. At the very beginning, the PSSTs were asked "please evaluate your knowledge in the seven different biological learning themes". The themes were as follows: (a) the structure of living organisms; (b) the vital function of living organisms, such as photosynthesis, nutrient, energy and adaptation; (c) food chain and food web; (d) species identification and species recognition; (e) the tree of life and systems of organisms; (f) nature and the seasons, e.g., in connection to breeding of species; and (g) different ecosystems. A 5-point Likert scale was used to gather data regarding the PSSTs' perceived knowledge of biological themes using a questionnaire (1=inadequate, 2=marginal, 3=fair, 4=good, and 5=excellent). The questionnaire was pre-tested by biology STs prior to the study. No changes were made to the questionnaire. All of the PSSTs (n=439) answered the questionnaire voluntarily, but the answers of eight PSSTs were omitted from the statistical cluster analysis (n=431) due to their failure to respond to all of the themes in the questionnaire.

Actual Knowledge

In this study, actual knowledge means the knowledge that the PSSTs possessed at the particular moment of the study programme in biology. The PSSTs' actual knowledge concerning animal and species name knowledge was measured at the beginning of the study programme.

Questions concerning the PSSTs' species and animal name knowledge in relation to the following four ecosystems were used: the spruce-dominated coniferous forest (SCF), the Finnish fen (FEN), the savannah (SAV) and the tropical rainforest (TRF). These ecosystems were all illustrated using pictures.

A middle-aged coniferous forest illustrated the SCF. The FEN was presented in a drawing of a few coniferous trees and a typical field layer, rich with different plant species. A tree savannah was depicted in the picture of the savannah, and the layers of the TRF were clearly drawn. Neither the SAV nor the TRF drawings were labelled with any specific geographical location (Yli-Panula & Matikainen, 2013; Yli-Panula & Matikainen, 2014).

Students have shown to prefer to study animals rather than plants, and recalled animals more easily (Balas & Momsen, 2014). Therefore, the PSSTs were asked to write on the pictures the names of ten animals that they thought live in the corresponding ecosystem, and to link the animal name knowledge to the proper ecosystem(s) (e.g., ants live in various ecosystems) or to the food chain/web animals. Placing the right animals in their ecosystem was used as the measure of the students' animal and species name knowledge. The PSSTs did not ask any questions about the test before starting to name the animals.

Data Analyses

K-means Cluster Analysis

In order to identify individual differences in the PSSTs' perceived BCK, a K-means cluster was run with two clusters. Discriminant analyses were conducted to confirm the resulting two-cluster solution, which placed 97.7% of the participants back into the correct classification. In order to confirm the strength of this classification, the results of the discriminant analyses revealed that three-cluster and four-cluster solutions showed less strength, with 94.7% and 91.9% placed in the correct group, respectively. The two clusters (Table 1) were labelled as *High* (n = 226) and *Low* (n = 205) level groups.

Table 1

Mean scores of perceived knowledge of biological themes by two cluster groups of PSSTs (high- and low-level cluster groups)

Biological themes	Cluster	
	High (n = 226)	Low (n = 205)
a) Structure of living organisms	2.99	2.07
b) Vital function of living organisms	3.25	2.21
c) Food chain, food web	3.30	2.40
d) Species identification and species recognition	3.00	2.17
e) Tree of life and system of organisms	3.19	2.20
f) Nature and the seasons	3.17	2.41
g) Different ecosystems	2.96	1.92

Species and Animal Name Knowledge Scoring

The PSSTs were asked to write the name of ten animal species on the pictures of four different ecosystems (maximum 40 animal names). One point was given for each species name that was placed in the right ecosystem. Zero points were given for an answer that was not on the species level, was incorrect (giving a species name that belongs to a different ecosystem or to a higher taxa), or if there was no answer. The named animals on the species, genus or family level were counted as "animal name knowledge", and all correct answers gain one point each, while incorrect answers were scored with zero points.

Reliability can be thought of as the trustworthiness of the procedures and data generated (Stiles, 1993). Reliability is concerned with the extent to which the results of a study or a measure are repeatable in different circumstances. There were no difficulties encountered during the present study. At the beginning of the test situation, the PSSTs received detailed guidelines for answering the questionnaire, and they had no problems when answering the questions. The number of answered questionnaires was high (n = 439), and all of the participants answered the inquiry. The result of an inquiry is seen to be reliable if the answered percentage is over 50%. The selected methods were chosen as suitable for solving the research problems (Metsämuuronen, 2009).

The validity of the study is based on the conceptions of readers regarding how they can apply the presented results and conclusions in their conditions (ecological validity, Lincoln & Cuba, 1985, p. 298). The inquiry was carried out only in one Finnish university, and the ecological validity would be better if the study had also been carried out in other Finnish universities and abroad. The research process is described thoroughly (Cohen, Manion, & Morrison, 2011) in terms of what supports ecological validity. The validity is also demonstrated in the sense that the results support previous studies (Williamson, 2005). The fact that those participating in the research remained anonymous largely guaranteed that they provided sincere answers. However, the attitudes of a few of the PSSTs may have affected their willingness to answer the questionnaire (cf. Olkinuora, 1990). For example, if the PSST did not like species identification and biology, the level of answers may be poorer than it would have been otherwise.

Results

Primary School Student Teachers' Perceived Knowledge Levels of Different Biological Themes

Based on the PSSTs' self-evaluation regarding their perceived knowledge, many of the PSSTs (194 out of 439) evaluated their knowledge of the different biological themes to be fair (Table 2).

Table 2
The levels of the PSSTs´ (n = 439) perceived knowledge (inadequate, marginal, fair, good, excellent) of the seven different biological themes (a-g)

Biological themes	inadequate 1	marginal 2	fair 3	good 4	excellent 5
a) Structure of living organisms	9	39	41	11	0
b) Vital function of living organisms	6	32	45	16	1
c) Food chain, food web	3	28	50	18	1
d) Species identification and species recognition	7	35	42	15	1
e) Tree of life and system of organisms	10	40	38	10	2
f) Nature and the seasons	5	22	51	20	1
g) Different ecosystems	10	43	39	7	1
Mean %	7	34	44	14	1

Over 70% of the PSSTs evaluated their knowledge of "nature and the seasons" (f) as fair (3) or good (4). One-sixth or less of the PSSTs evaluated their knowledge to be good or excellent depending on the biological theme. More than 50% of the PSSTs felt that their knowledge was marginal or even inadequate concerning the biological themes of "different ecosystems" (g) and "the tree of life/systems of organisms" (e). The PSSTs evaluated their knowledge of different ecosystems as being the most incomplete. They also evaluated their knowledge regarding "the structure of living organisms" (a) to be rather marginal.

The Number of Animals Named by Primary School Student Teachers

The animals of the spruce-dominated coniferous forest were correctly named the most often. Some 86% of the PSSTs achieved a good level (8–10 named animals) when naming animals in this Finnish forest ecosystem (Table 3). Almost all of the participants were able to name 5 animals, and 69% of the

animals were named at the species level. Animals of the Finnish fen were the least known, with *only 38% of the PSSTs being able to name only 0–4 animals.* However, 65% of all of the animals mentioned were named at the species level.

Table 3
The number and percentage of PSSTs (n = 439) who were good (8–10 animals), fair (5–7 animals) or poor (0–4 animals) at naming animals in Finnish ecosystems

Ecosystem	good number	(8-10 names) %	fair number	(5-7 names) %	poor number	(0-4 names) %
SCF	377	86	53	12	9	2
FEN	161	37	110	25	168	38
TRF	220	50	154	35	65	15
SAV	316	72	97	22	26	6
Total	1074	61	414	24	268	15

Note. SCF = spruce-dominated coniferous forest; FEN = Finnish fen and exotic ecosystems; TRF = tropical rainforest; SAV = savannah.

The PSSTs had good name knowledge of exotic tropical rainforest animals and savannah animals. Half of the PSSTs were able to name 8–10 animals from the tropical rainforest, although only 29% of the mentioned animals were at the species level. Furthermore, 72% of the PSSTs achieved the good level when naming animals from the savannah, with 39% of these animals being named at the species level.

Primary School Student Teachers' Perceived Knowledge of Biological Themes in Relation to Their Animal and Species Name Knowledge Expressed Yearly

The results showed two cluster groups among the participants indicating a high (n = 226) or low (n = 205) level of the PSSTs' perceived knowledge of biological themes (Table 1). In order to examine the STs' perceived knowledge of biological themes in relation to their animal name knowledge, the total number of animal names that the PSSTs had provided for all four ecosystems was used in the analyses. The results of ANOVA revealed that there is no interaction between the PSSTs' perceived knowledge of biological themes and the year in which they had enrolled in the study programme $F(4,421) = .63$, $p > .05$. The difference in the PSSTs' animal name knowledge between the high- and low-level groups was very similar each year (Figure 1).

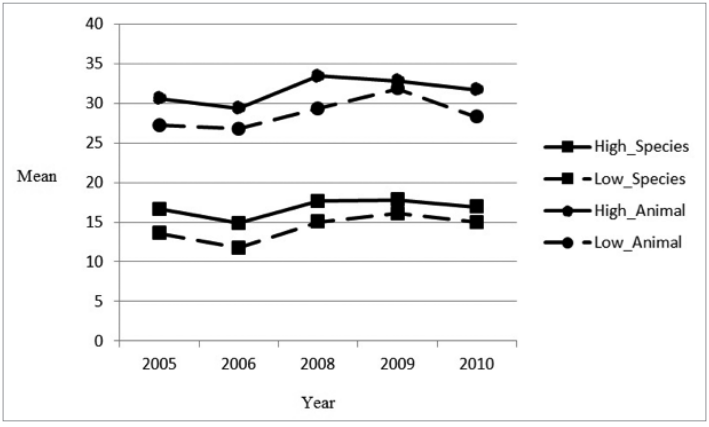

Figure 1. The means of the PSSTs' animal and species name knowledge (maximum 40 animal names), with a high (n = 226) or low (n = 205) level of perceived knowledge of biological themes expressed yearly

Furthermore, the results revealed that the year that the PSSTs had enrolled in the study programme had an impact on their animal name knowledge, $F(4,421) = 5.30$, $p < .001$. The results showed that the level of the PSSTs' perceived knowledge in biological themes also has an effect on their animal name knowledge, $F(1,421) = 18.05$, $p < .001$. PSSTs who belonged to the high-level cluster group tended to have better animal name knowledge than PSSTs who had a low level of perceived knowledge in biology.

In order to examine the PSSTs' perceived knowledge of biological themes in relation to their species name knowledge, the total number of species named by the PSSTs with respect to the four ecosystems was used in the analyses. The results of ANOVA revealed that there is no interaction between the PSSTs' perceived knowledge of the biological themes and the year that they had enrolled in the study programme $F(4,421) = .36$, $p > .05$. The difference in the PSSTs' species name knowledge between the high- and low-level cluster groups was very similar each year.

The results revealed that the year that the PSSTs had enrolled in the study programme has an impact on their species name knowledge, $F(4,421) = 7.46$, $p < .001$. Moreover, the results showed that the level of the PSSTs' perceived knowledge also has an effect on their species name knowledge, $F(1,421) = 28.13$, $p < .001$. PSSTs with a high level of perceived knowledge in biological themes tended to have better species name knowledge than those with a low level of perceived knowledge in biology.

The Animal Name Knowledge of the High or Low Level Group of Perceived Knowledge in Relation to the Four Ecosystems

Firstly, the PSSTs' animal name knowledge (in each cluster group for each year) was compared separately for the four ecosystems, and none of the results of the four ANOVAs were significant. This indicated that the differences between the high- and low-level cluster groups' animal name knowledge in the four different ecosystems were the same for each year (Table 4).

Table 4

The high- and low-level cluster groups of PSSTs based on perceived knowledge (PK) of biological themes in relation to the actual animal name knowledge (AAK) and actual species name knowledge (ASK) of four different ecosystems

	Actual knowledge of animal names (AAK) concerning four ecosystems	**Actual knowledge of species names (ASK) concerning four ecosystems**
Perceived knowledge (PK) in high- and low-level groups yearly	the differences were the same between the groups in PK and AAK in each year concerning four ecosystems *Fs* (4, 421) < 2.08, *ps* > .05, η^2s < .02	the differences were the same between the groups' PK and ASK in each year concerning four ecosystems *Fs* (4, 421) < 1.24, *ps* > .05, η^2s < .02
Comparison in perceived knowledge between the high- and low-level cluster	high-level group of PK had better AAK in all four years in comparison to lower level group *Fs* (1, 421) > 8.53, *ps* < .01, η^2s > .02	high-level group of PK had better ASK regarding SCF, FEN and SAV in comparison to lower level group *Fs* (1, 421) > 4.41, *ps* < .05, η^2s > .01 no difference regarding TRF *F* (1, 421) = 1.84, *p* < .05, η^2s = .004
The impact of the year the student teachers' enrolled to the study program on their performance	equal AAK each year concerning local ecosystems (SCF, FEN) *Fs* (4, 421) < 2.00, *ps* > .05, η^2s < .02 however, different concerning exotic one (TRF, SAV) *Fs* (1, 421) > 6.59, *ps* < .001, η^2s > .05	equal ASK each year concerning the Finnish FEN *F* (4, 421) = 2.31, *p* > .05, η^2s = .02 different concerning SCF, SAV and TRF *Fs* (4, 421) > 2.61, *ps* < .05, η^2s > .02

Note. SCF = spruce-dominated coniferous forest; FEN = Finnish fen; exotic ecosystems (TRF = tropical rainforest and SAV = savannah).

Secondly, the effects of the PSSTs' levels of perceived knowledge on their animal name knowledge in four ecosystems were investigated. All four of these ANOVAs were significant, suggesting that the PSSTs who belonged to the high-level cluster group tended to have better animal name knowledge concerning all ecosystems than those with a lower level of perceived knowledge.

Thirdly, the effects of the year that the PSSTs had enrolled in their study programme on their animal name knowledge in the four ecosystems were observed. Interestingly, the results revealed that the PSSTs in each year tended to have similar animal name knowledge concerning the spruce-dominated coniferous forest (SCF) and the Finnish fen (FEN), but different animal name knowledge concerning the savannah (SAV) and the tropical rainforest (TRF).

Species Name Knowledge of the High or Low Level of Perceived Knowledge in Relation to the Four Ecosystems

Firstly, four ANOVAs were conducted separately for each ecosystem to investigate interactions between the PSSTs' levels of perceived knowledge in biological themes and the year that the students had enrolled in their study programme. None of the results of the four ANOVAs were significant, indicating that the differences between the high- and low-level cluster groups' species name knowledge in the four ecosystems were the same for each year (Table 4).

Secondly, the effects of the PSSTs' levels of perceived knowledge in biological themes on their species name knowledge in the four ecosystems were investigated. The results of ANOVAs revealed that the PSSTs in the high-level cluster group tended to have better species name knowledge concerning all ecosystems than those who had a low level of perceived knowledge in biology. However, no difference was found for species name knowledge in the tropical rainforest ecosystem between the PSSTs belonging to the high- or low-level cluster groups.

Finally, the effects of the year that the PSSTs had enrolled on their species name knowledge in the four ecosystems were observed. The results revealed that the PSSTs in each year tended to have similar species name knowledge concerning the Finnish fen (FEN), but different species name knowledge concerning the spruce-dominated coniferous forest (SCF), the savannah (SAV), and the tropical rainforest (TRF).

Discussion

The study aimed to investigate Finnish PSSTs' perceived knowledge of biological themes in relation to their actual animal and species name knowledge. PSSTs were asked to link the animal names to the proper ecosystem and, when possible, from one ecosystem to another. They were also asked to show their knowledge concerning, for instance, animals in relation to the food chain/food web. The survey was conducted once per year for five years using a

questionnaire. Furthermore, a K-means cluster analysis with two clusters and ANOVA were used.

Species knowledge means achieving the highest level of conceptual and procedural competence (Weinert, 2002) involving human interaction with species in real situations and also involving the sustainable management of biotopes and ecosystems. *This kind of idea is included in Finnish primary school teacher education (Faculty of Education, University of Turku, 2014), as well as in the Finnish national core curriculum* (FNBE, 2014).

The first main result revealed that the level of PSSTs' self-evaluation of their perceived knowledge did not depend on the year of enrolment. PSSTs with a high level of perceived knowledge in biological themes had better actual animal and species name knowledge than PSSTs with a low level of perceived knowledge in biological themes. The results support Johnson's (1994) findings that the higher one's perceived knowledge level, the greater one's continued involvement in the respective activities and subsequent achievements will be.

Concerning metacognitive skills (cf. Ziegler & Montplaisir, 2014), the PSSTs evaluated the level of their BCK. The majority of the PSSTs evaluated their BCK as fair, good or excellent with regard to the vital function of living organisms, food chain/web, species identification and recognition, and nature and the seasons. It can therefore be supposed that they will take action to teach these themes in the future. However, less than one-sixth of the PSSTs evaluated their BCK to be marginal or even inadequate with regard to different ecosystems, the tree of life and systems of organisms, and the structure of living organisms. They also evaluated their knowledge of these themes as being the most incomplete. Consequently, it seems that they will not dare to use demanding thinking skills or to act to achieve deep teaching and learning goals in these themes. *According to Johnson (1994), the greater one's feeling of knowing an issue, the more time one wants to spend working on that issue. Perceived knowledge also has implications for behaviour.* Attitudes are more predictive of behaviour when they are associated with high rather than low levels of perceived knowledge of a topic (Davidson et al., 1985).

The results of this study also revealed that the year that the PSSTs enrolled had an impact on their animal or species name knowledge. Our data were collected at the beginning of the biology course in the university; thus, the differences in each year might correspond to differences in the PSSTs' prior knowledge, as learning proceeds primarily from prior knowledge (Roschelle, 1995). Prior knowledge forces a theoretical shift in which one views learning as conceptual change (Strike & Posner, 1985); however, conceptual change occurs slowly and involves a complex restructuring of prior knowledge to encompass

new ideas, findings and requirements. Our results support studies by Klingenberg and Brönnecke (2011) that show discrepancies in the basic biological knowledge acquired by graduates.

The PSSTs tended to have similar species name knowledge concerning *the Finnish fen, but different* knowledge *concerning the spruce-dominated coniferous forest, the savannah and the tropical rainforest.* The animals and species named in the local Finnish ecosystems were the most common ones, and the same names were mentioned every year. *The results support the study of Yli-Panula and Matikainen (2014). The* animal names listed for the exotic ecosystems were based on the PSSTs' prior knowledge; thus, the variation can be attributed to their hobbies, interest in living organisms, and/or school history. Only a few of the PSSTs had good species name knowledge, especially concerning the TRF. The result supports the findings of Yli-Panula and Matikainen (2014). The PSSTs' real animal and species name knowledge was in harmony with their perceived knowledge level concerning the different ecosystems.

Further Research

Some questions could be investigated further; for example, through the systematic observation of PSSTs during species identification teaching and learning situations. A different methodological approach, such as a case study, would also enrich the data and further develop the conclusions reached.

Ethical Issues of the Study

At the beginning of the study, every PSST received information of the study, e.g., the goals and confidentiality issues of the study were described. They also had the possibility to refuse to participate in the study (Eskola & Suoranta, 2014). All of the PSSTs were willing to participate and approved the course of action.

Implications of the Study

One point of departure for environmentally responsible behaviour is environmental sensitivity and knowledge of ecology (Hungerford & Volk, 1990; Jeronen, Jeronen, & Raustia, 2009), and species knowledge is an important part of ecological knowledge and understanding (Weinert, 2002). Teachers have a key role when supporting students in their understanding of scientific information concerning relations between human beings and the environment (Volet,

Vauras, Khosa, & Iiskala, 2013). The PSSTs' low level of species name knowledge gives rise to several questions. How should species identification be taught in order to improve the understanding of students and STs regarding its importance in relation to sustainability? What pedagogical knowledge and educational practices could contribute to the cultivation of the qualifications teachers refer to as a prerequisite for success when supporting the self-evaluation processes of students? Kunter and others (2013) state that teacher educators would be ill-advised to focus exclusively on the transmission of content-specific knowledge. The present study supports this finding. One key could be for teachers to emphasise the following educational issues more than they presently do (Fadel, Bialik, & Trilling, 2015): 1) what we know and understand, 2) how we use what we know, and 3) how we behave and engage in the world. Strategies for coping with work-related demands and maintaining engagement in one's career would be important additions to the teacher education curriculum.

Acknowledgements

The authors warmly thank our college lecturer Eila Matikainen for the valuable work in transforming the data from the questionnaire to excel format.

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