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Understanding Students Ideas about Animal Classification

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ABSTRACT

Classification is the arrangement of objects such as e.g. organisms, ideas, or information into groups. Its purpose is to make things easier to identify, describe, organize, find and study. Although classification itself is meant to help people to unify or clarify objects they are interested in, publications show that students might find it difficult to classify plants, animals and other organisms. The goal of the study has been to investigate Polish students' conceptions and attitudes towards animal classification and reveal the gaps between these and current scientific knowledge. The study has been conducted by surveys and in-depth interviews of 34 pupils, from primary schools. The research shows that students have similar conceptions about animal classification and also that children see the purpose behind animal classification but find it hard to apply in practice. Moreover, students were using different factors to distinguish animal classes from the ones used by scientific community. For example, they differentiated animals on the basis of: food they consume, respiratory system and utility for humans. Authors suggest that more stress should be put on these aspects during designing lessons about animal classification.

Keywords: animal classification, primary student's conceptions

INTRODUCTION

Cultural Influences

From an early age children try to differentiate animate objects from inanimate ones so they could create their own picture of nature (Reiss & Tunnicliffe, 1999). According to human the nature theory, the way of classifying the world which surrounds us is similar for all the humankind, and sometimes it might be naive and inaccurate, regardless of whether someone is an adult or a child (Linquist, Machery, Griffiths, & Stotz, 2011). Moreover, humans like to categorize and create lists of very different things and elements, no matter if they are realistic or not, as noticed by Eco (2009). However, children's concepts about classification of the world might be a problem even at the elementary level, when differentiating what a living organism is and what is not (Bell, 1981). In Japan, children tend to think about stones as living creature – partially because according to some Japanese beliefs, stones can have a soul (Inagaki & Hatano, 1993). Also, defining what an animal is, can be difficult for students. Trowbridge and Mintzes (1988) while studying this issue, showed that for many pupils, the only known animals are their own pets – e.g. dogs, cats (mostly mammals). Such findings can be linked with earlier works of Barrow (2002) who noted that the classification of insects and their life cycles is a major challenge for students. He demonstrated that, when talking about insects without the context of insects' habitat, respondents were unable to give the correct answer about their taxonomy or ecology. Furthermore, Kattman (2001) showed that when children know the animals and rules how to classify them – they still prefer to do it by their own characteristics such as locomotion or environment.

Psychological Perspective

From the work of Gelman (2009) it is known that children are essentialists and will look at the idea of animals from the perspective of their essence. Although there have been no research relating to Polish children at this age. One of them is the work of Rybska, Tunnicliffe and Sajkowska, who investigated children ideas about internal

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Contribution of this paper to the literature

- Connects human nature framework with the topic of animal classification, which could lead to development of tools that would make it more accessible in the classroom.
- Gives us deeper insight into attributes used innately by children to classify animals on which teachers should focus, while teaching about animal classification.
- Presents the gap between adults' and children's perception of animal classification.

anatomy of trees (2017), snails (2014) and earthworms (2015). What is interesting in connection with Gelman (2009) work is that as children draw their representation of these living organism and their internal structure, they often do not draw internal organs, but their essence – for example their usefulness – home for animals inside tree trunk (Rybska et al., 2017), or furniture in snails shell (Rybska et al., 2014).

In its nature, the classification is similar to the process described by psychologists and called categorization. People are do this in their minds, by building concepts and trying to find similarity to the prototype or expanding the network of the concept. Rosch, Mervis, Gray, Johnson, and Boyes-Braem (1976) has distinguished three levels of categories into which people classify objects in their surroundings - *superordinate*, *basic* and *subordinate*. Basic objects are the most inclusive categories whose members: (a) possess significant numbers of attributes in common, (b) have motor programs which are similar to one another, (c) have similar shapes, and (d) can be identified by average shapes of members of the class (Rosch et al., 1976). Usually objects that belong to this category are perceptual, and classification of an object to the basic category does not involve lots of cognitive effort. Superordinate categories are located at the top of a categorization processes. They show a high degree of generality and offer abstract, non - perceptual information (that is why they are called a category wide attribute). They show a low degree of inclusion and include basic level categories. Subordinate level categories are located at the bottom of the folk taxonomy. They are very detailed, show particularity of the objects and a low degree of class inclusion. They have clearly recognizable, identifiable and highly detailed characters and numerous individuating specific features.

According to Trzebinski (1985), based on Rosch et al.'s research one might conclude that the basic concept consists of two elements - a prototype and a set of representations of many examples that belong to the same concept. The collection of represents possesses a different degree of similarity to the prototype, and the smaller the similarity is, the weaker the relation of "being a referent" between the basic concept and the represented object. Taylor (1989) states that "the clear boundaries of natural categories depend on both the way the world is and what we know about it." Categorizations of concepts are culturally conditioned. Both concept and category, despite their core character, are dynamic beings that extend their reach. It would appear that not only the selection of terms used during educational events is important, but also the educational environment created by the teacher, the choice of didactic agents affecting the body of students and the ways of contact, cognition and experience of the means.

Concepts, as well as categorization of core characteristics, are dynamic beings with expanding ranges. From this perspective, we are trying to find the attributes used by students to make categorization such as biological classification, in order to find a prototype objects that are important for them in the process. For example, if we want to help students to create the concept of an amphibian, primarily we should let them observe and experience an animal, which is most commonly collocated with the concept of an amphibian, for e.g. a frog - with all of the specific details for this group: delicate and thin skin with slime, specific and primitive motor skills on the land, hyperventilation with help of the mouth cavity (buccopharyngeal cavity, buccal pump), as they do not have chest, reproduction dependent on the water etc. By this example, students construct their basic concept. Next, we can introduce them less typical animals like common newt – which may have similar characteristics as frog but is a little bit different – have a tail and live mostly in the water. In the end, fire salamander, as the most untypically looking Polish amphibian should be presented this way, students might be able to create abstract construct of the group of amphibians – which is the superordinate level (Rosch et al., 1976).

Polish Educational System

In Polish education system, the idea of animal classification, other than from essentialist and utilitarian perspective, is introduced in primary school as an adaptation of specific species to the environment, without special focus on the idea of animal classification, the rules which apply, the meaning of each range and taxon etc. After the recent reform, introduced this year, students will be familiarized with the idea of animal classification at similar age of eleven. Equally, pre and post reform concept of animal classification is treated similarly, and children encounter this concept for the first time during their formal education.

Taxonomy, as a branch of biology, is important as it shows interconnections between groups of organisms. But to know something and therefore to understand its value, reasons and means to protect it, one has to be interested

in the topic. Accordingly, the textbooks should contain representations of animals typical and native for a given country and these animals should also be presented by a teacher during lessons. However, due to their appeal, the photographs in textbooks more frequently show exotic and more colorful species, frequently omitting visually attractive native ones. Authors, in their research, show that teachers prefer attractiveness of the textbooks more than their essential correctness (Sajkowska & Rybska, 2014). Other publication on the matter of protecting amphibians and reptiles touch on them only from the perspective of protective actions such as cleaning environment for living animals, species inventories or safe transfer of individual through communication areas during mating season (Lewandowska, 2013; Zielinski, 2007). One of the few publications in Poland, which deals with protecting amphibians through the process of education, is work of Kolenda (2011) who proposes didactical intervention is a small city in Poland and after that, organizes cyclical annual actions of cleaning amphibians' environment (Kolenda, 2014).

Human Nature – Framework

The animal classification, which appears in folk biology, is usually very complex, but in general, we can distinguish two parts. The first part, corresponding with human nature, is a classification based on describing the surrounding world (Linquist et al., 2011). In this case, the description of an animal is very accurate as in the past centuries, humans were closer to the nature, and plants' and animals' morphology or behavior were quite commonly known. The second part is mainly tentative as it consists of various beliefs and superstitions. In this case, humans tend to anthropomorphize animals attributing them some human characteristics. It is popular to say that someone is hard-working as an ant or a bee, or strong as an oak, brave like a lion, or sensitive as mimosa, or even when the name of an animal is synonymous to some behavior as in the case of chicken (Kean, 2012; Lakoff, 1993; Linquist et al., 2011).

Since children usually have their own (mental) version of folk biology, the whole concepts become even more inquiring (Atran, 1998; Medin & Atran, 1999). Children much more often ascribe human template to plants and animals (Gould, 1977). In 1977, Gould presented the idea that ontogeny of children up to 10 years old and their development of concepts mimic cultural evolution of humans, where the spiritual elements and believes in nature phenomenon are gradually getting replaced by scientific discoveries through the centuries (in that case of humans as a species), or gained through the education (in case of children).

Previous researches in the field of animal classification was conducted in New Zealand (Bell, 1981), USA (Trowbridge & Mintzes, 1988), Slovakia (Prokop & Tunnicliffe, 2008) or Taiwan (Yen, Yao & Chiu, 2004), however none of these papers focus on children from central European farmland landscape, such as Poland. In Balmford, Clegg, Coulson, and Taylor (2002) students from Great Britain were given the task to classify both animals present in their neighborhood and Pokemons (fictional creatures from popular children's cartoon) into appropriate groups. Results show that students were more efficient in assigning Pokemons to appropriate groups and classes (as they were classified in the cartoon) then in classifying animals present in their environment to appropriate classes. This example suggests that it is not impossible for young people to apply an artificial classification - they just have to be interested in it (Balmford et al., 2002). The topic has recently been reapproached by many researchers, thanks to an enormous popularity of the interactive mobile game Pokemon Go, and some researchers argue that this application, or other social media applications, such as Facebook, might increase outdoor movement of the youngest and may lead to an increasing number of encounters with some of the species - like hedgehogs (Dorward, Mittermeier, Sandbrook, & Spooner, 2016) or even to discovering new species (Skejo & Caballero, 2016). These attitudes could potentially be used for rising environmental awareness.

Nevertheless, among numerous investigations about animals and attitudes towards them, none of the researches was specifically focused on students' attitudes toward animal classification together with describing the attributes and the prototypes they find important or valid while classifying organisms. For example, Trowbridge and Mintzes (1988) widely investigated animal classification phenomena, but only focusing on students' conceptions about it, not considering the attitudes and whether students see the sense in the animal classification or not.

Following research has the goal to show the gap between scientific knowledge of animal classification and students' conceptions about it by asking open questions about the topic and usefulness of the animal classification for humans within a framework of human nature.

METHODS

The instruction for the interviews were based on initial surveys carried out before by authors. The interviews/the surveys were conducted in 5 primary schools from the urban area in Poznan attended by pupils between 6 and 13 (K1-6) as suggested by (Bizzo & Caravita, 2012). The in-depth interviews were conducted in a separate room or in the corner of a classroom. A total number of 34 pupils were interviewed (one from K4 – 10yo,

seventeen from K5-av. 11yo, seventeen from K6-av. 12yo), 22 of them were girls and 13 were boys. All of them were summoned individually while they were engaged in their regular work for the interviews and teachers were asked to ensure that pupils of an equal range of abilities were interviewed (equal numbers at each age range classified by their teachers as 'above average', 'average' and 'below average').

What we would like to find out is whatever kids will ascribe the human-cultural classification to biological taxonomy. Therefore, the major problems addressed by the interviews were: 1) How do students understand animal classification - and if they see it as something connected more with physical or functional similarities and not the biological kinship? 2) What activities in the classroom, should we undertake to change found folk taxonomy into scientifically correct concepts? 3) Are students aware of the gap between their concepts and scientific knowledge about animal classification? To resolve these problems, and for the better understanding of students' concepts of animal classification, four major questions were asked to students in accordance with instructions without any prompts:

1. Do you like animals? Do you have any pets?
2. Is there any goal of animal classification? If there is, what is it?
3. What would happen if there were no animal classification? Their prediction of not having animal classification at all.
4. How would you classify animals? On the base of what predicament/attributes?

The first questions was asked to state students' attitudes toward animals – as Prokop and Tunnicliffe's (2010) work shows, having a pet, or liking one, might influence answers of students, and authors wanted to know if in the interviewed group, there are students who do not like animals, which might make results inconclusive.

Questions from two to four referred directly to students' knowledge and attitudes towards animal classification.

Moreover, we were interested in observing the differences in the students' answers in relation to their gender or age.

Pupils' answers were audio recorded. The questions were asked in predesigned order to each pupil. If the pupils did not understand any of the questions, researcher explained them in detail. Pupils were chosen from the class without any previous notice and consequently, they were not able to prepare themselves for the interviews. To motivate pupils, each of them received a verbal encouragement and a praise. In cited transcripts "R" means Researcher, "B" stands for boys, and "G" for a girls.

Statistical Analysis

Recordings were analyzed by two researchers, whom has made content analysis and categorization of data. Data were implemented to Excel program separately for each student, and then were measured results of frequency in each category.

RESULTS

Results are presented in order in which questions were asked in interviews.

1. Do you like animals? Do you have any pets?

IAs a response to the first question, majority of respondents claimed that they liked animals (96%) and they owned one (82%). Most of them had a dog as a pet.

2. Is there any goal of animal classification? If there is, what is it?

In the response for the second question, all of the pupils claimed that animal classification was important (100% of respondents). But, when asked about the goal of animal classification and why we do it, the children's answers varied. About 60% of pupils claimed that the goal of animal classification was to differentiate animals from each other, rest of the respondents had no idea what the purpose was, but the question number three helped them to express themselves.

3. What would happen if there weren't any animal classification? Their prediction of not having animal classification at all.

The question number three in the survey was: what would happen if we removed animal classification? This, in contrast with question number two, encouraged students to use their imagination. All of the answers were divided on 10 categories. In the answers - one of the students claimed, that if we did not use animal classification, animals would not exist (2%- one boy), there would be mess and animals would get mixed up (43%), or that it would be hard to differentiate them (26%). Some students pointed out, that it would be hard to talk about animals without misunderstandings (7%) or recognize them just on the basis of morphological features (5%). Other ideas were also worth mentioning. There were pupils who said that in that situation it would not be easy to remember

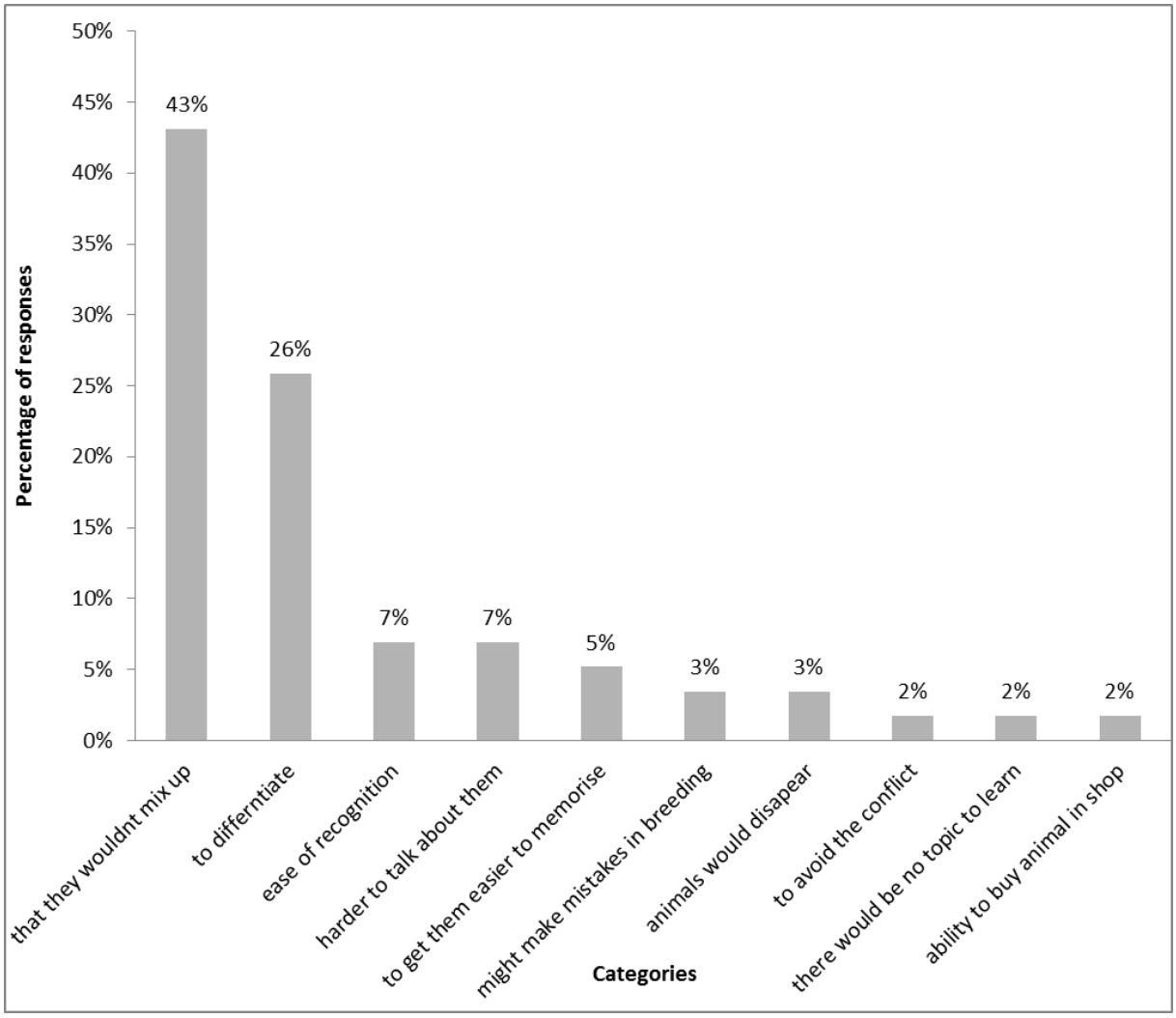

Figure 1. Percentage of responses to the question: Based on what category, can we classify animals? (N=34)

animals (5% - one girl and one boy) or that without animal classification all animals would be in one large uniform group and therefore, they might end up fighting each other (2% - one girl). In last two categories, students claimed more anthropocentric and practical ideas like – there wouldn't be any topic to learn (2%) or it would be hard to buy animals in the shop (2%). All of the answers are presented in **Figure 1**.

4. How would you classify animals? On the base of what predicament/attributes?

Last question concerned the categories used in classification asking what key students would use to divide animals into different groups. The answers varied but we grouped them into 8 categories: morphology (28% of responses), environment (23% of responses), reproduction (16% of responses), behavior (9% of responses), ecology (mostly level in food chain) (9% of responses), type of locomotion (7% of responses), adaptation (5% of responses), organ of respiration (5% of responses). All of the answers are presented in **Figure 2**.

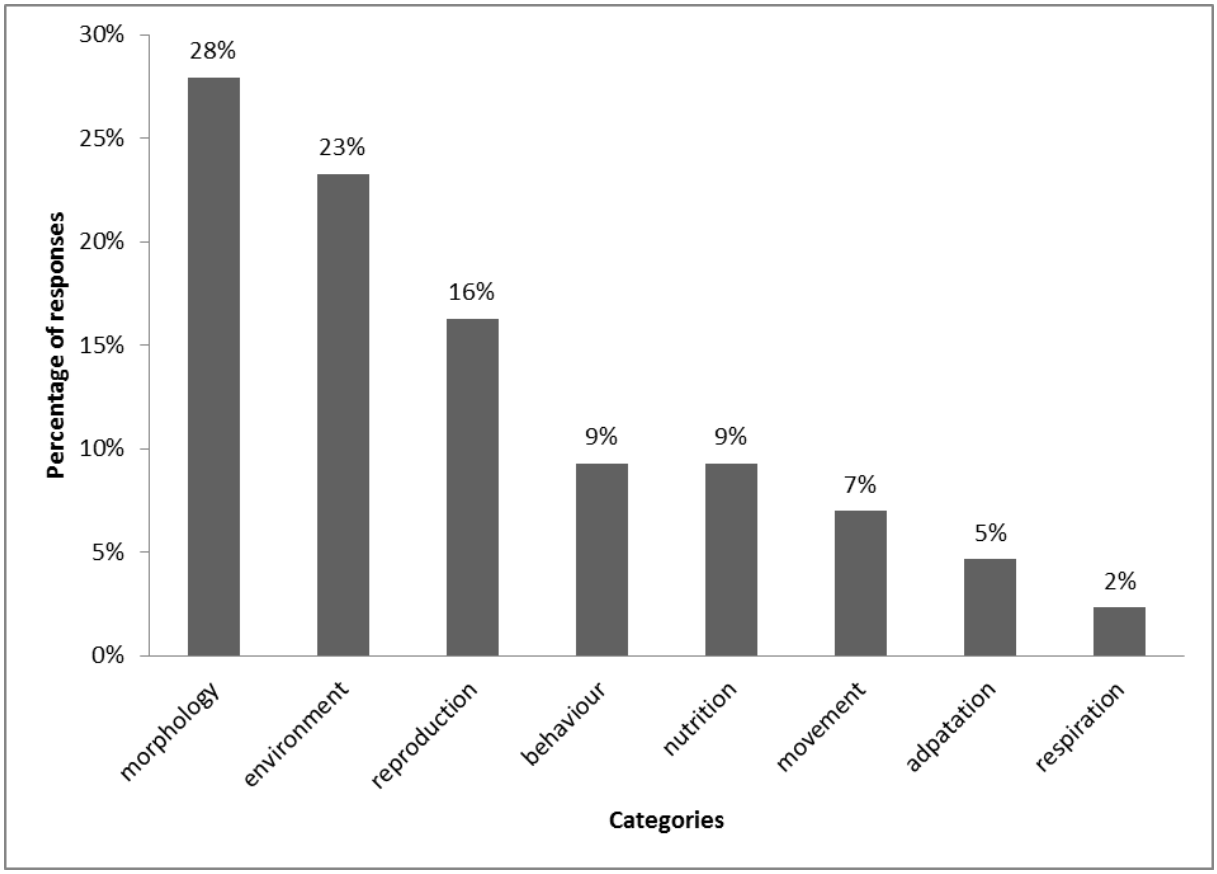

Figure 2. Percentage of responses to the question: Base on what attributes, can we classify animals? (N=34)

Table 1. Differences between genders in claimed categories to classify animals (G – girls, B – boys, G% - percentage of answers for girls, B% - percentage of answers for boys)

Categories	FG	MB	FG%	MB%
Morphology	7	5	16.3%	11.6%
Environment	7	3	16.3%	7.0%
Reproduction	7	0	16.3%	0.0%
Behavior	3	1	7.0%	2.3%
Nutrition	4	0	9.3%	0.0%
Movement	2	1	4.7%	2.3%
Adaptation	1	1	2.3%	2.3%
Organ of respiration	0	1	0.0%	2.3%

There were differences between girls and boys - for example, in the category of morphology, 7 girls and 5 boys claimed that it was an important issue for animal classification, on the other hand, 7 girls said that reproduction was important to divide animals and none of the boys had similar ideas. All differences between gender are presented in **Table 1**.

Qualitative Analysis

The first question, which focused directly on the animal classification was the one which asked whatever students see any goal of animal classification. In this case, more boys (100%) than girls (93%) were convinced about that. When students started to explain their reasoning, one boy from 6 grade, said that:

"B: We differentiate animals, to recognize morphological features of an animal more easily.

R: What features?

B: Oh, for example what hide they have, where they live…"

However, that was the only one response which refer to significance of animal classification. Most of the boys claimed, that classification is based on animal anatomy:

"B: We differentiate animals because of how they look and what they have inside.

R: What do animals have inside?

B: Lungs, or heart…

R: And how can it be the key for classification?

B: Because, we can look at the different animals, check if they have hearts for example, and if they have something in common".

In this case, it can be observed, that this boy was more thorough with his observation and was aware of anatomy of animals and differences between them. This type of explanation was not observed in younger groups.

Another issue, raised only by boys, was adaptation, which was explained, for example, in such a way:

"B: I think, the classification of animals should be created on the basis of their adaptation,

R: Can you explain what adaptation is?

B: It is how they take care of themselves in the environment where they live.

R: And how can it be crucial for taxonomy?

B: Because if they are in the same environment, they can be close to each other, like family"

The idea of adaptation was quite interesting, although only one boy referred to this issue.

On the other hand, girls were more focused on such ideas as reproduction:

"G: We can differentiate animals, by the way how they reproduce and what the eggs look like,

R: Can you describe it?

G: Some animals have transparent eggs, some not, and some are born alive, without eggs.".

In this response, a girl focused on a very important issue in differentiation of species, which is reproduction. These were very insightful, and in the future, this collection might be very useful to construct more complex concepts about animals.

Moreover, two girls were focused on the way how animals move:

"G: Animals move differently, snakes can wriggle and others can run,

R: What others?

G: Others, such as horses.

R: And beside horses?

G: There are frogs, which jump or birds which fly."

From this conversation, an assumption can be made, that girl claims snakes cannot run, which is correct. She also assigns the right kind of movement to other animals.

One of the girls, puts stress on utility of the animals for humans:

"G: Animals can be differentiated because of the use for humans. For example cows for milk or chickens for eggs".

This sentence showed that this girl had a pragmatic approach to animals, but also that she was aware that some food is provided by animals.

Differences in Groups

The answers to first question shows differences between genders. The main difference that we observed, was students' explanation of the goal of animal classification. Girls had different ideas about it than boys. Authors divided students' answers into four categories: communication, kinship, key to classify and behavior.

The differences between genders were also observed in the answers to the second question. Majority of the boys (with the exception of two of them) responded that without animal classification there would be a disorder. On the other hand, girls had more varied replies. More girls than boys claimed that without classification it would be harder to memorize the animals, the lack of classification can lead to a conflict between animals, or that the animals would simply vanish. This result might show that girls are more empathic than boys. One of the girls compared the outcome to mixing two different groups in schools - if we merged two classes, students would be not happy to interact with some girls and boys from the outside of their class. All the categories, with specific examples are presented in **Table 2**.

Table 2. Differences in categories in particular groups of students

Categories	Boys	Girls
Communication	-	Different animals from different groups might fight with each other
Kinship	adaptation and origin is important in animal classification	animal kinship based on similarity of their external appearance
Key to classify	environment, anatomy, adaptation and respiration.	differentiation, reproduction, movement and food
Behavior	Animals despite being in the same group do not interact with each other	Animals in the same groups interact with each other, if we mix animals from different groups, they will be mainly exposed to negative consequences

DISCUSSION

Our research shows that students were interested in animals and at the same time they failed to define animal classification scientifically. Having that in mind, researchers should look at other factors which might influence these results such as: social context, motivation or utilitarianism.

An important factor in the acquisition of information should be its social context. It is significant to draw attention to the conflict between the knowledge passed on us, for example, by parents and society, and scientific knowledge, which is given to us by teachers and textbooks (Mji & Makgato, 2006). Often, information provided by media, parents or textbooks, can be conflicted with scientific knowledge and leads to students' misconceptions (Barrow, 2002; Gericke, 2009; Sajkowska & Rybska, 2014). All of the above mentioned papers agreed that the motivation and interests of students is what we should be focused on. In our study, majority of the students declared their interests in animals and even owned some pets. In researched group, there was only one student who declared that he did not like animals and did not have any interests in them. To analyze how their interest influence their ideas towards animal classification further research should be conducted in a group with lower interests in animals.

The other factor which may have influence is motivation of students towards animal classification. Despite the age, humans - children and adults - have to see the purpose of their actions. When we are assigned to the task which, in our opinion has no goal, we are not motivated to do it, and also information gained in this way (after learning to exam in the subject which is useless for us) will be forgotten in a very short time (Rabinowitz & Vastag, 2012). And only when students are interested in something, gained knowledge will remain in their memory and will be used by them. Also, some of previously published works, had concluded that the interests of students are what researchers and teachers should focus on (Arends & Kilcher, 2010; Doyle, 1977; Marsh & Roche, 1997).

Our results show that for students, the utilitarian approach is most important, as they were thinking about animal classification as a tool. For example, as presented in works of Balmford et al. (2002) and Dorward et al. (2017) about Pokemons, children are able to learn classification when they are interested and see the purpose, as they knew that water Pokemons can defeat fire Pokemons, and that their strength depends on how big and evolutionary advanced they are. This was similar in both papers that students knew how to classify and how to use the Pokemon. What is also in agreement with our results, is that students' answers were always human centered – as they also referred how they can use animal classification for their purposes. It was evident, especially in question concerning what would happen without animal classification, as the answers were "It would be harder to learn" or "we couldn't divide them" or "there would be a mess". All of the respondents failed to notice the use of the classification for the research and protection of animals. But this result is not unexpected as it is linked with human nature theory, where human is in the center of everything. This is an important implication for researchers and teachers how to turn attention of students towards different aspects of classification and present them with a more holistic ecological view. In this way, we could teach them to think not only from human perspective but also from environmental perspective. The approach to build their own classification presented by Rosch and coworkers (1976) might be easier for students to understand. For example, if we want students to be able to create abstract and artificial concept of group of amphibians, teachers and textbooks might help with constructing a basic level by use of example of a frog with details and then gradually introduce more complicated native amphibians (like a newt or salamander), and allow them to create a superordinate level which is a general and abstract concept of higher taxonomy group. In our opinion, didactics should take these findings into consideration and try to apply them in their teaching processes.

While taking a closer look to gender differences, our results stays with agreement with Spelke (2005), that cognitive abilities of boys and girls (or male and female), from birth to maturity, do not support the claim that men have greater intrinsic aptitude for science. Both groups are able to learn scientific concepts at a superordinate level, they are able to use these concepts and possess common abilities to represent objects, numbers, language, and space

etc. What we can observe, are differences in so called cognitive profile, the example of which can be a more empathic approach in classification represented by girls than boys. Also, girls seems to pay bigger attention to the aspects of relations (eg. with the environment) while boys, in their explanations, are more focused on the organizational aspects. Baron-Cohen (2002) in their work suggest two kinds of approaches: empathizing and systematizing, and in our studies, girls presented more empathizing dimension then systematizing one, despite that, in their research, they did not tend to prescribe it to gender (Baron-Cohen, 2002; Zeyer, 2010). Developing future research in that direction is needed.

Nevertheless, looking at the aspects of taxonomy - one major question may arise - how should taxonomy be taught in order to put more pressure on its use in the environment research and study? For example, the modern taxonomy of animals is based on the phylogenetic origin and is often supported by genetic and morphological data, however, the research shows that students better memorize things connected with ecology or behavior (Cardak, 2009; Kattman, 2001). On the other hand, if a particular student learns about different animal taxons far away from wildlife, and their only source of information are textbooks, it is not surprising that their mental models are incomplete or just wrong (Bizzo, Monteiro, Lucas, & Bianco, 2012; Gericke, 2009; Sajkowska & Rybska, 2014). Therefore, it can be assumed that a lack of direct experience can be an important obstacle in understanding animal classifications. It was shown that contextual teaching is far more effective than teaching and learning without context (Ruiz-Mallen, Barraza, Bodenhorn, & Reyes-García, 2009). The obtained results help us to more deeply and holistically understand the idea of teaching about animal classification, by proving educational implications that it should be based on/and relate to students' ideas and interests about it.

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