Pre-service Teachers' Conceptual Structures and Reasoning Patterns on Animal Classification

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Abstract The main purpose of the study was to investigate pre-service teachers' perceptions of the criteria used to classify animals. In this regard, it was also aimed at exploring conceptual structures and reasoning patterns shaping the pre-service teachers' perceptions. The participants of the present study were 324 pre-service teachers attending science education and biology education departments in Turkey. With the aim of gaining insight into pre-service teachers' perceptions of animal classification, qualitative research method was followed in which the participants were interviewed. In addition to qualitative data, quantitative data were also collected by classification forms and in this way it was aimed to bring variety to analysis results and reinforce them. As a result of the study, the conceptual structures shaping the pre-service teachers' perceptions leading to their evaluations are subsumed under the categories of "morphological, anatomic and physiologic characteristics", "behaviour", "habitat" and "systematic". In light of the findings of the current study, it can be argued that some characteristics of animals were given greater priority while classifying them and this leads to development of some erroneous information and alternative conceptions. More holistic evaluation of the characteristics of animals may allow the development of a better perception of animal classification.

Keywords Teacher Education, Animal Classification, Pre-service Teachers, Conceptual Structure, Reasoning

1. Introduction

Classification research dealing with grouping or categorization of animals make possible to understand the world of living things that seems to be complicated and chaotic in a systematic order. In addition, classification system lays the ground for the better conception and protection of biological diversity. Protection of biological diversity and unity is of great importance not only to maintain the ecological balance of nature but also to ensure ecologically sustainable development. Classification research lays the scientific ground for the research in the fields of ecology, also genetics and evolution. Through biological classification enabling the collection of living things within certain groups based on their similarities and hereditary links, it becomes easier to understand many features possessed by a living thing and its similarities to and differences from other creatures. Thus, knowledge about biological classification research is of great importance to understand the characteristics of living organisms and the relationships among them and to ensure sustainable life.

Preliminary classification research was based on an artificial classification differentiating living organisms according to their color, design, habitat and superficial similarities. Today, in line with the advancements observed in modern biology, the artificial classification is replaced by natural classification. As such, now organisms are attempted to be classified in such a way as to represent their evolutionary relationships. The principles of biological classification that are the outcomes of many scientists' efforts invested to reveal the links between organisms are continuing to change in light of scientific developments. Even so, primary characteristics to be possessed by any classification system are obvious. These characteristics should allow the differentiation of different living things from each other and present the criteria required for this differentiation.

Science education research focusing on the classification of living organisms shows that students experience some difficulties in classing living organisms, they commit mistakes while classifying them, they make over- or under generalization and as a result of these, alternative conceptions occur [1-5]. In the related literature, there are many similar findings reporting that while students have a tendency to relate animals having a certain physical shape consisting of head, arms and legs to the vertebrate, they usually relate animals creeping, curling and having a flat and formless body to the invertebrate [1,4]. For instance, children from almost all age groups define the frog as a reptile, the penguin as a mammal and the snake as an invertebrate [4-7]. Moreover, a number of researches

revealed that school students from different age groups were reported to have many alternative conceptions about mammals [6], birds [8], reptiles and amphibians [9]. Although these findings vary depending on the age and education level of the study group, alternative conceptions are reported to be quite resistant [2]. Based on the belief that teachers transfer the alternative conceptions they possess to their students, a study was conducted by Burgoon and Duran [10] to investigate teachers' conceptions of animal classification. It was found that the percentage of the teachers correctly classifying all of the 6 animals given is just 7% [10]. In the same study, it was found that 65% of the teachers classified the snake and 54% of them classified the tortoise as invertebrate. According to Marulcu [11] unless individuals' experiences with the animals around them change, their mental models of animal classification remain unchanged. Therefore, teaching activities need to provide students with various experiences related to characteristics of different animals so that they can understand the criteria employed in classification.

As a result of a study conducted with the participating of children from different age groups (4, 8, 11 and 14 years old), it was found that all the students primarily take the anatomic features of animals into consideration while defining them [12]. In the same study, it was also reported that some of the senior students also used animals' behavioral and habitat-related features to define them. Kattmann[13] conducted a study with children aged 9 and 10 and reported that the criteria used by the students in the classification of animals are related to their habitats and locomotion. In light of a study carried out in Taiwan, it was reported that while identifying animals, aboriginal children primarily use their movement and eating attributes [14] The findings of these studies reveal that though students' perceptions of animals change depending on their ages and experiences, they also based on classification criteria.

The research made in countries such as New Zealand [15], America [4,5], England [2], Germany [3], Slovakia [6] and Taiwan [7,14] in relation to the classification of animals provides comprehensive information about the alternative conceptions of students. In these researches, while the alternative conceptions held by elementary, secondary and high school students were investigated, their change patterns over time were also explored and as a result, it was reported that the alternative conceptions are stable and resistant to any change. The current study builds on previous work in other countries and more particularly focuses on pre-service teachers' knowledge structures and reasoning patterns about criteria for animal classification in Turkey.

Knowledge about the criteria used in the classification of living organisms is believed to be effective in the prevention of the formation of erroneous information and conceptions. Thus, from the beginning of schooling, great importance should be attached to resources used in science instruction and competencies of teachers. When the related literature is examined, it is seen that research on the classification of animals mostly focuses on alternative conceptions possessed by students from different levels of schooling, but there is a lack of research dealing with pre-service teachers' perceptions of the criteria used in the classification of animals. In the current study conducted for the purpose of filling this gap in the literature, the first aim was set to be to elicit the perceptions of criteria used in animal classification. Based on the idea that the science teachers should assume the main responsibility for imparting the targeted information and conceptions to students, pre-service science and biology teachers were included in the present study to determine their related competencies. It is believed that by determining the pre-service science and biology teachers' conceptual structures and the reasoning patterns, it will be possible to make some evaluation of the education programs offered to students before and during higher education.

2. Methodology

In the present study investigating the pre-service science and biology teachers' perceptions of the criteria used to classify animals, qualitative research method allowing comprehensive and detailed analysis was employed. In addition to qualitative data, quantitative data were also collected to diversify and reinforce the study findings. As a result of the analysis of the collected data, categories were established and the conceptual structures possessed by the pre-service teachers in relation to the animal classification were determined.

2.1. Participants

The participants of the study were pre-service teachers from the science education and biology education departments of universities. The data of the study were collected from 324 pre-service teachers through classification forms. Out of the participants, 36% were pre-service science teachers and 64% were pre-service biology teachers. The age of the participants ranged from 19 to 25 and 77% of them were female and 23% were male. Instruction about the concepts and topics related to the main focus of the present study, classification of animals, is given to pre-service science teachers within second year Biology I and Biology II courses. This instruction includes the topics such as diversity and classification of living organisms, classification of animals, issues of animals, growth, development, breeding, feeding, digestion, respiration, excretion, circulation and neural system. Pre-service biology teachers should take first-year General Biology I and General Biology II courses and in addition to them, they get some instruction about the classification of animals within second-year courses of Biology of the Invertebrate and Laboratory and Biology of the Vertebrate and Laboratory.

2.2. Data Collection

In the present study, data collection tools allowing

in-depth analysis to determine the reasons behind the pre-service teachers' perceptions of the animal classification and to reveal the knowledge structures they possess in relation to related concepts were employed. As such, beside data collection forms, interviews were conducted to support the analysis of the data.

Through the administration of two different data collection forms, the pre-service teachers were asked to classify various animals into their systematic groups. In the first form, names of 20 animals were ordered, and the pre-service teachers were asked to classify them as "invertebrate", "vertebrate" or "neither of them". In the second form, the names of 30 animals were ordered and the pre-service teachers were asked to classify them into their sub-systematic groups as coelenterate, worm, arthropod, mollusk, echinoderm, fish, amphibian, reptile, bird and mammal. For the development of the forms, first related literature was reviewed and the data collection instruments and items in these instruments mentioned in the literature were capitalized on [1,2,4,5,7,13]. In the data collection form used in the current study, unlike the research reported in the literature, the pre-service teachers' knowledge and skill levels in relation to the classification of vertebrate and invertebrate into sub-systematic groups were also investigated. While determining the names of animals to be included in the form, the names popular in daily language were preferred and great attention was paid for them to be known animals. For this purpose, first, two pre-service teachers one of whom is from a biology education department and the other from a science education department were asked whether there is an animal name they have never heard before among the names of animals included in the form.

Within the context of the study, semi-structured interviews were conducted with 12 pre-service teachers, which were voluntary students. To decide the number of interviewees, the responses of the pre-service teachers to the questions were considered. When the concepts and the processes used by the interviewees began to re-express, it was decided to reach out to enough data source. The interviewees were selected from different years of study and each interview lasted for 20 to 30 minutes.

The interview items were developed to elicit how the pre-service teachers perceive, conceptualize and evaluate the criteria used in the animal classification. First the related literatures were examined for determining the interview items. While developing the interview form, in order to ensure the comprehensibility of each item, an alternative item was developed and in this way it was aimed to gather comprehensive information about the opinions of the pre-service teachers. Moreover, additional items were developed to be asked when necessary so that more detailed data could be collected. The pilot interview was administered to two pre-service teachers and their opinions were taken about the comprehensibility of the items. Moreover, opinions of two experts of biology education were sought to establish the validity of the items. In line with

their opinions, final form of the interview form was given and a sample of the questions is presented below:

- If there were not such a classification of animals, how would you classify them?
- Can you describe the animal that comes to your mind and that you can visualize when you hear the word invertebrate?
- What do you consider while classifying an animal that you do not know?

2.3. Data Analysis

The interview data collected in the study were qualitatively analyzed by using inductive approach. In this regard, first interview data were transcribed and then they were reduced by organizing the statements. After the coding of the data, the related concepts were subsumed under groups and in this way categories were created. The characteristics of the categories were defined and then they were interpreted with the support of quotations taken from pre-service teachers' statements. In order to establish the reliability of the results, findings reported by the related research in the literature were taken into consideration while naming the categories and the consistency of the data collected from the classification forms used in the present study were compared with the results. In addition to the analysis of the interview data, descriptive analysis of the data collected from the classification forms was conducted and the results were reported in the form of frequencies and percentages.

3. Results

With the first analysis of the pre-service teachers' responses to the classification forms requiring them to classify the animals, preliminary findings related to their evaluations of classification criteria were obtained. Findings obtained as a result of the descriptive analysis of the students responses to the classification forms were organized in three separate tables. First, frequencies and percentages calculated for the data collected through the first form asking students to classify 20 different animals as "invertebrate", "vertebrate" or "neither of them" are presented in Table 1.

The correct classification of the animals as "invertebrate" or "vertebrate" by the pre-service teachers varied depending on the individual animal. The animals classified correctly to the greatest extent are dolphin (96.0%), mouse (94.4%) and frog (89.5%) and it is noteworthy that all these animals are vertebrate. These animals are followed by lizard (87.3%) and tortoise (87.0%), which are also vertebrate, in terms of correct classification. The invertebrate animals classified correctly to the greatest extent are lumbricus (89.2%), leech (88.6%) and snail (88.0%). Moreover, 83% of the pre-service teachers correctly classified jellyfish as invertebrate. On the other hand, the percentage of the

pre-service teachers holding the alternative conception that the snake is an invertebrate animal is 26.5%. A similar alternative conception was also found for the ray; 28.7% of the pre-service teachers classified it as an invertebrate.

The animals correctly classified to the lowest extent by the pre-service teachers are crab (39.2%) and scorpion (38.6%) from the group of invertebrate. High majority of the pre-service teachers classified them as vertebrate animals (50.6%, 50.9%, respectively). Another invertebrate for which low percentage of correct classification was observed is cockroach (54.0%). These findings show that the pre-service teachers have a tendency of grouping animals having external skeleton as vertebrate.

Another remarkable result seen in Table 1 is that more than 10% of the pre-service teachers did not put hydra (19.8%), mussel (16.0%), sponge (13.9%), starfish (13.3%) and sea-urchin (11.7%) in either of the groups. When these results are considered together with the other results presented in the table, it seems to be obvious that the pre-service teachers experience greater difficulties in classifying invertebrate than vertebrate.

The pre-service teachers' frequencies of correctly classifying the animals as vertebrate and invertebrate were examined and when the mean of all the participants were evaluated out of 20 points, it was found to be 15.10. When the means of the pre-service teachers were evaluated depending on the department they are attending, it was found that pre-service biology teachers' mean score gained from the first classification form is higher than that of the pre-service science teachers. When evaluated out of 20 points, the mean score of the pre-service biology teachers was found to be 16.19 and that of the pre-service science teachers was found to be 13.12.

Table 1. Frequencies and percentages of the pre-service teachers' responses to the animal classification

	Invertebrate		Vertebrate		Neither of them		No response	
	f	%	f	%	f	%	f	%
Centipede	**216**	**66.7**	82	25.3	19	5.9	7	2.2
Cockroach	**175**	**54.0**	110	34.0	32	9.9	7	2.2
Crab	**127**	**39.2**	164	50.6	24	7.4	9	2.8
Dolphin	8	2.5	**311**	**96.0**	3	0.9	2	0.6
Frog	18	5.6	**290**	**89.5**	7	2.2	9	2.8
Hydra	**236**	**72.8**	10	3.1	64	19.8	14	4.3
Jellyfish	**268**	**82.7**	24	7.4	28	8.6	4	1.2
Leech	**287**	**88.6**	11	3.4	19	5.9	7	2.2
Lizard	30	9.3	**283**	**87.3**	4	1.2	7	2.2
Lumbricus	**289**	**89.2**	15	46	15	4.6	5	1.5
Mouse	14	4.3	**306**	**94.4**	2	0.6	2	0.6
Mussel	**236**	**72.8**	25	7.7	52	16.0	11	3.4
Ray	93	28.7	**190**	**58.6**	22	6.8	19	5.9
Scorpion	**125**	**38.6**	165	50.9	25	7.7	9	2.8
Sea-urchin	**247**	**76.2**	22	6.8	38	11.7	17	5.2
Snail	**285**	**88.0**	16	4.9	19	5.9	4	1.2
Snake	86	26.5	**225**	**69.4**	9	2.8	4	1.2
Sponge	**266**	**82.1**	6	19	45	13.9	7	2.2
Starfish	**248**	**76.5**	22	6.8	43	13.3	11	3.4
Tortoise	25	7.7	**282**	**87.0**	9	2.8	8	2.5

Note: The correct responses are marked in bold in the table. (n = 324)

In the second form, the pre-service teachers were asked to classify 30 different animals into the systematic groups of vertebrate and invertebrate that are "coelenterate", "worm", "arthropod", "mollusk", "echinoderm", "fish", "amphibian", "reptile", "bird" and "mammal" and the mean of the pre-service teachers was found to be 17.62 out of 30. The data collected through the administration of the second form are presented in two different tables as the samples of invertebrate animals and the samples of vertebrate animals. In Table 2, the frequencies and percentages calculated for the pre-service teachers' responses related to the classification of invertebrate into their systematic groups are given.

In Table 2, it is seen that the pre-service teachers' responses to the classification of the invertebrate into their systematic groups varied to a great extent. The animals correctly classified to the greatest extent are grasshopper (84.9%) and ant (79.9%) and these animals can be seen by the participants frequently in their daily lives. However,

though bee (65.1%) and butterfly (55.9%) can also been seen by the participants in their daily lives, their ratio of correct answer in their classification is not high. Another finding found here is that 9% of the pre-service teachers classified bee and 13% of them classified butterfly as a bird from vertebrate. The percentage of the pre-service teachers classifying octopus as a fish is 9.6.

Another remarkable finding reported in Table 2 is related with jellyfish and starfish. The pre-service teachers' percentage of correctly classifying jellyfish and starfish is low and they were classified as mollusk to a great extent (55%, 24%, respectively). A similar result was found for leech and the percentage of the pre-service teachers classifying leech as worm and mollusk are the same (36.7%). These results indicate that the pre-service teachers think that invertebrate animals mostly belong to the group of mollusk. And nearly 20% of the pre-service teachers did not give any responses to the classification of mussel (18.8%) and coral (17.9%) from invertebrate.

Table 2. Frequencies and percentages of the pre-service teachers' responses to the classification of invertebrate

	Coelenterate		Worm		Arthropod		Mollusk		Echinoderm	
	f	%	f	%	f	%	f	%	f	%
Ant	3	0.9	1	0.3	**259**	**79.9**	3	0.9	1	0.3
Bee	5	1.5	1	0.3	**211**	**65.1**	2	0.6	4	1.2
Butterfly	1	0.3	10	3.1	**181**	**55.9**	7	2.2	1	0.3
Coral	**136**	**42.0**	3	0.9	5	1.5	76	23.5	17	5.2
Grasshopper	2	0.6	3	0.9	**275**	**84.9**	3	0.9	3	0.9
Jellyfish	**64**	**19.8**	2	0.6	10	3.1	178	54.9	10	3.1
Leech	40	12.3	**119**	**36.7**	4	1.2	119	36.7	2	0.6
Mussel	69	21.3	3	0.9	16	4.9	**135**	**41.7**	17	5.2
Octopus	11	3.4	-	-	34	10.5	**186**	**57.4**	7	2.2
Sea-urchin	33	10.2	3	0.9	11	3.4	40	12.3	**180**	**55.6**
Snail	25	7.7	43	13.3	18	5.6	**174**	**53.7**	3	0.9
Starfish	54	16.7	-	-	12	3.7	79	24.4	**117**	**36.1**
Tenia	65	20.1	**150**	**46.3**	17	5.2	12	3.7	2	0.6
Tick	16	4.9	7	2.2	**214**	**66.0**	4	1.2	5	1.5

Note: The correct responses are marked in bold in the table. (n = 324)

Table 3. Frequencies and percentages of the pre-service teachers' responses to the classification of vertebrate

	Fish		Amphibian		Reptile		Bird		Mammal	
	f	%	f	%	f	%	f	%	f	%
Bat	2	0.6	1	0.3	1	0.3	40	12.3	**261**	**80.6**
Chameleon	2	0.6	17	5.2	**210**	**64.8**	12	3.7	14	4.3
Chicken	-	-	-	-	3	0.9	**263**	**81.2**	30	9.3
Crocodile	-	-	14	4.3	**255**	**78.7**	-	-	27	8.3
Dolphin	55	17.0	1	0.3	-	-	3	0.9	**253**	**78.1**
Duck	3	0.9	3	0.9	2	0.6	**244**	**75.3**	41	12.7
Frog	5	1.5	**194**	**59.9**	26	8.0	1	0.3	18	5.6
Hedgehog	-	-	3	0.9	17	5.2	-	-	**141**	**43.5**
Penguin	8	2.5	5	1.5	2	0.6	**162**	**50.0**	110	34.0
Ray	**217**	**67.0**	14	4.3	2	0.6	3	0.9	7	2.2
Salamander	11	3.4	**124**	**38.3**	45	13.9	1	0.3	1	0.3
Seahorse	**84**	**25.9**	8	2.5	-	-	-	-	11	3.4
Seal	96	29.6	2	0.6	3	0.9	1	0.3	**200**	**61.7**
Swallow	2	0.6	1	0.3	3	0.9	**276**	**85.2**	8	2.5
Tortoise	1	0.3	22	6.8	**205**	**63.3**	1	0.3	28	8.6
Trout	**316**	**97.7**	2	0.6	-	-	-	-	3	0.9

Note: The correct responses are marked in bold in the table. (n = 324)

In Table 3, the frequencies and percentages related to the pre-service teachers' responses to the classification of the vertebrate into their systematic groups are presented.

As can be seen in Table 3, the vertebrate animal sample that was classified correctly to the greatest extent is trout (97.7%). It is followed by swallow (85.2%) and chicken (81.2). Though chicken was correctly classified to a great extent, it is classified as mammal by 9.3% of the pre-service teachers. The same is true for penguin. Penguin was correctly classified as a bird by 50% of the pre-service teachers; yet, 34% of the participants erroneously state that penguin is a mammal.

Another alternative conception was detected for bat. Though bat was correctly classified as a mammal by 80.6% of the pre-service teachers, 12.3% of the participants misclassified bat as a bird. Some participants have an alternative conception about seal, which is a mammal. While 61.7% of the pre-service teachers classified seal as a mammal, 29.6% misclassified it as a fish. In a similar manner, while dolphin was classified as a mammal by 78.1% of the participants, it was misclassified as a fish by 17% of them.

The vertebrate for which 12% of the participants did not give any responses are frog (12.3%) and salamander (12%). Belonging to amphibian group, these two animals were misclassified as a reptile by some pre-service teachers (8%, 13.9%, respectively). The vertebrate animal sample for which 22.8% of the pre-service teachers did not give any responses is seahorse. The lowest correct response percentage (25.9%) was found for the classification of seahorse among the vertebrate animal samples in the form. Seahorse was usually misclassified within the invertebrate

groups of mollusk (17%) and echinoderm (11.7%), though it is a vertebrate. In a similar manner, though it is vertebrate, hedgehog was misclassified as invertebrate. Hedgehog that was correctly classified as a mammal by 43.5% of the pre-service teachers was misclassified as a member of echinoderm by 35.5% of the participants.

These findings seem to support the findings obtained through the administration of the first form but also show that some of the pre-service teachers make mistakes while classifying some animals as vertebrate or invertebrate. The results obtained from the second form revealed that the pre-service teachers are more successful in classifying vertebrate than invertebrate. In general, descriptive statistics showed that the frequencies and the percentages of correct responses for many of the animal samples are not high.

While the data presented in Tables 1, 2 and 3 represent the pre-service teachers' evaluation of the classification of animals, the main purpose of the current study is to determine the perceptions making up the causes behind these evaluations; thus, the conceptual structures elicited as a result of the analysis of the interview data are presented below. It was observed that the pre-service teachers' conceptual structures of the criteria considered in animal classification are subsumed under the categories of "morphologic, anatomic and physiologic features", "behavior", "habitat" and "systematic".

3.1. Morphologic, Anatomic and Physiologic Features

The high majority of the pre-service teachers think that the criteria taken into consideration in the classification of the animals are based on morphologic, anatomic and physiologic

features. It was observed that the pre-service teachers frequently mentioned morphologic, anatomic and physiologic features together and the percentage of mentioning them was found to be 57.35. Considering morphologic and anatomic features, high majority of the pre-service teachers (72%) in this group stated that while classifying animals, their external appearance is taken into consideration. In this connection, they stated that bodily features such as the shape of the body, presence of extremities and properties of the skin are considered. Some quotations from the statements of the pre-service teachers are presented below:

> "While conducting the classification of animals, their most remarkable external features are taken into consideration. Then the structure of the skin, its surface and whether there is hair or not are examined. Whether it is soft or hard is important. Whether it has a distinct [body] shape or it is shapeless, these are important criteria." (Student 7, 4th year, female)

> "Whether there is a backbone is the first thing considered. [It is classified] according to the structure of skin. For instance, the skin of frogs and worms is wet but that of humans is dry. Whether the body is hairy or scaly is important. Extremities are also important; for example, legs of snakes got lost over time." (Student 5, 3rd year, male)

> "The most important feature in classification is the backbone and then the extremities. For instance, fishes have fins. Vertebrates have an upright body structure. They seem to have stronger external appearances. Invertebrates are relatively smaller and softer creatures." (Student 6, 2nd year, male)

Some of the pre-service teachers (28%) stated that besides morphologic and anatomic features, physiologic features are also considered in the classification of animals. It was particularly emphasized that support and movement systems and circulation and reproduction systems are features capitalized on in animal classification. In this regard, some quotations from the pre-service teachers' statements are presented below:

> "First features considered [in animal classification] are the backbone and external features. For example, are they crusty or thorny or do they have extremities? Whether the animal is cold-blooded or warm-blooded is also taken into consideration, for this purpose, its blood circulation is considered." (Student 2, 4th year, female)

> "While animals are classified, the neural system is examined. In this connection, chorda structure, digestive system, coeloma cavity, blood circulation and reproduction are important features to be considered. The structure of the heart offers some insights; it is important to determine whether it carries arterial or venous blood." (Student 5, 3rd year, male)

In the above-given samples of the pre-service teachers

claiming that the criteria used in animal classification are based on their morphologic, anatomic and physiologic features, the external appearance of animals come to the fore. Special emphasis is given to the existence of the backbone in this category and the pre-service teachers mention morphologic and anatomic features more than their physiologic features in animal classification. However, the pre-service teachers did not provide detailed descriptions related to these three groups of features and they offered superficial and general explanations. The high percentage of wrong answers given by the pre-service teachers to the questions in the classification forms supports this finding. It was observed that in the classification forms, the animals were classified according to their external appearance and as a result, the pre-service teachers commonly made mistakes.

3.2. Behavior

The percentage of the pre-service teachers stating that behavioral features such as movement, hunting and feeding are important in the classification of animals was found to be 22.47. The pre-service teachers emphasizing the movement features of animals mostly took into consideration their flying, swimming and crawling movements and stressed that fact that invertebrates move slowly and can curl. In this connection, some quotations from the pre-service teachers' statements are presented below:

> "Their feeding and reproduction patterns are important features in their classification. Their feeding patterns show whether they are carnivore or herbivore. Then whether they creep or not is also important, whether they can fly or not and their speed while moving are important in classification. For instance, some lizards move very fast. When I hear the word invertebrate organisms, what comes to my mind first is their movements, ability to curl." (Student 12, 1st year, female)

> "If it moves slowly, then it is invertebrate. Vertebrates move faster. There is a prey-hunter relationship among vertebrate animals. Normally, fishes move slowly, but when they come across a threat, they can move very fast." (Student 10, 3rd year, male)

> "Hunting is an important criterion. Invertebrates do not match the definition of the concept of hunting." (Student 11, 4th year, male)

The pre-service teachers' responses to the question "How would you classify animals, if there were no biological classification of them or you did not know anything about this classification?" were primarily subsumed under this category. Some quotations from the pre-service teachers' responses are given below:

> "If I were, I would classify them as flying ones, swimming ones and creeping ones. That is, I would look at their movements." (Student 5, 3rd year, male)

"I was thinking that bat is a bird, because it has wings. I could have classified kangaroo as a member of jumping animals. For example, I would not feel confused, if I was asked whether dolphin is a fish or a mammal. Gorillas can walk on their two feet, I would differentiate them from monkeys. That is, I would differentiate them based on their movements. More simply, as swimming ones, flying ones, running ones and jumping ones." (Student 4, 3rd year, female)

In the responses of the pre-service teachers stating that movement, feeding and hunting features of animals are among the criteria used to classify animals, the ability of move and speed come to the fore. In addition, the pre-service teachers seem to put greater emphasis on movement patterns of animals than other behavioral features. The results obtained from the classification forms also support this finding. The pre-service teachers' responses to the questions in the classification forms reveal that the pre-service teachers give greater priority to their movement patterns while classifying animals and this leads to some misclassifications.

3.3. Habitat

It was observed that the pre-service teachers stating that the habitat is an important criterion in animal classification mostly used general statements and did not make detailed explanations while explaining their opinions about the issue. In this connection, the pre-service teachers exhibited a strong tendency of classifying them as those living on land and those living at sea. The percentage of the pre-service teachers' statements in regard to habitat category was found to be 7.55. Some pre-service teacher quotations in relation to this category are presented below:

"Invertebrates usually live in water and are very small, even they cannot be seen. But, we can see insects around us, they live on land; therefore, we think that they are vertebrate." (Student 4, 3rd year, female)

"When I hear the word "invertebrate", organisms living in water come to my mind. [For instance] jellyfish." (Student 1, 1st year, female)

"While performing the classification, usually what is considered is where animals live, which animals they live with and which animals they feed on. And what kind of benefits they offer to their environments is also important." (Student 7, 4th year, female)

Most of the statements evaluated under the category of habitat mostly appeared in the responses given to the question "If you were, how would you classify animals?". Some of the pre-service teachers gave responses to this question such as "those living in water, those living on land and those living in the sky". This result is parallel to the responses given to the items in the classification forms and explains the mistakes made by the pre-service teachers. Classifying the animals primarily considering their habitats, the pre-service teachers displayed similar mistakes in the classification forms.

3.4. Systematic

Opinions of the some of the pre-service teachers about the criteria used in animal classification indicate that they are aware of the importance of the features in scientific classifications. The percentage of their responses given based on the idea that animals are classified according to their similar and different features is 12.63. While most of the statements considered here are related to the morphologic structure, one of the features taken as a criterion in the scientific classification, some others focus on similarities and differences related to reproduction and feeding. Some quotations from the pre-service teachers' statements expressed under the category of systematic are presented below:

"While conducting a classification, first backbone is looked at and then extremities and skull are considered. They can be classified as those are gnathostomata, those are agnatha, or those having a skull, not having a skull. The animals not having a skull are simple animals." (Student 6, 2nd year, male)

"While classifying animals, first their shapes and body structures are examined. Existence of extremities and backbone are looked at. Mouth structure is examined to see whether it has a peak or mouth. Whether it has teeth is considered and in this way, it can be determined whether it is a carnivore or herbivore. Their reproductive organs are examined." (Student 3, 2nd year, male)

"It is difficult to understand that a whale is a mammal. If I did not know that the whale gives birth, I would not classify it as a mammal because it lives in water and looks like a fish." (Student 7, 4th year, female)

The responses given by the number 6 student to the question "If you were asked to classify an animal you do not know anything about, which features of it would you consider?" are dealt with under the category of systematic and are as follows:

"First, I would look at its backbone. If it has a backbone, we can distinguish it from the invertebrate. Then I would examine it to see whether it has features similar to animals having backbone. For instance, I check to see whether it has a gill, then it might be a fish. I check it to see whether it has a skull. I look at its mouth structure. Some species do not comply with the systematic in classification; that is, there are some exceptions." (Student 6, 2nd year, male)

The most remarkable finding that can be derived from the examples given is that the pre-service teachers are presenting reasons for the systematic features taken as criteria in animal classification. These criteria were attempted to be explained by relating to morphologic structures or feeding and

reproduction patterns or their habitats. Such explanations given by some of the pre-service teachers reveal that they developed a holistic perception of the classification unlike other pre-service teachers.

Another notable finding obtained from the analysis of the interview data is that all of the interviewees stated that they know vertebrate animals better than invertebrate animals. The reason stated by the pre-service teachers for this is that they were able to see vertebrates around or via communications tools. Moreover, the experiences they lived as a result of seeing vertebrates around had some influences on their opinions about animal classification. Some of the relevant responses are presented below:

> "I think I know the vertebrate better. There are not many visible samples of the invertebrate. They do not have many visible and observable samples around." (Student 1, 1st year, female)

> "As the vertebrate are bigger, they are more visible. They are everywhere in our common living area. We see, touch and stroke them. We see the vertebrate on TV. Documentaries are more related to the vertebrate." (Student 10, 3rd year, male)

> "I saw a dead snake, its flesh was eaten by rats and only its skeleton was there. Then, I understood that the snake is a vertebrate animal. I thought that it was invertebrate as it could curl." (Student 11, 4th year, male)

The common opinion of all the pre-service teachers is that they know vertebrate animals better than invertebrate animals and this is parallel to their responses to the classification forms. According to the results obtained from the classification forms, the pre-service teachers are more successful in classifying vertebrates than they are in classifying invertebrates. Some sample statements showing that they know invertebrates less are as follows:

> "I am confused about whether insects are vertebrate or invertebrate. As they are small, I am prone to consider them invertebrate. I think that it must be invertebrate if it is small. But, we see them a lot around, then we think that they are vertebrate. Moreover, the structures of insects seem to be including a skeleton. They have legs and feet. Thus, I feel confused." (Student 4, 3rd year, female)

> "If it moves slowly, then it is an invertebrate. Invertebrate animals are smaller and softer." (Student 10, 3rd year, male)

The pre-service teachers stated that when they hear the word "invertebrate", what come to their mind are mostly animals such as worm, sponge and jellyfish. None of the pre-service teachers stated any arthropoda sample. As can be seen in the above-given examples, the pre-service teachers experience difficulty in classifying the arthropoda as invertebrate and this finding is supported with the analysis of the classification forms. Besides the categories given in the classification forms, another category under the heading of

"others" was also included for the pre-service teachers to express their own opinions freely when they think that any animal cannot be classified under the given headings. Under the category of "others" mostly insects were written. This shows that the pre-service teachers could not classify insects as arthropods and accordingly as invertebrate. The reason found for this result is related to the responses given to another interviews question and stems from the features used by them to differentiate the vertebrate form the invertebrate. In this connection, some sample statements are given below:

> "If it is soft and round, then it is an invertebrate. And also small organisms." (Student 1, 1st year, female)

> "There is no extremity in invertebrate animals, they have no certain shapes. Their skeletons are not developed." (Student 2, 4th year, female)

> "Invertebrates are softer. Vertebrates are harder due to chorda." (Student 8, 4th year, female)

> "If it is small, then it could be an invertebrate. When I touch, if it makes me feel soft, then I classify it as an invertebrate. Thus, many people feel confused about snakes. Snakes can wiggle and curl. Backbone is not something that can wiggle." (Student 4, 3rd year, female)

What is observed in the above examples is that the pre-service teachers identify the invertebrate with characteristics such as being soft, small and flexible; yet, the vertebrate with their rigid structures. This perception of the pre-service teachers is reflected by their responses to the classification forms to a great extent and as a result, they made some mistakes while classifying the animals as vertebrate or invertebrate. Pre-service teachers stating that some animals do not belong to the both groups can be interpreted as another finding indicating that they experience some difficulties in distinguishing vertebrate animals from invertebrate animals.

4. Conclusion and Discussion

The findings of the present study offer significant insights into the pre-service teachers' conceptual structures making up their perceptions of the criteria used in animal classification and the reasons behind these structures. Preliminary findings offered by the analysis of the data collected from the classification forms point out that the pre-service teachers make mistakes in classifying animals as vertebrate and invertebrate, they experience greater difficulties in classifying invertebrate animals into their groups and they cannot classify some animals either invertebrate or vertebrate. It was observed that the conceptual structures shaping the pre-service teachers' perceptions are subsumed under the categories of "morphologic, anatomic and physiologic features", "behavior", "habitat" and "systematic". When the data collected from the classification forms were reanalyzed, it

was observed that the pre-service teachers attached greater priority to one of the categories of the criteria while making their evaluations. This finding indicates that the pre-service teachers do not create any connections among the morphologic, anatomic and physiologic features of the animals, their habitats and behaviors. That is, the pre-service teachers' opinions about the features of the animals seem to be isolated and disconnected.

Majority of the pre-service teachers emphasized the external appearance of the animals considered within the context of morphologic, anatomic and physiologic features in the classification of animals and thus, claimed that animals are classified based on their body shapes, existence of extremities, structure of skin and physiologic systems. In a similar manner, Tunnicliffe and Reiss[12] also reported that while classifying animals, students predominantly use anatomic features. Yen, Yao and Mintzes[7] concluded that students have a tendency to use morphologic features while differentiating vertebrates from invertebrates. Braund[2] stated that the students regarding the shape and size of an animal as an indication of the existence of the backbone think that long, thin and shapeless animals must not have a backbone. Braund conducted his study with students aged 7-15 and concluded that this is a dominant viewpoint among all age groups. Though the present study was conducted with the pre-service teachers, it was observed that, some of the participants have the idea that soft, shapeless, small and curving animals cannot have a backbone. For instance, as in many other studies [2,4,5,7,10], the idea that the snake is an invertebrate animal is widespread among the participants (27%). Some research conducted with students from different age groups concluded that alternative concepts are stable and resistant to change [1,4] and this finding concurs with the findings of the present study conducted with the pre-service teachers. Different from other studies, a notable finding of the present study is that the pre-service teachers stated that crab (51%), scorpion (51%) and cockroach (34%) whose have an external skeleton are vertebrate animals. This indicates that the pre-service teachers associate the existence of an external skeleton with the backbone. Moreover, the pre-service teachers also misclassified ray as an invertebrate (29%), hedgehog as echinoderm (36%) and jellyfish as mollusk (55%) and this is thought to have resulted from the pre-service teachers' attaching priority to morphologic, anatomic and physiologic features in the classification of animals.

In the present study, anatomic features were mostly mentioned together with morphologic and physiologic features. This result may indicate that the pre-service teachers can make connections between morphologic, anatomic and physiologic features or they cannot separate them from each other. The pre-service teachers most intensely emphasized morphologic, anatomic and physiologic features in animal classification but while they were expressing their opinions, they followed a general and superficial approach and could partially explain the reasons behind their opinions.

Considering behavioral characteristics as criteria employed in animal classification, the pre-service teachers emphasized the behaviors such as movement, hunting and feeding. Besides flying, swimming and crawling movements of the animals, the pre-service teachers also emphasized their speed of movement. Chen and Ku[14] reported that movement and feeding are the characteristics most frequently mentioned by the students in the classification of animals. In the same study, as the students' classification of animals is based on their visual experiences, they classify the animals crawling as insect, the animals flying as bird and the animals swimming as fish. The finding that behavioral characteristics are among the criteria employed in the classification of animals concurs with the findings reported in the literature [7,12,13]. As in other studies, in the behavioral characteristics, the movement comes to the fore. The pre-service teachers regarding movement ability and speed as criteria have a tendency to define invertebrate animals as slow and vertebrate animals as faster. Though bee and butterfly are invertebrate animals, they were classified as bird by some of the pre-service teachers (9%, 13%, respectively). This may be because they attached greater priority to their behavioral characteristics in the classification. Similar case emerged for bat, some of the pre-service teachers (12%) classified bat as bird though it is a mammal. Moreover, though it is a bird, penguin was classified as a mammal by some of the pre-service teachers (34%).

Some criteria considered by the pre-service teachers in animal classification were related to the habitat. In this connection, the students were observed to mostly focus on terms such as those living on land, in water and in the sky. That is, they preferred to use general explanations and avoided presenting detailed explanations. In a similar manner, Tunnicliffe and Reiss[12] reported that habitat is among the criteria considered in the classification of animals; yet, it is mentioned less than anatomic features. Yen, Yao and Mintzes[7] also stated that the frequency of mentioning the habitat-related features is less than morphologic, movement, feeding and anatomic features. These researchers stress that habitat is attached greater importance in distinguishing amphibians and reptiles. It is believed that some pre-service teachers misclassified octopus as a fish though it is an invertebrate and dolphin and seal as a fish though they are mammals (10%, 30% and 17%, respectively) because they attached greater importance to habitat-related criteria.

Another category emerged in the presented study is the category of systematic. This category was not observed in similar studies. This may be because the participants of the present study are from higher education. The pre-service teachers found opportunities to be in learning settings from the very beginning of their undergraduate education where they could learn about features of animals and principles of scientific classification. And this is believed to have had great influence on their perceptions of animal classification. As a result, it seems that some pre-service teachers'

perceptions of the criteria used in animal classification are based on features considered while conducting scientific classification. It is interesting that these pre-service teachers proposed some reasons for the systematic features used as criteria in the classification of animals. The criteria used in the classification were attempted to be explained by relating to the morphologic structures of animals or their feeding and reproduction patterns or their habitats. Such attempts reveal that some pre-service teachers have a holistic perception of animal classification unlike other pre-service teachers.

It was determined that the pre-service teachers' perceptions of the criteria used in the classification of animals are shaped within the framework of the above-mentioned categories. The findings of the study show that attaching greater priority to some features of animals than others while classifying them result in their developing misconceptions about animals. Evaluation of the features related to the criteria used in the classification of animals by means of a holistic approach might lead to the development of an appropriate perception of animals. In this way, understanding the relationships of animals in nature will be possible and thus a grounding consciousness could be developed for a better understanding and protection of biodiversity. Protection of biodiversity and unity is necessary for sustainable life, thus, prospective teachers who will be responsible for the education of future generations should be equipped with correct information and concepts about living organisms in nature.

5. Educational Implications

When pre-service teachers have scientifically-based conceptual structures related to the animal classification, they can develop appropriate perceptions of the criteria used in classification. The results of the current study revealed that there are some mistakes committed and difficulties experienced in the classification of animals similarly with other research results [2,5,7,9,14]. For the elimination of the difficulties experienced while conducting classification, some researchers proposed instructive approaches such as showing examples and sample cases, using visuals and conducting classification activities to develop correct concepts [2,5] and some others suggested that constructivist approach should be followed to provide students with opportunities to develop and apply their own concepts [3].

One of the important findings of the current study is that first-hand experiences are effective in the acquisition of correct and valid information about the features of animals. Another finding shows that pre-service biology teachers performed better in animal classification than pre-service science teachers. This may be because pre-service biology teachers take some laboratory courses including instruction about vertebrate and invertebrate animals that are not taken by pre-service science teachers during their undergraduate education. These two findings indicate that instructional activities conducted in a natural setting or in a laboratory will

contribute to the acquisition of correct information and conception about the features of animals. Organization of formal and informal environments where students can observe and interact with animals can also make important contributions.

The study concluded that the pre-service teachers are knowledgeable about some criteria related to animal classification; yet, their information is not linked to each other. Enabling pre-service teachers to associate anatomic features with physiologic features, behaviors and habitats can help them to develop a holistic perception. Instructional approaches and methods to be followed for this purpose can be directed to concept teaching or can be based on concept construction approaches. In this line, concept maps which enable interrelating concepts, discussion activities through which peer learning can occur and use of materials and models allowing concrete experiences can be suggested to facilitate the creation of connections. More emphasis should be put on the incorporation of courses and approaches to develop student competencies on the issue into teacher training programs.

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