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Pre-Service Science Teachers' Conceptions of Systematics and Taxonomy

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ABSTRACT

This study aims to examine the pre-service science teachers' conceptions of Systematics and Taxonomy. Sample of the study consists of 54 preservice elementary-science teachers enrolled in a compulsory General Biology course. Groups were asked to classify 100 representatives of traditional phyla and kingdoms before the subject of Classification of Life's Biodiversity was presented. While the subject matter was being presented, participants were required to identify their mistakes, and write reflection papers addressing the reasons for these mistakes. Data were analyzed through qualitative data analysis techniques. Findings revealed that the preservice teachers' earlier school experiences did not help them to overcome their tendencies to utilize intuitive folk taxonomy and/or analogue comparison, and semantic similarities as their main criteria of classification.

Keywords: Classification; Conception; Preservice Science Teachers; Systematics; Taxonomy.

INTRODUCTION

Systematics and Taxonomy, the sub-disciplines devoted to naming and classifying living organisms, are central to biological sciences. They organize and structure scientific reasoning across a wide range of sub-disciplines from evolution and ecology to anatomy and physiology (Yen, Yao & Mintzes, 2007). Despite this essential role in organizing understanding of biological diversity, a number of investigations demonstrated lack of taxonomic knowledge and ability to identify organisms not only by the general public but also by the educated scientists (Leather & Quicke, 2009). Besides, the preconcepts of living organisms pupils constructed in everyday life do not always correspond to biological ones. Worse still, such conceptions are resistant to change (Wasmann-Frahm, 2009).

'Systematics and principles of taxonomy' is a part of elementary science and secondary school biology curricula in Turkey. Formal curricula intend all students to learn about classification systems that categorize species into recognized taxonomic groups starting from the early grades. Yet, despite all the explanations in the formal curricula, little is known about how Turkish students understand, use and learn taxonomy. There is no particular study exploring the ways taxonomic issues were taught in Turkish schools, either. Although taxonomy is integrated to teacher education programs in Turkey, little is known about how primary and secondary school teachers are trained to deal with taxonomic issues.

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This study aims to examine the Turkish pre-service science teachers' conceptions of systematics and taxonomy. It is assumed that the teachers' knowledge and instructional preferences have a potential influence on the way these subjects are learned (De Fina, 2003). Examination of preservice teachers' conceptions is therefore significant to identify their probable misconceptions and inadequate knowledge about systematics and taxonomy. This way, transfer of preservice teachers' probable misconceptions to future students can be avoided. When the sources of preservice teachers' inadequate knowledge are addressed and difficulties in understanding and applying taxonomic principles are identified, better strategies to teach systematics and taxonomy can also be developed. The research question guiding the study was:

- How do Turkish preservice science teachers classify the living things?

Knowledge of Systematics and Taxonomy

The modern system of classification, the so-called Linnaean Taxonomy, uses common evolutionary relationships and morphological similarities to bring order to over 2.5 million known species of plants and animals. Yet the intuitive folk taxonomy (Halverson, Pires & Abell, 2012) and the analogue comparison (Eichberg, 1972; in Wasmann-Frahm, 2009) are based on overall similarity and one or two isolated common properties by a very subjective view depending on the context (Kinchin, 2000). For instance, the common idea that 'penguins, whales and sea-lions are fish' reveals a classification based on habitat and locomotion criteria (Wasmann-Frahm, 2009). Intuitive folk taxonomy would separate reptile and birds. Crocodiles would be grouped with lizards and turtles based on reptilian characters. On the other hand, modern phylogenetic classification place crocodiles with birds based on shared common ancestry (Halverson, Pires & Abell, 2012). Although both intuitive folk taxonomy and analogue comparison may trigger such misconceptions, they are not the sole reasons of errors in classification. A wide range of experiential differences, linguistic factors, conceptual problems and limitations in logical reasoning ability can also cause errors in classification (Yen, Yao & Mintzes, 2007).

Multiple misconceptions have been reported in the literature related to the knowledge of systematics and taxonomy. The most important findings of a recent study by Yen, Yao and Mintzes (2007) indicate that for most students, the concept label animal refers to vertebrates especially to common, well-known mammals and birds. Students also tend to use external morphology, habitat and movement in distinguishing vertebrates and invertebrates. Tunnicliffe and Reiss (1999) indicate that pupils of all ages mainly recognize and use anatomical features when naming the animals. However, as pupils age, their reasons for grouping animals become more complicated that they begin to show evidence of an embedded taxonomic knowledge. For instance, older pupils are more likely to also use behavioural and habitat attributes to group animals. Similarly, Kattmann (2001) report students' preference to classify creatures along the criteria of habitat and locomotion. Kattmann (2001) points to students' tendency to continue using these criteria even after learning the categories of biological taxonomy.

Yen, Yao and Mintzes (2007) quote early works by Bell (1981) in New Zealand, Ryman (1974) in the United Kingdom and Trowbridge and Mintzes (1985, 1988) in the United States that also revealed children's difficulty in classifying vertebrate and invertebrate animals into their appropriate taxa. Habitat and external features such as the presence or absence of appendages, the texture of the body surface, and the size of body parts, were used as visual cues for classification. Bell (1981)'s study also provided evidence that individuals of all ages and educational backgrounds subscribe to a narrow, "restricted or everyday idea" of the concept animal and use it in reference to pets and common "barnyard and zoo" creatures, especially to large mammals possessing four legs and fur, and making audible and familiar

sounds. Kubiatko and Prokop (2007) also quote earlier works by Trowbridge and Mintzes (1988), Kellert (1985) and Braund (1991) that pupils of all ages classify crawfish as a vertebrate or think that penguin is a mammal, and classify turtles and reptiles as amphibians or invertebrates. Kubiatko and Prokop (2007) report Slovakian elementary school students' serious problems with several common mammals as they see the habitat of animals as a more important criterion than taxonomy. Culturally transferred myths, and semantic similarity between some mammals and fishes are the other sources of difficulties Slovakian students experience in classifying animals. Similarly, Türkmen, Çardak and Dikmenli (2005) highlight linguistic factors as the reasons of Turkish students' misconceptions related to the meaning of systematic units. They report Turkish students' difficulty in classifying human beings, bacteria, protozoa, fungi, bats, dolphins and penguins.

As seen from the above mentioned examples, research on systematics and taxonomy mainly report significant findings for student groups. Bebbington (2005) reported that secondary biology teachers have also been unable to identify more than three species of common British wild flowers. Bebbington (2005) noticed that teachers at primary and secondary school level are not well trained to deal with taxonomic issues. Kubiatko and Prokop (2007) also point to teachers' lack of interest in taxonomy as the sources of students' misconceptions.

As greater stress is placed on ecological studies and the understanding of biodiversity, knowledge of species and taxonomic categories is becoming increasingly important. Yet, as stated by Kattmann (2001), this will fail to have any effect if the preconceptions of not only students but also of their teachers continue to be neglected. Both teachers and students should be able to identify at least a reasonable proportion of the more common species that surround them. They could be able to name an organism, recognise the major distinguishing features and place its ecological context (Katmann, 2001). When they perceive environment in its entirety, they become more prone to care about and conserve it (Papworth, Coad, Rist & Miller-Gulland, 2009).

METHODOLOGY

Sample of this study consists of 54 preservice elementary-science teachers enrolled in a compulsory General Biology course in a Turkish university. General Biology is a 6 hours a week-course, allocating 2 hours laboratory work. Content covers the Cell, Cell Division, and Classification of Life's Diversity in the autumn semester. Classification of Life's Diversity is a 12 hours subject of the course. Preservice teachers had previously studied biology in the secondary school, and General Biology is their first biology-related course in the science teacher education programme. Preservice teachers are expected to state, define and give examples of the components of taxonomy: description, identification, nomenclature, and classification at the end of the course (Simpson, 2006).

a) Data Collection

The study was conducted in three steps:

First step: Names of 100 species e.g. representatives of traditional phyla and kingdoms, and A3 size papers were handed to groups of three at the beginning of the subject "Classification of Life's Diversity". Names of the specimens were taken from the formal elementary and secondary school curricula. Photographs and/or line drawings were not used as they might hint the classification tasks. Preservice teachers were not provided with any verbal cues either. The underlying assumption was the preservice teachers' previous exposure to the names of these specimens for several times when they were learning about 'systematics and principles of taxonomy' in the elementary and secondary schools as intended by the

formal curricula. Thus preservice teachers had already constructed mental models about the specimens and in order to elicit these models the word representations were solely used.

Preservice teachers were asked to classify the given species in subsequent three class hours. They worked in groups as the group work reinforced their ability to share diverse perspectives. They challenged each others' assumptions and exchanged their previous knowledge in forming the rationale of their task as the subject matter is not presented yet. It was intended to activate preservice teachers' prior knowledge through this collaborative activity (Kinchin, 2011). It is assumed that when a larger number of examples, including those of several habitats, is taken into account, preservice teachers would follow a general approach, and construct or use their own mental models (Kattmann, 2001).

Second step: "Classification of Life's Diversity", the characteristics and representatives of traditional kingdoms including the given species, were taught in 12 class hours including laboratory work and class activities such as observation of plant and animal cells under the microscope, preparation and observation of protozoa culture, fish dissection, categorization of samples brought i.e. fungi, plants and animals, etc. Throughout the classes, preservice teachers were expected to participate in discussions. As their works were handed back, they were asked to identify and mark the mistakes with red pens on the classifications they made. Then, the reasons for their mistakes were discussed within and between groups and with the researcher. This way, conditions for conceptual change were created i.e. preservice teachers were involved in useful arguments, and the learning situation brought up their misconceptions and created discrepancies between their old convictions and scientific view (Posner, Strike, Hewson & Gertzog, 1982). They were provided with opportunity to reconstruct their existing conceptions of classification (Wasmann-Frahm, 2009).

Third step: At the end of 12 class hours, preservice teachers were assigned to write individual reflection papers. They were required to discuss the reasons of their mistakes and address the sources of their inadequate knowledge. This way, in-depth results were sought (See Table 1 for the schedule of data collection).

Table 1. *Schedule of Data Collection*

3 class hours classification activity: group work and discussion	
4 class hours: Classification of Life's Diversity I: Monerans, Protists and Fungi Activity: Categorization of samples brougt Discussion and correction of mistakes made	2 class hours: Laboratory work (preperation and observation of protozoa culture)
4 class hours: Classification of Life's Diversity II: Plants and Animals Discussion and correction of mistakes made	2 class hours: Laboratory work (observation of animal and plant cells under the microscope, fish dissection)
Assignment: Individual reflection papers	

b) Data Analysis

Data were analyzed in two steps. First, the classifications made on A3 papers were evaluated. Pre-service teachers' classification criteria were identified. Mistakes were listed, grouped and categorized. Then, the reflection papers of the teachers were subjected to content analysis. Raw data were coded and thematized. Similarities and differences in responses were identified and grouped. Pattern of responses were drawn, inferences and generalizations were made (Miles & Huberman, 1994; Patton, 1990) about preservice teachers' reasoning of classification, misconceptions and sources of inadequate knowledge.

FINDINGS

The work of eighteen groups was evaluated. It was seen that all groups used the Linnaean classification during the group works. They categorized living things under four main groups i.e. Protists, Fungi, Plant and Animal Kingdoms. Although examples were not provided, 7 groups included Monerans in their classification, too. Main groups of classifications made were at the class level i.e. vascular and nonvascular plants for plant kingdom, and invertebrates and vertebrates for animal kingdom.Five groups used Invertebrate Chordates as a separate phylum in the Animal Kingdom. Eleven groups classified vascular plants as angiosperms and gymnosperms. There were groups which classified Plant Kingdom as 'spore-producing vascular seed plants-vascular seed plants and non-vascular plants', 'land plants and water plants (2 groups)', and 'green algae and land plants'. For Vertebrates, fish, reptiles, birds, amphibians and mammals were mentioned as subcategories by all except three groups which classified invertebrate chordates as vertebrates as well. Only one group classified mammals as egg-laying, pouched and placental mammals. For invertebrates; sponges, cnidarians, arthropods, annelids, molluscs and echinoderms were mentioned as the subcategories by 10 groups. Echinoderms were not included in 2 groups' classification and molluscs were not included in one group's classification. Two groups included crustaceans as a separate class and a group categorized insects as a separate phylum under invertebrates. There was also a group which classified invertebrates as land and water invertebrates. For protists, subcategories were slime molds, algae and protozoans in 5 groups. 4 groups also classified protozoans as ciliates, flagellates, amoeboids, and sporozoans.

When the classification of the given examples were examined, it was seen that preservice teachers had difficulty in classifying vertebrates, invertebrates and invertebrate chordates, angiosperms and gymnosperms, and protists. As seen in Table 2, they wrongly classified three mammals as fish i.e. seal, whale and walruse, and as an echinoderm i.e. walruse. Similarly, they classified four reptiles as invertebrate, amphibian and mammal i.e. snake and lizard as invertebrates, turtle as an amphibian and dinosaur as a mammal (3 groups). Preservice teachers also classified birds i.e. penguin, hen and duck, as mammal. 3 groups classified shark as a mammal. 4 groups classified salamander as a mammal, and 4 groups classified it as a reptile.

Table 2. *Preservice teachers' mistakes in classifying vertebrates*

	Wrong	Correct
Seal	Fish (3 groups)	Mammal
Walruse	Fish Echinoderm	Mammal
Whale	Fish	Mammal
Turtle	Amphibian	Reptile
Dinasour	Mammal (3 groups)	Reptile
Snake	Invertebrate	Reptile
Lizard	Invertebrate	Reptile
Penguin	Mammal (2 groups)	Bird
Hen	Mammal	Bird
Duck	Mammal	Bird
Salamander	Reptile (4 groups) Mammal (4 groups)	Amphibian
Shark	Mammal (3 groups)	Fish

As seen in Table 3, preservice teachers also made mistakes in classifying invertebrates. 5 groups classified squid as a fish. Sea anemone was classified as a gymnosperm. Sea cucumber, sea star and sea urchin were classified as molluscs. Coral and jellyfish were

classified as echinoderms. Crab and lobster were classified as molluscs. Silkworm and butterfly were classified as bird. Flukes and earthworm were classified as reptiles.

Table 3. *Preservice teachers' mistakes in classifying invertebrates*

	Wrong	Correct
Squid	Fish (5 groups)	Mollusk
Sea anemone	Gymnosperm	Cnidarians
See cucumber	Mollusk	Echinoderm
Sea star	Mollusk	Echinoderm
Sea urchin	Mollusk	Echinoderm
Coral	Echinoderm	Cnidarians
Jellyfish	Mollusk	Cnidarians
Crab	Echinoderm	Arthropod
Lobster	Mollusk	Arthropod
Silkworm	Bird	Insect
Butterfly	Bird	Insect
Flukes	Reptile	Flatworm
Earthworm	Reptile	Annelida

Preservice teachers also made mistakes in classifying protists. For instance, 3 groups classified slime molds as fungi and a group classified it as a moneran. As seen in Table 4, Amoeba and plasmodium were classified as monerans. There was also a group which classified mushroom as a protist.

Table 4. *Preservice teachers' mistakes in classifying protists and fungi*

	Wrong	Correct
Slime mold	Fungi (3 groups) Monera	Protist
Amoeba	Monera	Protist
Plasmodium	Monera	Protist
Mushroom	Protist	Fungi

Preservice teachers also had difficulty in classifying plants. As seen in Table 5, they classified dicotyledon angiosperms i.e. strawberry, bean, chickpea, pear and apple as monocotyledons, and monocotyledon angiosperms i.e. garlic and onion as dicotyledons. There were groups which classified moss as an angiosperm and a dicotyledon. Similarly, ferns were classified as an angiosperm, a dicotyledon and as a nonvascular plant (2 groups). There were also 3 groups which classified horsetails as a nonvascular plant. One of the groups classified horsetails as an animal.

Table 5. *Preservice teachers' mistakes in classifying plants*

	Wrong	Correct
Strawberry	Monocotyledon (3 groups)	Dicotyledon
Bean	Monocotyledon (2 groups)	Dicotyledon
Chickpea	Monocotyledon (2 groups)	Dicotyledon
Pear	Monocotyledon	Dicotyledon
Apple	Monocotyledon	Dicotyledon
Banana	Dicotyledon (3 groups)	Monocotyledon
Garlic	Dicotyledon/Gymnosperm	Monocotyledon/Angiosperm
Onion	Dicotyledon/Gymnosperm	Monocotyledon/Angiosperm
Moss	Angiosperm/Dicotyledon	Nonvascular plant
Ferns	Angiosperm/Dicotyledon Nonvascular plant (2 groups)	Seedless vascular plant
Horsetail	Nonvascular plant (3 groups) Animal	Seedless vascular plant

There were examples that the preservice teachers had never heard of and/or had no idea about their characteristics. Some of these examples are tunicates (10 groups), amphioxus (10 groups), diatoms (5 groups), walruse (5 groups), lichens (5 groups), wheat (3 groups), taenia (3 groups), moss (2 groups), cedar (2 groups), horsetails (2 groups), dinosaur (2 groups), sea cucumber (2 groups), salamander (2 groups), platypus, abies, garlic, onion, banana, bean, chickpea, tulip, grasshopper, housefly, jellyfish, coral, snail, fluke, planaria, butterfly, silkworm, seastar, sea urchin, carp, crab, penguin, kangaroo, horse, and lizard (1 group).

Although majority of the groups could not classify tunicate, 2 groups classified it as a fish. One group classified it as an insect, one group classified it as a protist and one group classified it as a hydra. Classification of lichens was also problematic for the preservice teachers. 3 groups classified lichens as fungi, 2 groups classified as a protist and 2 groups classified as algae.

Reflections on the Mistakes Made

Preservice teachers listed the followings as the reasons of their mistakes in classifying the given examples: lack of interest and curiosity towards environment (n=7), not watching scientific documentaries (n=7), not observing living things in the environment (n=4), not following scientific journals (n=4), living in cities (n=3), not attending field trips (n=2), and fear of animals (n=2). They mentioned that "they memorized information about systematics and did not really learn" in the secondary school (n=3). They used their senses and external features of the examples as their main criteria of classification (n=2). One of the preservice teachers also pointed to the semantic similarity as his/her reason of mistakes.

Preservice teachers made the following explanations for the particular mistakes they made:

'Earthworm crawls. Therefore I classified it as a reptile.'
'Sharks are big as whales. Whales are mammals. Therefore I classified shark as a mammal (n=3)'
'Dinosaurs have big bodies. Mammals also have big bodies. Therefore I thought dinosaurs were mammals too.'
'Dinosaurs had had feet and they did not crawl. In cartoons, they walk, run, even fly. I thought they were mammals'
'Dinosaurs were huge. Big animals are mammals. Therefore, I classified dinosaur as a mammal.'
'Penguins do not fly. Their feathers are not similar to birds'
'I thought penguins give birth to their offspring'
'Penguins are similar to seals. Seals are mammals. Therefore, I classified them as mammals'
'Salamenders are similar to lizards. Therefore, I classified them as reptiles' (n=2)
Jellyfish is soft. Therefore, I classified it as a mollusc.'
'Seastar has a soft body. Therefore, I classified it as a mollusc'. (n=2)
'Crabs and lobsters' legs misdirected me.'

Reflections on the Activity

15 preservice teachers stated that they were both mentally and physically active during the activity i.e. they were grouping and regrouping the given examples in a group. They both enjoyed and learned. Working in groups and visualizing their mental images of classification helped preservice teachers (n=10) to realize their misconceptions, and contributed to their new learning. One of the preservice teachers stated that '*This activity helped me to correct my mistakes. It was more efficient then trying to memorize them from the text*'.

Although they studied classification of life's diversity starting from the early grades, there were also preservice teachers (n=3) who mentioned that they newly learned the

classification criteria. One of the preservice teachers mentioned that '*Too many terms and concepts make learning systematics and taxonomy difficult. Till this time, we were not involved in such a student-centred activity. We were motivated to learn, search and discus during this activitys. I think it was highly effective for us*'. Similarly, 5 preservice teachers mentioned that the activity was very interesting. One of them stated that '*It was very thought provoking. After the class, I sought for all the examples we wrongly classified*'.

DISCUSSION

This study intended to examine the participant preservice teachers' conceptions of systematics and taxonomy through an instructional activity in which they were expected to categorise the representative examples into taxonomic groups. As stated by Vosniadou and Brewer (1992), determining preservice teachers' conceptions this way contributed more to their conceptual development and conceptual change considering their previous learning difficulties of systematics and taxonomy.

The classification criteria used by the groups showed that preservice teachers had basic knowledge about the Linneaen Taxonomy. They were knowledgeable about five kingdoms and different phyla as the "five kingdom" model that is commonly used in the Turkish elementary and secondary school science curricula. However, classifications they made highlighted their tendency to utilize intuitive folk taxonomy and/or analogue comparison. It is also inferred that they had difficulty in remembering what they learned and/or memorized about classification of animal and plant kingdoms.

Paralleling the findings of previous research (Kattmann, 2001; Kubiatko & Prokop, 2007; Yen, Yao & Mintzes, 2007; Wasmann-Frahm, 2009), preservice teachers' mistakes revealed the fact that they used habitat, locomotion and common features i.e. body size, external features, etc. as their main criteria of classification. For instance, sea mammals were classified as fish because they live in sea as fish do. Snake and lizard were classified as invertebrates because they look similar to earthworms and move like them. Hence earthworms were classified as reptiles as they crawl. Shark was classified as a mammal because it is big as whales. Dinosaur was classified as a mammal because of its body size and feet. Penguins were classified as mammal because they do not fly. Salamander was classified as a reptile as it moves like reptiles. Silkworm i.e. larvae of a moth and butterfly were classified as bird because they fly.

Semantic similarity was another reason of preservice teachers' mistakes of classification as identified in Yen, Yao and Mintzes (2007), Kubiatko and Prokop (2007) and Türkmen, Çardak and Dikmenli (2005)'s studies. However, it should be kept in mind that the preservice teachers were not provided with verbal cues, photographs and/or line drawings of the examples similar to the previous studies mentioned. The task demanded them to first use the linguistic clues, interpret them and then to match them with their existing cognitive structures. In the mean time, linguistic interpretations of some examples' names misled the preservice teachers as such the Turkish name of squid. Direct translation of squid's Turkish name is 'ink fish' that the preservice teachers classified it as a fish. Similarly, horsetails were classified as animals (as its name reminds horse) by the preservice teachers because of their Turkish names. Slime molds were classified as fungi. Although direct translation of slimemolds' Turkish name is 'soft mushroom', it is also considered that slime molds were previously classified in the Fungi Kingdom, and some sources still use this wrong classification.

Although there were examples that the preservice teachers had never heard and/or had no idea about their characteristics such as tunicates, amphioxus, diatoms, etc., it is critical to note that preservice teachers were not knowledgeable about the examples they see in their daily lives either. For instance, they classified hen, duck, strawberry, bean, chickpea, pear, apple, garlic and onion wrong. They listed grasshopper, housefly and banana among the

examples that they do not know their characteristics. Preservice teachers mentioned that they made some of the classifications by heart such as classification of tunicates as fish, as insect, hydra and protist. As mentioned by the preservice teachers living in cities and having no opportunity to observe/contact various plants and animals, not watching documentaries and following journals and not attending field trips also influenced their responses. However, preservice teachers' comments about the activity highlighted the fact that their mistakes were mainly originated from the way they learned systematics and taxonomy in the past i.e. memorization of loaded information in the elementary and secondary schools. It is inferred that they were not exposed to biodiversity. They also lacked the experience of using scientific knowledge to classify a set of given examples in the school. Therefore, they had difficulty in classifying the given examples. Thus, they tended to use analogue comparison and/or intuitive folk taxonomy. Actively working in groups was yet more stimulating and efficient than listening and trying to memorize the representative examples of each taxa as mentioned by one of the preservice teachers.

Findings of this study point to the fact that instead of overloading information, effective instructional approaches should be used to teach systematics and taxonomy. Preservice teachers' prior knowledge should be explored and their alternative ideas about classification should be identified. This way instructional strategies that help preservice teachers to overcome the difficulties in understanding and applying biological classification can be developed (Kattmann, 2001). It should be kept in mind that their knowledge of living things is not necessarily gained from formal education which may serve simply to amplify and extend existing knowledge (Tunnicliffe, 2011). Preservice teachers should be provided with opportunities to endow their curiosity as they are expected to reinstall their future students' understanding and appreciation of nature (Leather & Quicke, 2009). As seen in this study, collaborative group work and/or constructivist- based tasks in a sequence might improve pre-service teachers' understandings. Interactive computer programs and web links also provide additional opportunities for observations, or with alternatives for live samples, dissections, preserved species, and prepared slides. Instructional activities which require comparing and contrasting, applying and analyzing also contributes to the development of preservice teachers' critical thinking skills (De Fina, 2003).

Limitations of the Study

This study has some limitations due to the possible influence of the number and set of examples presented to the preservice teachers. Preservice teachers could use different criteria in their classifications if they were presented with a smaller number and sets of examples (Kattmann, 2001; Tunnicliffe & Reiss, 1999). It is also accepted that designation of status to a particular ranking is in a state of flux. Previously recognized phyletic patterns may already be outdated as taxonomists working from different perspectives analyze new types of genetic data to establish current facts, interpretations and classification schemes (Starr & Taggart, 2001).

The study was conducted in an introductory biology course. Although preservice teachers were asked to categorize the representative examples into taxonomic groups, they were not asked to categorize the examples on the basis of their derived ancesteral traits. The small sample size may also form a limitation in generalizing the results. The results can be interpreted as culturally biased since semantic similarities between some invertebrates, vertebrates and plants were identified as a reason of mistakes preservice teachers made. However, results of the study were in line with most of the international research on systematics and taxonomy.

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