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TURKISH PRESERVICE SCIENCE TEACHERS' UNDERSTANDING OF NATURAL SELECTION: SOME PRELIMINARY FINDINGS

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Abstract

The present study examined a group of senior pre-service science teachers' conceptual understanding of natural selection through the Conceptual Inventory of Natural Selection (Anderson, Fisher, & Norman, 2002). The findings indicated that participants of this study possessed a moderate level of conceptual understanding of natural selection. Specifically, considering key aspects addressed by the Inventory, participants found to have relatively higher levels of understandings about population stability, natural resources, limited survival, and variation within a population. However, their understanding on variation inheritable, differential survival, biotic potential, and change in a population was limited. Participants also seemed to have inadequate understanding of origin of variation and origin of species. Additionally, they held variety of misconceptions related to each key aspects of natural selection.

Keywords: Natural selection; evolution; pre-service science teacher

INTRODUCTION

As a mechanism of evolution, natural selection has long been recognized as one of the most important and difficult concept of the science curriculum to learn. In spite of its importance, research studies have consistently reported inadequate understanding of and various misconceptions about natural selection among biology teachers (Nehm & Schonfeld, 2007) and college students (Bishop & Anderson, 1990; Nehm & Reilly, 2007). For example, according to the study by Bishop and Anderson (1990), even after an average of 1.9 years of biology courses, non-biology majors demonstrated limited understanding of natural selection on the pretest and misconceptions related to 'origin and survival of new traits in populations', 'role of variation within population', and 'change of proportion within population'. Similarly, Nehm and Reilly

(2007) revealed that most of the participants possessed poor understanding of natural selection and employed various misconceptions despite the fact all participants completed a semester of introductory biology course and majority (about 83%) stated that they had taken instruction on natural selection in high school. Besides, the study by Nehm and Schonfeld (2007) resulted in various teacher misconceptions including (a) use and disuse of traits explains their appearance, (b) traits appear when they are needed, and (c) environment causes evolutionary change. Although many science teachers acknowledged the importance of identifying students' misconception, they had difficulty in finding appropriate assessment tools for this purpose. This idea has motivated researchers to construct concept inventories which are research-based tools assessing learners' conceptual understanding of topics about which they hold misconceptions (D'Avanzo, 2008). D'Avanzo claimed that these inventories help teachers identify students' misconceptions as well as incorrect reasoning from the beginning of a course and follow achievement level as the lessons progress. Accordingly, in an effort to measure knowledge of and misconceptions about natural selection, Anderson, Fisher, and Norman (2002) developed the Conceptual Inventory of Natural Selection (CINS). Considering the fact that teachers' conceptual understanding of natural selection will affect students' understanding of the concept, in this study, the CINS has been utilized to assess pre-service science teachers' conceptual understanding of natural selection as well as to identify their misconceptions.

METHOD

A total of 35 senior pre-service science teachers who completed the course on evolution participated in the current study. The Conceptual Inventory of Natural Selection (Anderson et al., 2002) was utilized to assess participants' conceptual understanding of natural selection with respect to ten key aspects namely biotic potential, population stability, natural resources, limited survival, variation within a population, variation inheritable, differential survival, origin of variation, origin of species, and change in a population (see Table 1 for scientific concepts addressed by key aspects). The CINS consists of 20 items with one correct answer and three distracters in multiple choice formats. Each item uses common misconceptions as distractors. Anderson et al. indicated that while constructing the CINS items they relied on actual studies conducted by scientists in evolution, like the Galapagos finches, which makes the CINS *more realistic and comprehensive*. CINS were translated and adapted into Turkish by the authors of the current study and carefully examined by a group of experts in biology education and biology. For the present study, the reliability coefficient computed by Kuder Richardson 20 was found to be 0.57 that is somewhat low; but it is comparable to estimates in the study of Anderson et al.

FINDINGS

Preliminary findings showed that of a possible 20 correct responses on the CINS, a mean score of 9.91 (*SD*=2.63) with a range of 5-16, was attained by the pre-service science teachers, indicating a moderate level of conceptual understanding of natural selection. Specifically, considering key

aspects addressed by the CINS (see Table 1), participants had relatively higher levels of understandings about population stability, natural resources, limited survival, and variation within a population. They possessed limited comprehension of variation inheritable, differential survival, biotic potential, and change in a population. However, participants seemed to have inadequate understanding of origin of variation and origin of species.

Table 1. Key aspects, correct responses and percentages of participants with correct responses

Key aspects	Correct Responses	% of participants with correct responses
Biotic potential	The finch population would increase dramatically	42.9
	The guppy population would grow slowly at first, then would grow rapidly, and thousands of guppies would fill the pond	45.7
Population stability	The population remains relatively stable, with some fluctuations	85.7
	The guppy population will stay about the same size	71.4
Natural resources	When food and water are scarce, some birds may be unable to obtain what they need to survive	80.0
	It is likely that sometimes there is enough food, but at other times there is not enough food for all of the lizards	65.7
Limited survival	Finches compete primarily with closely related finches that eat the same kinds of food, and some may die from lack of food	65.7
	The lizards least successful in the competition for food are likely to die of starvation and malnutrition	77.1
Variation within a population	The guppies share many essential characteristics, but also vary in many features	40.0
	All lizards in the populations share many similarities, but there are differences in features like body size and claw length	88.6
Variation inheritable	All characters that are genetically determined	51.4
	Lizards with a particular coloration and pattern are likely to pass the same trait on to offspring	48.6
Differential survival	High number of offspring that survived to reproductive age	54.3
	Lizard B	42.9
Change in a population	The proportion of finches having different traits within a population change	37.1
	The proportions of guppies having different traits within a population change	40.0
Origin of species	The finches were quite variable, and those whose features were best suited to the available food supply on each island reproduced most successfully	25.7
	Groups of lizards must have been geographically isolated from other groups and random genetic changes must have accumulated in these lizard populations over time	11.4

Origin of variation	Changes in the finches' beaks occurred by chance, and when there was a good match between beak structure and available food, those birds had more offspring	11.4
	Random genetic changes and sexual recombination both created new variations	25.7

Apart from, participants held variety of misconceptions related to each key aspect. Examples of some common misconceptions are provided in Table 2. Specifically, when participants were asked how the different beak types first arose in the Galapagos finches, majority of the participants (65.7%) selected the wrong choice that 'the changes in the finches' beak size and shape occurred because of their need to be able to eat different kinds of food to survive'. They attributed evolutionary change to need. In another item, participants' conceptual understanding of survival of fittest was assessed. More than half of the participants (57.1%) appeared to equate it with longevity. Slightly less than half (45.7%) held misconceptions that 'in order to survive, different groups of lizards needed to adapt to the different islands, and so all organisms in each group gradually evolved to become a new lizard species'. Another common misconception is that 'mutations occur to meet the needs of the finches as the environment changes' (40%), followed by 'if a breeding pair of finches was placed on an island under ideal conditions with no predators and unlimited food so that all individuals survived, the finch population would grow slowly and then level off' (37.1%). Thus, considerable amount of participants held various misconceptions related to key aspects of natural selection.

Table 2. The frequency distributions of participants' misconceptions addressed by the CINS

Key aspects	Misconceptions	% of participants with misconceptions
Biotic potential	The finch population would grow slowly and then level off	37.1
Population stability	It is impossible to tell because populations do not follow patterns	17.1
Natural resources	Since lizards can eat a variety of foods, there is likely to be enough food for all of the lizards at all times	22.9
Limited survival	Many of the finches on an island fight with one another and the physically strongest ones win	17.1
Variation within a population	The guppies are all identical on the inside, but have many differences in appearance	28.6
Variation inheritable	Any characteristics that were positively influenced by the environment during a finch's lifetime	28.6
Differential survival	Lizard D	57.1
Change in a population	Mutations occur to meet the needs of the finches as the environment changes	40.0

Origin of species	In order to survive, different groups of lizards needed to adapt to the different islands, and so all organisms in each group gradually evolved to become a new lizard species	45.7
Origin of variation	The changes in the finches' beak size and shape occurred because of their need to be able to eat different kinds of food to survive	65.7

DISCUSSION and CONCLUSION

In the current study, we attempted to unravel pre-service science teachers' conceptual understanding of natural selection. Descriptive statistics indicated that pre-service science teachers had a moderate level of conceptual understanding of natural selection (M= 9.91, SD = 2.63) and held variety of misconceptions related to key aspects in natural selection. In other word, they are inadequate prepared in the natural selection. This finding partly attributed to controversial nature of topic. Another possible explanation is that natural selection is not covered or poorly covered in their elementary and high school curricula as well as teacher education programs. Supporting this finding, the study by Nehm and Reilly (2007) showed that second-semester biology majors had remarkably inadequate understanding of and various misconceptions about natural selection even though all participants completed a semester of introductory biology course and majority (about 83%) stated that they had taken instruction on natural selection in high school. In addition, studying with non-biology majors, Bishop and Anderson's study (1990) revealed that participants held misconceptions related to 'origin and survival of new traits in populations', 'role of variation within population' and 'change of proportion within population'. Moreover, in their study, Nehm and Schonfeld (2007) identified that biology teachers possessed many misconceptions about natural selection including (a) use and disuse of traits explains their appearance, (b) traits appear when they are needed, and (c) environment causes evolutionary change.

Considering significant role of pre-service science teachers in teaching of natural selection in the future, findings in the present study are not satisfactory. This is because teachers with inadequate understanding about natural selection are not likely to be able to develop scientifically accurate conceptions in their students. We attributed the present findings to the inadequacy of education on natural selection as well as evolution in teacher education programs. Therefore, we suggest that teacher training programs should be designed to promote sound conceptual understanding of natural selection. Such an understanding could be fostered through identifying students' misconceptions and changing of misconceptions with scientific conceptions as supported by others (e.g. Gregory, 2009; Nehm & Reilly, 2007). Specifically, in their study, Nehm and Reilly demonstrated that active learning and an evolution-infused introductory biology curriculum resulted in significant but limited success. Furthermore, Sundberg (2003) supported active learning rather than traditional instruction in dealing with students' misconceptions related to nature of evolution. However, present study is limited relatively small number of participants.

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