

Exploring Students' Understanding of Species: A Study with Class VIII Students

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The paper reports an exploratory study on middle school level textbook representation of concepts of species and Class VIII students ideas of species. Thirty seven students (mean age: 13) participated in this study. It was found that students hold complex or hybrid views about species. Students' idea of the ability to inter-breed and similar characteristics among individuals of a species category, is similar to the textbook definition. However, their idea about species remain restricted to animals only. It is found that even school textbooks portray diversity of animals more than diversity of plants. Students hold several alternative views and misconceptions about species. The paper attempts to link textbook representation of species and students' understanding of species.

Introduction

In biology, the concept of species “is one of the primary levels of integration” among systematics, genetics, ecology, physiology, study of behaviour, etc. (Mayr, 1957 as in Richards, 2010). Though the study of evolutionary biology relies on an understanding of species (Cracraft, 2000), the studies on students' conception of species have been fewer than needed (Munson, 1994). According to, Leach et al. (1992), children between 5-16 years of age could recognise three different “varieties” of dogs as dog. However, only a few 16 years old students could state the rationale they used in grouping all the three varieties of dogs as dog. These 16 year old students mentioned genetics as the basis of their grouping but had no knowledge about “the genetic basis of the species concepts”.

The current understanding of species, does not provide definite answers about whether all dog varieties are members of same species (Hey, 2001). The multiplicity of species definition demands careful attention from school level biology educators on how the concept should be taught. Sharp (2009) has developed a teaching module for university students which introduces speciation through several species concepts. However, similar documentation for middle and high school students is lacking.

The concept of species: history of the debate

“Species problem” is a century long debate (Richards, 2010). The history can be traced back from the time of Aristotle. The Aristotelian view defines categories as “characterized by a property or set of properties that are necessary and sufficient for membership in that category”. All the characteristic properties together form the essence of a category. From the similar understanding species is a category and each species has an essence of that species. Such understanding of essence stems from “realist view” and provides each category an ontological status (Hey, 2001). In contrast, according to Darwin's theory of evolution, species is something that evolves from another species, changes over time, produces new species and eventually may become extinct and therefore is not fixed over time (Francis, 2007; Richards, 2010). Several centuries in evolutionary biology have enriched our understanding of origin of species but the progress has led to further difficulties in defining the species itself. Darwin himself held nominalist view about species:

...we shall have to treat species in the same manner as those naturalists treat genera, who admit that genera are merely artificial combination made for convenience. This may not be a cheering prospect; but we shall at least be freed from the vain search for the undiscovered and undiscoverable essence of the term species. (Darwin, 2004; pp. 665)

Probably, Darwin's caution of “vain search for the undiscovered and undiscoverable” has dampened the efforts of biologists' attempt to define species. Interestingly, there was a renewed interest in the origin of species in the 1930s and 1940s and again in 1960s to 1990s. However, most of the research is scattered in technical journals (Cracraft, 2000; Coyne and Orr, 2004).

The question is whether species are discrete or continuous; “real”, “objective entities” or “purely arbitrary constructs” of human mind. Only if species are “real” entities then can we attempt to define them (Mayr, 1982;

Coyne and Orr, 2004). According to Biological Species Concept “species is a group of interbreeding organisms that is isolated from other such groups” (Mayr, 1996). Naturally, the definition fails to account for the asexually reproducing organisms (Hey, 2001; Richards, 2010).

Conceptualizing species as 'real' biological entity amounts to “species fixity” and is inconsistent with the understanding of Darwinian speciation (Mallet 2001, as in Coyne and Orr, 2004). However, in most cases the process of speciation is so slow that in any experimental time scale, species will be like a discrete species (Coyne and Orr, 2004).

For Levin (1979), species is an abstract construct that gives a sense of diversity in the living world. Researchers use convenient working definitions of species for organism under study in either explicit or implicit ways. There are studies that show correspondence between “folk species” and “Linnaean species” but the findings are insufficient to conclude that “species are real rather than nominal categories” (Hey, 2001).

Significance of species concept in conservation biology

Species is the fundamental unit of biodiversity. There are disparities in species counts and most of the discrepancies arise due to different ways of defining and conceptualizing species by the respective researchers. There are more than 22 species concepts (Mayden, 1997), that too incomplete and none of them “seems adequate” (de Queiroz, 1999). The multiple definition of species has serious implications in conservation biology. Firstly it poses ambiguity in counting the total number of species and impedes implementations of biodiversity conservation legislations specific to species conservation. Another serious problem is in identifying specific disease causing species (Richards, 2010).

Motivation for the study

The recent, Indian National Curriculum Framework (NCERT, 2005) envisioned a shift towards constructivist teaching and learning. The position paper National Focus Group on Teaching Science mentioned six criteria to fulfill in an ideal science education curriculum: a) cognitive validity, b) content validity, c) process validity, d) historical validity, e) environmental validity, and f) ethical validity (NCERT, 2006a). In response to the framework, a new set of textbooks has been developed to address the goals mentioned in the policy document (NCERT, 2006b). Now it is important to know how students understand or interpret the textbook content, which can be used as feedback for regular teaching to avoid misrepresentation of the content. Moreover, it is important to carefully analyse the content and presentation of the content in the backdrop of above mentioned six validity criteria. The textbooks are analysed for the content and cognitive validity only. The study with students have explored the students' understanding of the species concept and their possible connection with textbook as a learning source. It is hoped that the analysis would provide inputs and insights for further improvements of textbooks and classroom discussion.

Study

The course was conducted over eight days in two sessions with students of class VIII titled “Energy and Environment”. In the course students were mainly introduced with energy, sources of energy for human use, environment and ecosystem in particular, photosynthesis, energy and material flow in the environment, increasing energy need and possible environmental consequences. The sessions of the course consisted of multiple modes of interaction and students' productions in terms of completing worksheets, whole class discussion, guided activities etc. (Shome, 2009). In this study we will report only students' ideas of species in response to completing a worksheet on “Environment”.

Participants

Forty students (30 boys, 10 girls) of Class VIII of mean age 13 from three English medium schools voluntarily participated in the course. Thirty seven of the students (28 boys, 9 girls) were present on the day of this study. Announcements of the course for the students of class VIII were sent to each school. Guardian's written consent was taken before accepting participants to the course.

Research Question

The study was guided by three major questions. The first question addressed the content and other two addressed the cognitive aspects.

1. What ideas do textbooks portray about species?

2. What are the students' ideas about species?
3. What is the relation between the ideas expressed by students and those in textbooks?

Framework of the study

According to the constructivist paradigm of learning, students do not passively receive information. They construct their knowledge based on their prior understanding. Students' understanding of living and non-living, animals and plants have been studied in the Indian context. It is found that most students consider only larger animals in animal category and exclude fish, insects and human beings from the category. Moreover, students show a preference towards animals over plants in their discussion of living beings (Chunawala et al., 1996; Shome, 2009). Their concept of species would also be connected to how they conceptualise plants and animals. Textbook is an important source from which students construct knowledge. Therefore, it was important to study whether the textbook presentation of content in some way reinforces the existing misconceptions, or presents some conflicting ideas.

To address this aspect and answer the first question all the NCERT science and social science textbooks from Class I to VIII were analysed. Addressing the second question was important for two reasons. One is to explore students' species concepts before introducing them to ecological concepts. And second was to help address the third research question. In the study students' existing ideas have been viewed as potential instances for initiation of discussion in the classrooms and not as misconceptions. The ideas would have origin in their history of evolution of concepts itself. And some of them would still be valid. Therefore, the existing students' conceptions become a resource for rich classroom discourse. The focus of the third question was to find a correspondence between students' ideas about species and textbook representation of species. Becoming aware of these two dimensions would help teachers to address the concept better in their classroom teaching learning.

Data and findings

Textbook analysis

The soft copies of all the NCERT textbooks on science and social science for Class I to VIII were searched for the word "species". The chapters containing the word "species" were first identified and sentences include the word species are listed. Next, all the sentences (only from the chapters mention the word species) those mention organisms and their varieties in relation to species are listed. The related sentences or in some cases phrases in the exercise as well as summary of the chapters were also included in the analysis.

All the selected sentences were listed according to the Class, subject and chapter. The sentences were read several times to find some patterns on: concepts of species introduced in the textbooks, and variety of organisms are associated in the context of "species".

Findings

The word "species" first appeared in Class VI Geography textbook in the context of Biosphere. When it appears in the next higher class in the same subject, it tends to be more about animals in the discussion of species. It is interesting that except in Class VI Geography and Class VIII Civics, all textbooks predominantly gave preferences to animals in connection to species.

It is important to note that Class VIII Science introduces a chapter on "Conservation of plants and animals". The chapter discusses the causes of deforestation and associated environmental change, threat to biodiversity, idea of endemic, endangered and extinct species and also provides a definition of species.

Except Class VIII, Science, all textbooks have devoted almost same number of sentences to describe the diversity of plants and animals. The textbook devoted 13 sentences to explicitly mention the animal diversity, while plant diversity is mentioned only by two sentences. At the same time, the explicit mention of names of animals in these chapters of Science are three times as high as that of plants. Interestingly similar disparity (close to two times) between these two is also evident in Geography textbook of the same Class and Class VI as well.

Student questionnaires

In the worksheet on "Environment" students were asked to define the term "species". The question was open ended to get rich responses from the students. The responses were listed in text document and later rephrased in terms of complete sentences without changing the meaning. All the sentences were read several times to develop a coding scheme. The coding scheme was validated by two scorer-raters and sufficient agreement (91%) was reached.

Findings

The preliminary analysis of students' responses suggest two major categories of ideas on species. Primarily students view species as either organism or animals. Only one student's response was not coded due to its ambiguity. Therefore, sample size is considered as 36 for all percentage calculation.

1. Species are organisms: In this category of responses students (19 students, 53%) explicitly mention about organism or mentioned both the plants and animals or it implies to have included both. For example, definitions given by one boy and one girl are given here respectively:

"There are different types of or varieties of animals, plants and birds. They are called as species." (M/18).

"Species are a particular group of organisms of the same type" (F/10)

An example of response, where, organism is implied is given below.

"Species are living organisms or animals that are living in the earth". (M/22)

2. Species are animals: Seventeen (47%) of the students responses fall in this category.

"A group of animals which have same characters" (M/16).

Interestingly, the students' responses from both the above category follows one similar structure. Equal number (3) of students from both the categories associated species with members' ability to interbreed and having same character.

"Species are a particular group of organisms of the same type, which are capable of reproducing fertile offspring of their same kind." (F/10)

"The group of animals which possess common characteristics and are capable of interbreeding are called species." (F/2)

Six students from each of the category associated species with either ability to interbreed (3/2) or having same character (3/4).

"Species are those who are capable of interbreeding." (M/17)

"These are the animals which have a characteristics of interbreeding i.e. that they could reproduce within themselves and not with some other species." (F/12)

Nine (25%) students (4 and 5 from category 1 and 2 respectively) characterises species as endemic only.

"Species are animals found in a particular area." (M/13)

Total four students from both the categories classified species in at least one of three species categories mentioned in the textbook viz. endemic, endangered, and extinct.

"Species are living organisms or animals that are living in the earth. There are two types of species one is endangered species and second is endemic species." (M/22)

"There are two types of species: endangered and extinct..." (M/16)

Interestingly two students (1 from each category) associated organisms or animals related to other organism or animal in defining species.

"Species are a kind of animals who are related to a same group etc." (M/10)

"Species is a type of animal or a creature related to a particular animal/creature" (M/20)

Three students from first category mentioned species as varieties of living world. One of the student associated the idea of variety for a common class of animals, e.g. snake.

"There are different types of or varieties of animals, plants and birds. They are called as species." (M/18)

It is interesting to note that a few students conceptualise species as microscopic and harmful, rarely found, having large populations, and useful for human and environment only.

"The species are the animals which we can see with the microbes (microscope). They are harmful to us." (M/22/2)

"Species are some special kind of animals which are found very rarely for example – white elephant, white tiger..." (F/25)

“A species is a living organs (organism) which have a large number of population and have same kind of characters.” (M/19)

“Species are those which are capable of human activities. They are important for human and the environment.” (F/27)

Discussion

It is clear from the preliminary textbook analysis that portray of diversity of plants and animals are not always balanced. Particularly, the Class VIII, Science and Geography textbooks failed to present animals and plants with equal emphasis. One of the sources of students' misconception about species as “only animals” might have developed from the textbook itself. In textbook students were introduced to the biological concept of species (Mayr, 1996) and simultaneously mentioned that the members in a species share same characteristics. These similarities in morphological characters are one of the basis of species identification. Biologists do identify species based on morphological character and this serves to indicate reproductive isolation (Hey, 2001). Most plant species can be easily distinguished by morphological character (Richards, 2010). Textbook does mention about endemic, endangered, and extinct species. Unfortunately, some students attributed species as only endemic. And some other students interpreted the above three types wrongly and concluded that species can be classified only in these three ways.

Students' understanding of species appears to be complex. On one side they attribute biological species concepts to a living organism and at the same time consider species as only animal. Students see species as varieties and at the same time classify species in only three categories: endemic, endanger, and extinct.

It is heartening that students associate concepts of species with organisms' habitat and idea of relatedness. The ideas are close to other standard species concepts like Ecological Species Concepts and Phylogenetic Species Concepts. We can use these opportunities to initiate discussion on alternative species concepts. One student's response

Species are a particular group of living beings ... born through a same kind of source (F/21) reminds us the Buffon's quote:

We should regard two animals as belonging to the same species if, by means of copulation, they can perpetuate themselves and preserve the likeness of the species; and we should regard them as belonging to different species if they are incapable of producing progeny by the same means (Buffon, as translated in Lovejoy 1968 as cited in Mallet, 2010).

Several students rightly pointed out that members of the species share common characteristics and some of them mentioned that individuals of species are of same 'kind'. It is not clear whether students conceptualised these aspects. Some students mentioned criteria of similarities in species characterisation. Some of the students' misconceptions are random and appears to have no connection with textbook content. For example, ideas like species have large population, they are rare, species are microscopic etc.

Implications in teaching

It is observed that students' concepts of species are complex. Therefore, exploring students' concepts in fragmented way would not give actual picture of the students understanding of species. For example, if students are asked to define Endangered or Extinct Species, most students would correctly define them and even mention two animal examples. Therefore, the classroom discussions need to be structured in such a way that students' face conflicting ideas and share their ideas in the classroom.

On the other hand considering the multiple view of species concepts teachers need to address students' varied concepts about species. Each of the concepts can be a potential discussion topic to develop better idea about species. The discussion can be structured to encourage the students' views and at the same time challenge the idea with others. For example, students' ideas of similarities in character of the members in a species can be challenged with the examples where the similarities between the members of the same species or dis-similarities between the two species are very less. This discussion can be extended to morphological identification, which plays a crucial role to identify extinct species.

Conclusions

The paper reports a preliminary analysis of CBSE science and social science textbooks from Class I – VIII on how species concept is introduced as well as Class VIII students' species concepts. It is observed that students' concepts of species has several correspondence with textbook presentation of species concepts. However,

students have not understood many concepts and at the worst misinterpreted textbook content. Students' understanding seems to be fragmented and incomplete.

The paper cites several of the students' misconceptions and alternative conception of species. However, the study can be extended to larger sample to have better idea about the various concepts. The method of eliciting students' responses was similar to formal examination and therefore unable to check students spontaneous ideas about species. The study is inadequate to provide a coherent pattern in students' species concepts. The analysis of the textbook was an important dimension to explore the sources of students' varied responses. However, the analysis is limited to the chapters which have explicit mention of "species". In addition the graphics presented in the textbooks are also not analysed.

The findings reported in this paper would help structuring more elaborate study on students' and teachers' concepts of species. Finally, we need to encourage and appreciate students' multiple ideas about species and use it as a platform for rich discussion in the classroom.

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