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Research paper

How Spanish primary school students interpret the concepts of population and species

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This article presents research concerning the way in which primary school pupils in southern Spain interpret the concepts of population and species. The results show that, for the concept of population, there was an intense anthropocentrism in pupils' responses, while for the concept of species, only animals were considered as living creatures. These interpretations influence the vision that the students will develop of ecosystems and biodiversity, as well as their respect and care for living beings. We propose some suggestions in order to improve the teaching of these concepts in primary education.

Keywords: population; species; living beings; primary education; interdisciplinary

Introduction

The Spanish Official Curriculum highlights the study of ecosystems at the end of primary education (fifth and sixth grade, 11–12 years of age), dealing with such concepts as habitat, ecosystem, and trophic as well as non-trophic interactions between species (RD 1513/2006). The concept of species is usually presented in sixth grade (12 years of age). In textbooks for this educational level, a species is commonly defined as 'a group of living beings with similar characteristics that are able to reproduce together and produce descendants with these same characteristics'. The concept of population is usually absent from textbooks at this level, although many texts describe insect societies or many other groups of birds and mammals (as for instance herds). In contrast, the concept of population is used in the official curriculum and in texts to describe the different kinds of organisation and grouping in human societies (world human population, Andalusian population, Spanish population, European Union population). Human activity in ecosystems is also introduced in the sixth grade (12-years-old), giving examples of negative effects, such as biodiversity loss, which is usually defined as species extinction. However, diversity is manifested at many levels, from the individual to the ecosystem, including the species and population (Allen and Hoekstra 1992). The introduction of these two terms in primary schools is a good form to initiate the pupils in the study of biodiversity and ecosystems. This will make them respect biodiversity and care for its conservation in the present and in the future. However, introducing both concepts is not only defining them, but rather getting people to recognise their nearest species and populations. Since it is not possible to analyse the whole species, we can identify more common populations, both plants and animals, and learn about their utility and function.

The biological knowledge of children is mediated by drivers at individual (Carey 1985) and social levels (Inagaki and Hatano 2002). The consensus in the education community is that knowledge builds in people's minds (Driver et al. 1994). In this process of building, previous ideas play a pivotal role (Driver, Guesne, and Tiberghien 1985). A good example of this is well studied in biology with plants. Several

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authors have documented that students have a problem with identifying plants as living beings or as having the characteristics associated with living organisms (De Manuel and Grau 1996; Mondelo, Martínez-Losada, and García-Barros 1998; Acher and Pujol 2003; Garrido Portela 2007), as most students tend to associate living things with animals (de las Heras Pérez and Jiménez Pérez 2010) and know less about plants than about animals (Barman et al. 2003; Bebbington 2005; Schussler and Winslow 2007). The characteristics of plants, such as the lack of discernible movement, the absence of a face, the uniform colour, the spatial groupings, or the fact that they are not typically harmful, can contribute to the attitude by humans of disregarding them as beings that deserve our attention (Schussler and Olzak 2008). This lack of attention has diverse consequences, such as the difficulty and/or disinterest in learning about them, leading to difficulty in learning and remembering their names, as shown in a study by Schussler and Olzak (2008), and increasing the propensity to under value their importance in ecosystems. This has a negative influence on attitudes in terms of caring and respecting living organisms and conserving them.

The concepts of population and species, which are introduced in Spain in the fifth and/or sixth grade of primary school (11–12 years of age), together with basic notions of ecology, may serve as the underlying structure of proposals for meaningful learning about living beings. Coinciding with Cañal (2003), we think that it is also fundamental that pupils must positively value biodiversity, coexistence, ecological solidarity, and the protection of other forms of life. We also believe that an appropriate handling of these concepts could improve these attitudes to them.

Another value of these concepts is the possible interdisciplinary treatment that can be given to them. This may add to the overarching character that should be present at the primary level, as reflected in the official Spanish curriculum. It has been stated that mathematics and social sciences can help with the didactics of biology in teaching the concepts of population and species, indicating a series of patterns for the secondary stage (Jiménez-Tejada, González-García and Hódar 2008). These same concepts can be carefully worked with using interdisciplinary education also at primary level, with the added advantage that it is possible for one teacher to intercede through mathematics and environmental knowledge and even from other areas of knowledge such as artistic education, physical education, and foreign languages.

Finally, it should be considered that the study of populations of living organisms constitutes a central aspect in biology, although this is taught mainly during the high school stage, due to its relationship with natural selection and evolution (Jiménez Aleixandre 1994). We agree with other researchers that more attention should be placed on teaching biology in elementary and primary school, since pupils learn concepts and develop language learning at a young age (Tunnicliffe and Ueckert 2011).

The planning of teaching-learning sequences requires knowledge of the previous ideas held in mind by students. If we use the concepts of population and species as the starting point for encouraging respect for biodiversity, it is first necessary to determine what the students understand by these two concepts. Thus, the basic aim of the present study is to determine what the students understand by the population and species concepts.

Methodology

We sent an email to all the schools in Granada in order to select the schools involved in this study, but only three of them replied. Our study included a total of 147 pupils from these primary schools in Granada (Spain). The sample includes one private school, with 99 students for this research, and two public schools, in which 20 and 28 students participated. All the students were in the fifth or the sixth grade (11-12 years of age, see Table 1). We consulted the official Spanish curriculum to determine at what stage the concepts investigated were introduced to students. The questionnaire used to gather alternative ideas from the students was formulated by the categories established in previous studies (Berzal de Pedrazzini and Barberá 1993; Berzal de Pedrazzini 2001; Jiménez-Tejada 2009), adapting it to the age and knowledge of the pupils of fifth and

Table 1. Characteristics of the sample pooled

Level	5th grade (11-years-old)		6th grade (12-years-old)	
School [a, b]	N° students	Concepts studied	N° students	Concepts studied
1 (Public)	8	NO	12	YES
2 (Private)	47	YES	52	NO
3 (Public)	14	NO	14	YES

Notes: (a) A public school in Spain is financed either by the National or Regional Government (Andalusia in our case). A private school is financed by the parents of the students, and usually is directed by religious orders; (b) Schools 2 and 3 are situated in the city of Granada, thus in an urban environment, while school 1 is in a small town (rural environment).

sixth grade. After being formulated, the questionnaire was validated by a committee of experts formed by teacher training professors for future primary school teachers from the University of Granada. The questionnaire was administered at the end of the last term of the 2009/2010 school year. Not all the students polled had studied the concepts of population and species at that moment when filling in the questionnaire, as shown in Table 1.

The questionnaire was administered in the main classroom, during the teaching of environmental science (sciences in primary school). Parents and teachers were informed of the administration of the questionnaire in the three schools by representatives of the school council.

We used the questionnaire as a method in diagnosing alternative ideas due to various advantages such as the ease of application, the guarantee of anonymity, or the access to broad samples in a relatively short time (Selltiz et al. 1976; Fox 1981).

The questionnaire included three multiple-choice questions, with one option being the most complete and correct, and the last a question requiring a brief answer (Table 2). All the questions were related to concepts of the individual, population, and species.

For question 4, which allowed students to respond more fully, different categories of responses were determined. These categories were not established a priori but rather, as in other works (Jiménez Aleixandre and Fernández 1989), the answers were categorised after the data gathering by defining categories in such a way that all data could be classified (open-mesh system, Weil-Barais and Corrover 1993).

For the statistical study, each question was submitted to a distribution analysis of frequencies of the different categories for the total sample. Also, Fisher's exact test was applied to determine whether there were significant differences by school, for each level in school, for type of school (public or private) or for geographic location (rural or urban school). For all these, in the first three questions, the incorrect or incomplete categories were pooled (*pooling procedure*, Zar 1996). In the fourth question, they were split, regardless of the reasoning, into affirmative and negative cases. Finally, contingency tables were used to analyse the relationships of answers between different questions.

Results and discussion

Question 1. What is an individual?

In the first question, as indicated in Figure 1, the most frequently answered option was 'a'. This reveals that the children had an anthropocentric point of view, a tendency that, according to Rus Arboledas (2000), can be explained by the egocentrism of children, although it also may reflect the influence of the use of this term in our everyday life (Romero 2011). These results are not exclusive to primary-school children, but are also found in secondary

Table 2. Questionnaire offered to the students

YEAR IN SCHOOL_____ SCHOOL_____

ANSWER THE FOLLOWING QUESTIONS MARKING **ONE CHOICE** THAT YOU BELIEVE IS THE CORRECT ONE.

1. What is an individual?

a) A person.
b) An animal or a plant.
c) A thing.
d) A person, animal or thing.

2. What is a population?

a) A group of people.
b) A group of people who live in the same place, for example in the same town or the same city.
c) A group of animals, plants, and people who live all together in the same place. For example people who live in a town with their domesticated animals and plants.
d) A group of living beings that are all of the same type and live in the same place.

3. What is a species?

a) A type or race of human being.
b) A type of animal that can be distinguished from the others by its appearance. For example, a species would be dogs, chickens, or people.
c) A type of living being, whether animal, plant, fungus, or bacteria, which can be distinguished from the others by its appearance.
d) A type of living being, whether animal, plant, fungus, or bacteria, which can be distinguished from the others by its appearance and, also, can reproduce only with those that are similar to it.

4. In a book appear the following definitions of population:

1st: Group of living beings of a species that live in an ecosystem.
2nd: Group of persons that live in a territory.
Do you think that the first definition can be applied to people? Why?

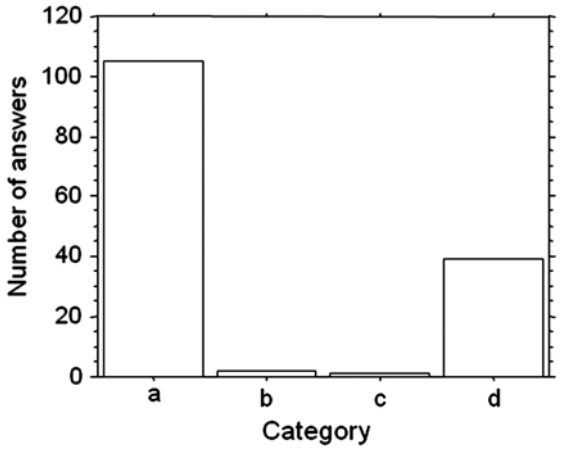

Figure 1. Number of answers for each category in question 1

students (Sánchez and Pontes 2010; Romero 2011) as well as in university students, as reported in other studies (Mateos Jiménez 1998; Jiménez-Tejada 2009).

The statistical analysis applied indicated no significant differences, between the school levels (χ^2=0.013, d.f.=1, p=0.9087), between schools (χ^2=0.812, g.l=2, p=0.6663), between types of school (χ^2=0.252, g.l=1, p=0.6160), or between geographic locations (χ^2=0.042, g.l=1, p=0.8377). The absence of definitions of the individual term in the texts (Jiménez-Tejada 2009), together with their use in everyday language could explain the lack of differences in all cases.

Question 2. What is a population?

As can be appreciated in Figure 2, most of the students answered with option b), with d) being the correct answer (chosen by only 8% of the pupils). Again, this reflects the anthropocentric vision of the child at this stage, relating the concept of population to human beings. This type of response has also been noted by other authors (Berzal de Pedrazzini and Barberá 1993; Helldén 2002; Sánchez and Pontes 2010; Romero 2011).

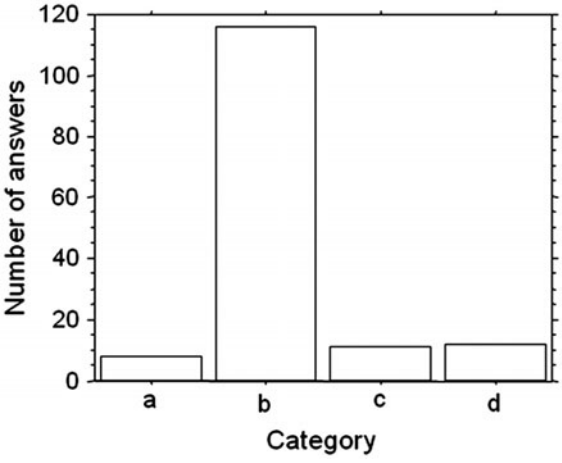

Figure 2. Number of answers for each category in question 2

The anthropocentrism implicit in the pupils' responses may be reinforced by the explanation given by teachers in earlier stages on the concept of human population. This is because, until fourth grade (10 years of age) in school the concept of population is normally used only when applied to the human being. The application to all living beings is introduced concretely in the fifth and sixth grade in primary school in Spain, but it is still seen simultaneously with human beings. Furthermore, we should remember that in these grades, the term population is used to describe different forms of human social organisation.

These anthropocentric responses, which may be the result of the direct observation and coexistence in society, does not appear to be exclusive to Spanish students, but also it has been discovered in other studies, such as in Berzal de Pedrazzini and Barberá (1993) with Argentinean students, in Helldén (2002) with Swedish students, or Jiménez-Tejada (2009) with Chilean students.

The statistical analysis applied indicates no significant differences between students' performances by school level (χ^2=1.337, d.f.=1, p=0.2475), between types of school (χ^2=3.665, g.l=1, p=0.0556), or between geographic locations (χ^2=0.897, g.l=1, p=0.3435). This lack of differences could be explained by the anthropocentrism current in the society (Develay and Ginsburger-Vogel 1986) and by the meagre instruction received by the students in this regard. It should be taken into account that the terms investigated are introduced for the first time in these grades in primary school. This would also explain the low percentage of responses in category d.

Question 3. What is a species?

The typological thinking, deeply rooted in society due to the popular use of the term species, could be the reason for the answers chosen by pupils. It should be noted that categories b, c and d included the sentence 'which can be distinguished from the others by its appearance'. Thus, it is not strange that the category a) received the fewest answers, dividing them equally among the other response in the other categories (see Figure 3). Although the pupils recognised species as more than only animals (options c and d), some indicated option b. It is possible that these students used movement as a criterion for defining the living being and thus would have excluded options that included plants and fungi. Despite that category d) was the one most commonly chosen, it hardly differed from c. In the choice of category c and d may have influenced the weight of the typological criterion on defining spe-

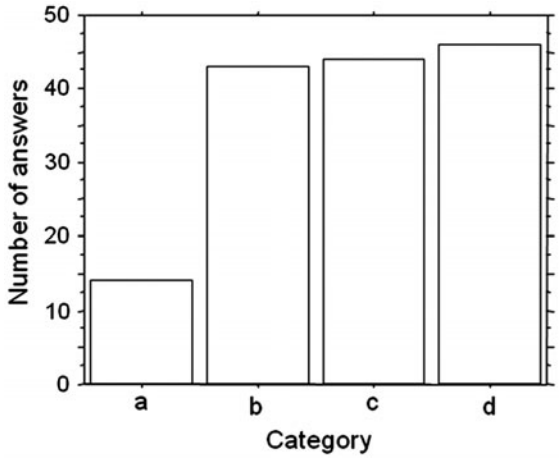

Figure 3. Number of answers for each category in question 3

cies (morphological similarities between individuals), and that reproduction is a vital function linked to the essential characteristics of living beings as individuals but not so much as a group (Mateos Jiménez 1998).

The statistical analysis indicated no significant differences either between school levels (χ^2=0.736, d.f. =1, p=0,3909), between types of school (χ^2=0.558, g.l=1, p=0.4552), or between geographic locations (χ^2=3.150, g.l=1, p=0.0759), but did between schools (χ^2=9.760, g.l=2, p=0.0076). The teaching of the concept species in different levels between schools could be responsible for the differences in correct answers. However, there were right answers in all schools, irrespective of whether the concept had been previously taught. Some other factors, such as the text used or the pedagogical procedures, could explain this finding.

Question 4. A book shows different definitions of population

For the categories created, examples of typical answers given by students were provided.

The categories in which the responses were grouped were the following. We also provide some examples of typical responses given by students.

Category 1: They do not answer, they answer yes or no but do not provide a reason, the answer is incoherent.

For example: 'Yes because it's right'; 'no because yes is not possible'; 'yes, because it is simpler'; 'yes it may be because I don't know'.

Category 2: No, people are not living beings.

'No, because people are not animals'.

Category 3: No, ecosystems are formed by animals and not by people or plants.

'No, because an ecosystem is for animals, not for people'; 'no, because ecosystem refers to animals'.

Category 4: Yes, people live in an ecosystem.

'Yes because people live in the ecosystem'.

Category 5: Yes people are living beings.

'Yes because we as people are living beings'.

In this question, the high number of responses belonging to the first category is very high (Figure 4), resulting in a highly significant difference in the number of answers in each category (χ^2=47.650, g. l=4, p<0.0001, goodness of fit test). The high number of responses to this category may be because the students, due to their age, did not understand the question (although they did not manifest this) or else, for being asked a question in which they were asked for a justification, they chose the simplest task, resulting in incoherency or response such as "because it is important" or "just because" due to the lack of a more thought-out explanation.

It is possible that the absence of a justification was due to the fact that this question seemed contradictory to them in relation to question two (concept of population), in which the most common answer coincided with the second option shown in this question.

Also, it could have been that the students found this question contradictory, in relation to question two (concept of population), in which the most common answer coincided with the second option shown in this question, and therefore they gave unexplained answers, thinking that they had given a response previously.

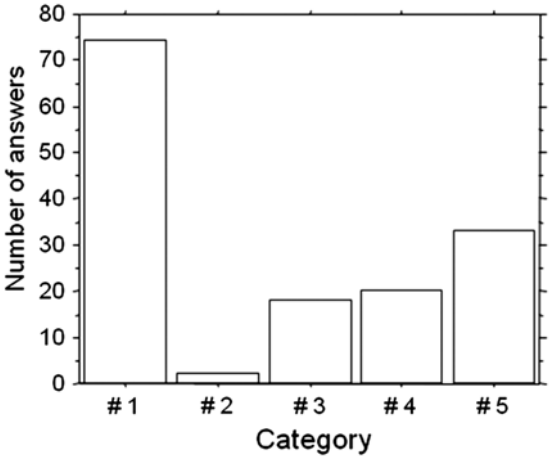

Figure 4. Number of answers for each category in question 4

The second category followed by the third, which had the fewest responses. The students that had answered could have had the idea that as people we form a group apart from the rest of living beings. The reason that ecosystems consist of animals but not of people and plants could be related to the influence of documentaries, which show lives of animals much more frequently, omitting or giving less emphasis to plant life. To separate people from the rest of the animals, *ie* not considering them as such, could be explained by the use of the term animal in everyday language that in many cases carries negative connotations.

Another interpretation of the answers is also possible in the third category, as it may reflect the mercantile and bucolic view that adolescents have regarding the environment. According to this vision, they perceive the environment as the origin of diverse resources (energy, food, construction materials) and of different forms of leisure and free time. People do not form part of the ecosystem but use it for individual or collective interests; this view of nature is also associated with anthropocentrism on considering nature something apart from humans but that it can be controlled and dominated by them (García Díaz et al. 1992). On the other hand, the same students indicated in their responses that plants do not belong to ecosystems. This statement could have several explanations that may be related. One would be that some students still have a problem with identifying plants as living organisms. Probably these still use movement to identify living beings, a criterion used in childhood (Garrido Portela, García Barros, and Martínez Losada 2009). Possibly, on not identifying movement in them, they are associated with other elements of the landscape, such as mountains, valleys or rivers. This makes it difficult to appreciate the important role of the producers in ecosystems.

In category four, one more step is taken in the reasoning of the students for including people in ecosystems because they themselves live in them; however, this confusion between habitat and ecosystem, observed also by Adeniyi (1985), could be the result of conceiving the ecosystem as something static and that could be modified at the whim of the human.

To determine whether there were differences according to the school, the level in school, type of school, and geographic location, we grouped the answers as affirmative or negative, regardless of the explanation given by the student. There were no significant differences found, either between schools (χ^2=2.957, d.f.=2, p=0.2279), between types of school (χ^2=0,005, d.f.=1, p=0.9419), or between geographic locations (χ^2=1.741, d.f.=1, p=0.1870), but there were between levels (χ^2=6.200, d.f.=1, p=0.0128); that is, affirmative answers were more frequent in the sixth grade (78%) than in the fifth (59%). These results, at least in part, could be because some students of the fifth grade had not studied this concept yet, while all those in the sixth grade had, either during that year in school or in the previous one. The influence of the pedagogical procedures should also be taken in mind.

When we analysed the relationships of answers between different questions we found no significant relation between the answers for the first and the second question (χ^2=0.335, d.f.=1, p=0.5625), but there was a significant relation between the first and the third question (χ^2=3.973, d.f.=1, p=0.0462), between the second and the third question (χ^2=4.191, d.f.=1, p=0.0406), and between the second and the fourth question (χ^2=7.842, d.f.=1, p=0.0051), When there are relationships between responses, the students gave the incorrect answer in both cases, and when they chose the correct option for one question they also gave the correct response for the other question. These relationships could show the strong influence of the everyday language and the meaning used in the school during the previous courses, being only in fifth and sixth grade (11–12 years of age) when these concepts are contextualised with all living beings and the study of ecosystems. Thus, most of the students showed a low skill in the use of these concepts, and consequently offered the wrong answers to the questions. Only a few students showed an adequate knowledge of the concepts.

Conclusions and education implications

The concepts of population and species are introduced in Spain for the first time in the curriculum of primary education in association with ecology, which, at this stage, has a marked environmental meaning. Given that both concepts are two of the first terms introduced to initiate students in ecology, it is necessary to identify prior ideas among students in order to improve the processes of teaching and learning in environmental education.

After analysing the results, we found several priority aspects that need improvement:

(a) That the concept of population should be associated not only with humans but with the rest of living beings.
(b) That human beings are also living beings and belong to the animal kingdom.
(c) That species are not just animals but also plants, fungi, bacteria, etc.

If our efforts are directed at improving these aspects, we will lay the foundation for success in the following school years as well as in other branches of

biology in which these two terms are related. Also, we will contribute to proper preparation in environmental education on transmitting a broader idea of biodiversity, which includes far more than the animal kingdom alone.

As no difference was appreciated between students of the fifth and sixth grade, in three of the four questions, it would be important to take into account treating the concepts in these grades in primary education.

The primary stage of schooling is suitable for the introduction of these concepts in the curriculum for, at least, two reasons.

First, the curiosity and interest pupils have for everything around them. At that age it is known that primary school children tend to show interest in numerous aspects of living beings: what they are like, how they live, what they do, etc.

Second, the primary school teacher is responsible for several different subjects (mathematics, art, social science, natural science), thus allowing a better interdisciplinary treatment of the concept of population. A similar proposal has been posed for secondary school education (Jiménez-Tejada, González-García and Hódar 2008), but in this case one of the main difficulties is the implication of different teachers for the different subjects in the Spanish educational system. We should make use of both advantages to formulate proposals that would enable globalised teaching and learning, as these are vital to an adequate environmental education.

It is also known, that this initial interest usually fades over successive courses as a result of pedagogical and didactic approaches, which are unproductive but are unfortunately quite common in classrooms (Cañal 2003). It is worth taking advantage of this interest, so that the student learns about living beings, avoiding traditional approaches that focus on the morphological or functional descriptions or in classifications of barely any meaning for the student (Garrido Portela and Martínez Losada 2009).

Environmental education goes beyond ecology and, as a transversal theme, permits the development of activities in which diverse areas of the curriculum can be integrated and put into practice by the same teacher without difficulty, as happens at higher levels, on having to coordinate with other people. Previously (Jiménez-Tejada, González-García and Hódar 2008), we proposed that in secondary education, both the science and social science teachers, as well as textbooks, would give a similar treatment to the concept of population. Given the advantage mentioned above, this suggestion can be made broadly to the teachers and textbooks for primary education.

The interest shown by the students in all things surrounding them and the learning by their own experiences should be taken advantage of by putting into practice activities in which the closest setting is the resource to use. The design of small studies in the closest parks, the school gardens, a school vegetable patch, photographic safaris to take images of different populations and species for examining similarities and differences within and between species constitute some of the resources to bear in mind not only in the area of knowledge of the environment but also in others, such as art and foreign languages.

We should not forget that at these ages young people usually spend many hours in front of the television and they begin using TIC (technology information, and communication), and thus the use of both resources to improve teaching–learning of the concepts analysed may be equally motivating. Documentaries, cartoons, films related to environmental education, interactive games, and computer simulations are resources that, for their attractiveness, should be used and taken advantage of, not only for the subject matter dealt with here.

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