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Developing the concept of 'ecosystem' through inquiry-based learning: a study of pre-service primary teachers

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ABSTRACT

We studied the initial conceptions of 73 pre-service primary teachers regarding the concept of ecosystem and examined how their understanding evolved as a result of participation in an inquiry-based learning exercise. The inquiry process involved identifying students' initial conceptions, making them aware of these, comparison of their ideas with scientific knowledge and knowledge building through activities in which they analysed points of agreement, discrepancies and conclusions. The activities were performed in groups and centred on the production of posters, which participants were required to compare in both the first and final sessions. This comparison, together with the qualitative analysis of the content of the posters, was carried out using a rubric designed on the basis of a literature review. The results showed that students progressed in their understanding of key aspects related to the concept of ecosystem. In particular, they became more aware of the role that humans play within such systems, although they continued to have difficulties with aspects such as identifying species in the aquatic ecosystem and discriminating between biotic and abiotic components.

KEYWORDS

Ecosystem; initial conceptions; inquiry-based learning; pre-service primary teachers; knowledge progression

Introduction

The inconsistent use of concepts and poor understanding of the elements of an argument that is often shown by pre-service primary teachers is an issue that, according to Marín and Cardenas (2011), needs to be addressed on the ontological, epistemological and conceptual levels. In the view of Rincón (2011), the roots of this problem are to be found in cognitive errors and learning difficulties related to the concept of ecosystem which affect different levels of education. At post-secondary level in particular there is a tendency to ascribe greater importance to animal as opposed to plant life (Bell-Basca et al. 2000), and to focus on what is most evident and closest to one's own experience. A further problem concerns the difficulty students have in grasping more abstract concepts. In this regard, it is noteworthy that greater emphasis is placed on antagonistic relationships, to the detriment of cooperative ones (Leach et al. 1996) and that little reference is made to habitat (predator-prey) and food dependencies, to the relationships between biotic and abiotic components (Brero 1997; White 2000). In other words, there appears to be a problem with considering the ecosystem as a system (systemic thinking) (Driver et al. 1994; Grotzer 2009) that doesn't allow integrate and understand main concepts as components of ecosystem, sub-system and relations established between them, among others (Booth and Sinker 1979).

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This problem persists among undergraduates. Studies by Eilam (2002) and Magntorn and Hellden (2007) have found that university students continue to struggle to understand the role of energy and ecological succession, and the complexity of ecosystems. In addition, higher education syllabuses tend to be designed in a way that assumes greater prior knowledge among students than they actually have. In this respect, Jones et al. (2015) point to the poor grasp of basic concepts shown by students and the need for undergraduate courses to focus more on deeper-learning teaching strategies in which key aspects of the nature of science and scientific research are addressed.

In this context, various lines of research have highlighted the importance of considering science-technology-society relationships in order to develop a deep understanding of the concepts, procedures and attitudes associated with environmental education (Vilchez et al. 2008). Within this framework, and in relation to the concept of ecosystem, it is particularly important that students recognise the extent to which they themselves form part of a given ecosystem, in other words, that they acknowledge their own role in the environment. If students could understand and admit a human role into local ecosystem, they could have a holistic and systemic vision of it, and that could allow them to identify and value the biodiversity of environment and the relations that exists among them (Aguilar 2012).

It is also important that they acquire the specific competences that will enable them to act in environmentally-aware ways (Acebal, Brero, and Sampietro 2014). In other words, it is necessary to implement activities that encourage students to participate, question and think critically so as to increase their knowledge and awareness of environmental issues (Marinopoulos and Stavridou 2002).

Of fundamental importance therefore are learning strategies that can foster conceptual and attitudinal changes in relation to these issues at all levels of education. In the context of secondary education, Eilam (2002) proposes the use of inquiry-based learning strategies so that students learn to apply their knowledge to larger scale ecosystems, at the same time as fostering their interest and motivation throughout the process. Osborne (2014) argues scientific practices, among them inquiry, should be the center of science teaching and learning. Inquiry demands to plan and carry out a designed process with the objective of answering questions or solving problems (Caamaño 2012). It involves the performance of skills among which are (NRC 2012): Identification of questions that guides scientific research, formulation of scientific explanations, design and implementation of process, recognition and analysis of data, as well as communication and defend a scientific argument. Thus, the inquire process implies enhancement of these skills and development of conceptual contents of science (Toma, Greca, and Meneses-Villagrá 2017).

For their part, Jussila and Virtanen (2014) describe an open-access learning environment designed specifically to develop an understanding of ecology, to enhance conceptual development and to provide a holistic view of ecosystems. The learning tools they suggest include concept maps, activating questions and self-assessment, among others. These authors highlight the importance of using contexts from a real ecosystem so that learners are exposed to the interactive systematic complexity of nature, wherein core ecological phenomena such as energy flow or population dynamics can be addressed.

The learning progression hypothesis provides another frame of reference for the building of knowledge and awareness (Garcia and Rivero 1996; García 1997), which may be guided —in terms of both the organisation and sequence of content — by inquiry. The idea here is that students start from their initial representations of the ecosystem and then design and implement procedures in the form of a research plan, enabling them to make modifications and produce more complex sub-structures in their final representations. This process allows them to see progressive changes in their understanding, awareness and responsibility, as well as to minimize the cognitive errors that act as obstacles to a systemic view of ecological issues and to develop value judgments in order to analyse human-nature relations (Özkan, Tekkaya, and Geban 2004).

Research questions and context

There is now a consensus among researchers in the field of science education that teachers' conceptions and epistemological beliefs influence their approach to the teaching of science (Martín, Prieto, and Jiménez 2015). Numerous scientific concepts, including that of ecosystem, are often considered from an analytic perspective that prioritizes an individual understanding of the objects of which they are comprised, those which will subsequently form the whole (Rincón 2011). This view may be apparent in the way in which the content of a subject is approached (Solomon 1992; Sánchez and Valcárcel 2000; Martín, Prieto, and Lupión 2014) and then taught (Solomon 1992; Ratcliffe 1997; Hodson 2003; España and Prieto 2010).

In light of the above, the present study sought to answer the following questions:

- What initial main conceptions do pre-service primary teachers have regarding the concept of ecosystem?
- How do these conceptions evolve when students engage in inquiry-based activities such as formulating hypotheses, designing a work plan or presenting conclusions in order to compare results, among others?

The study was carried out during the 2015–16 academic year in the context of the Degree in Primary Education offered by our university, specifically during the obligatory third-year module entitled 'Science Education'. The participants were 73 pre-service primary teachers and two university tutors — the module tutor, who acted as a participant observer, and a colleague from the same knowledge area who did not teach on the module and who took the role of observer. The student group comprised 50 females and 23 males ranging in age from 21 to 45 years (mean of age = 21,02; standard deviation = 4,32), and they were organised into 14 work groups of 4–7 students each (mean of members by groups = 5,08; standard deviation = 1,19).

Method

The method used involved three steps: a) identifying the initial main conceptions of students, b) making them aware of these, and c) comparing and contrasting these initial conceptions with knowledge gained through student-led inquiry (Porlán and Martín del Pozo 2006).

These steps were implemented through three work sessions in which we gathered data using instruments designed to serve as tools for both teaching and inquiry, in accordance with the objectives and competences set out in the syllabus for the module in question. A key goal of these sessions was also to encourage participants to think more systemically about the concept of ecosystem, taking into account its true nature and the complexity of the relationships between its constituent components, with special emphasis on the role of human beings within ecosystems.

Work sessions and instruments for data collection

The session 1 was designed to the students did some of the inquiry process' operations (NRC 2012; Gilbert and Justi 2016; Erduran and Jiménez-Aleixandre 2007): Observation, identification of questions and formulation of hypothesis. So, university tutor and students went out of the classroom to observe the area around classroom during 15 minutes. In this area could be observed around it some buildings of classrooms of the University and buildings of apartments, a highway and, a little further, an area of small factories at the west, the beach at the south and mountains at the north. When everybody came back to the classroom, the university tutor asked to students what specific things had called them their attention. A short debate was done about it.

After that, students were given the following activity where they could formulate their hypothesis: '*Imagine that we are in the mountains to the north of Malaga. Working in groups,* *produce a poster that shows the different features of the ecosystem in this area'*. The university tutor indicated: 1) they have to reflect about the different elements that were characteristics of the ecosystem of Málaga; 2) They could relate them with the previous observation and debate and with others that they thought; 3) they should indicate the elements with a high level of detail, including adding text if they thought it was necessary to clarify the content of them. The posters were produced in class and on A3 paper. Once the posters were finished they were displayed around the walls of the classroom so that students could see the work produced by other groups. One member of each group stood by that group's poster in order to do, first, a short presentation (2–3 minutes) about the content of it and, second, to answer any questions that other students might ask. This role was shared among the members of each group, with turns being taken every ten minutes. The total time spent on this activity was 2 hours: 1 hour for producing the poster and 1 hour of display. The tutor supervised the students' work without providing informative feedback about its content. The aim in this session was to explore students' initial conceptions regarding the concept of ecosystem and the role they believed they played within such a system. The posters produced by the student groups constituted the first instrument for data collection.

Session 2 began with students being asked to consider the following two questions: *Did any of the groups include humans in their drawings? What is my role within the ecosystem?* These questions were focused in the human role into local ecosystem looking for participants began to develop a holistic and systemic vision of ecosystem to promote their skills to identify and to value the biodiversity of environment and the relations that exists among them (Aguilar 2012).

With respect to the latter question, each group was asked to agree on a series of possible answers or hypotheses that they should present as follows: *'My role within the ecosystem is.......... because ....'*. Having done so, their task was then to accept or refute these hypotheses by drawing up a work plan for inquiry and data gathering, the results of which they would present in the next session (one week after). This activity lasted 60 minutes of which in the first 15 minutes each group formulated their hypothesis; and in the last 45 minutes each of them designed a work plan for inquiry and data gathering. Participants didn't receive any indication about how design work plan of inquiry and they hadn't any limitation to decide how search and get information. The aim was they to express their initial ideas about how to do an inquiry plan. So, they could plan visit library to get information of books or journals; use internet; visit museums; visit different environmental places; among others.

Once again the tutor supervised the students' work plan without providing informative feedback regarding its content. The aim in this session was to explore, on the basis of their proposed hypotheses, the students' initial conceptions about their role in the ecosystem.

Finally, session 3 began with a debate about whether the students' initial hypotheses were accepted or refuted as a result of the inquiry they had carried out during last week. One group presented its hypotheses and the conclusions reached, providing arguments as to why the hypotheses were accepted or not. This was followed by a discussion in which the students analysed commonalities and differences among their various hypotheses, conclusions and arguments, etc. Each group was then asked to produce a new poster that improved upon their initial one, these new posters were then displayed as before around the classroom. This session lasted a total of 3 hours: 1 hour for the debate, 1 hour to improve upon the initial posters and 1 hour for the display of new posters. The tutor took an active role in the debate, encouraging students through questions such as: Who started from the same hypothesis? Have you all reached the same conclusion? Who started from a different hypothesis? What conclusion have you reached? The tutor adopted a similarly active role during the poster display, looking for and commenting on commonalities and drawing attention to notable aspects. During the hour in which students improved their posters, the tutor's role was limited to supervising their work. Only at the beginning, she reminded the activity to improve upon the initial posters (*Imagine that we are in the mountains to the north of Malaga. Working in groups, you have to improve the initial poster* *to show the different features of the ecosystem in this area*). She also explained they should indicate the elements of the posters with a high level of detail including adding text to clarify their content. The aim of this session was to see how students' understanding of the concept of ecosystem and of their role within this system had evolved with respect to their initial conceptions. The final, improved posters were taken as a measure of their progress.

Data analysis

The content of the initial and improved posters was analysed using a rubric (Table 1) that we devised following a qualitative analysis of selected previous studies (Driver et al. 1994; Leach et al. 1996; Brero 1997; Bell-Basca et al. 2000; White 2000; Eilam 2002; Magntorn and Hellden 2007; Grotzer 2009; Rincón 2011), enabling us to compare our own hypotheses regarding students' understanding of the concept of ecosystem with the views of other authors. On the basis of this literature review we defined four dimensions of analysis: A. Components of the ecosystem; B. Subtypes of ecosystems; C. Relationships in the ecosystem; D. Human role. These dimensions were formulated in terms of their corresponding levels of conceptual development, from 1 to 4 in ascending order of complexity (Table 1). Note that dimension C comprises three sub-dimensions, labelled as follows: C1. Intraspecific relationships; C2. Interspecific relationships; C3. Relationships between biotic and abiotic components (Table 1).

In order to validate the rubric we asked two experts in the field of science education to apply it to three posters selected by the present authors. These posters were chosen as they illustrated, in our view, different levels of development along the same dimension of analysis. The analysis of the two experts coincided with our own.

Analysis of results

In general, students showed a notable improvement in their understanding of the concept of ecosystem across all the dimensions considered (Figures 1, 3, 5 and 7).

Regarding dimension A, Components of the Ecosystem, it can be seen in Figure 1 that all the groups were initially at the lowest levels of conceptual development. Specifically, the posters produced by four groups only made reference to biotic components or only depicted landscapes without differentiating and/or identifying the components of the ecosystem (Level 1), while the other ten groups depicted a landscape in which only biotic components (mainly animals) were identified (Level 2).

In their final posters, however, nine groups reached Level 3, since they now depicted a landscape in which both biotic and abiotic components were identified, and one group achieved Level 4, producing a poster that showed different components and which indicated whether they were biotic or abiotic (Figure 1). On the one hand, these results show that many students, having identified the different components of the ecosystem, still find it difficult to specify whether they are biotic or abiotic (Level 4). However, it is noteworthy that ten groups showed progress in their conceptual understanding, with four of them improving by two levels (see example in Figures 2 and 3). Only four groups maintained the same level.

With respect to dimension B, Subtypes of Ecosystems, it can be seen in Figure 4 that, overall, the students had a higher initial level of knowledge than was the case for the previous dimension (two groups at Level 1, seven at Level 2, four at Level 3 and one at Level 4). By the end of the inquiry learning process, however, most of the groups (i.e. 12) had reached the highest two levels of understanding: the seven groups at Level 3 produced posters that showed and/or named the subtypes of ecosystems, but without including plants and animals in each one of them, while the five groups that reached Level 4 depicted and/or named the subtypes of ecosystems along with their characteristic plants and animals. It should also be noted that nine of the student groups showed some degree of progress in their conceptual understanding.

Table 1. Rubric for analysing the initial and final posters.

DIMENSION	LEVEL OF CONCEPTUAL DEVELOPMENT			
	L1	L2	L3	L4
A. Components of the ecosystem. Degree to which the participants identify biotic and abiotic components of the ecosystem, specifying which are which.	Only names biotic components or only depicts landscapes without differentiating and/or identifying the components of the ecosystem.	Depicts a landscape in which only biotic components are identified, mainly animals.	Depicts a landscape in which biotic and abiotic components are identified.	Depicts a landscape in which different classes of component are identified, it being specified whether they are biotic or abiotic.
B. Subtypes of ecosystems. Degree to which the participants identify subtypes of ecosystems (terrestrial or marine), indicating their characteristic components.	Identifies (draws and/or names) some subtypes of ecosystems and names or draws some of their components.	Identifies (draws and/or names) the subtypes of ecosystems but includes only a small number (fewer than 3) of components in each one.	Identifies (draws and/or names) the subtypes of ecosystems, but does not include plants and animals in each one of them.	Identifies (draws and/or names) the subtypes of ecosystems, including their characteristic plants and animals.
C1. Relationships in the ecosystem: Intraspecific. Degree to which the participants establish intraspecific relationships (within the same species: reproduction, associations, etc.) between the biotic components of the ecosystem.	Does not establish any intraspecific relationship between the biotic components of the ecosystem.	Establishes at least one simple intraspecific relationship between the biotic components, but only implicitly (e.g. some associations for the same species or reproduction).	Establishes at least one simple intraspecific relationship between the biotic components and does so explicitly (e.g. some individuals of different sex and their offspring).	
C2. Relationships in the ecosystem: Interspecific. Degree to which the participants establish interspecific relationships (between species: symbiosis, predation, etc.) between the biotic components of the ecosystem.	Does not establish any interspecific relationship between the biotic components of the ecosystem.	Establishes at least one simple interspecific relationship between the biotic components, but only implicitly (e.g. drawing of a liquen).	Establishes at least one simple interspecific relationship between the biotic components and does so explicitly (e.g. bird that eats parasites of another animal).	Establishes at least one complex interspecific relationship between the biotic components (trophic chains or networks) and does so explicitly (e.g. drawing and explaining composition of a liquen).

(*Continued*)

Table 1. (Continued).

	LEVEL OF CONCEPTUAL DEVELOPMENT			
DIMENSION	L1	L2	L3	L4
C3. Relationships in the ecosystem: Between biotic and abiotic components. Degree to which the participants establish relationships between biotic and abiotic components.	Does not establish any relationship between the biotic and abiotic components of the ecosystem.	Establishes at least one relationship between the biotic and abiotic components, but only implicitly (e.g. a nest in a tree or place certain species next to each other).	Establishes at least one explicit relationship between the biotic and abiotic components (e.g. representing food chains or establishes energy flow relationships or material cycles).	Establishes at least one explicit relationship between the biotic and abiotic components, and includes an explanation of one or more processes (e.g. representing photosynthesis process, respiration process, energy flow and material cycles)
D. Human role. Degree to which the participants recognise that humans form part of the ecosystem and the influence/ role they have in relation to it.	Humans are not included in the ecosystem (they are neither drawn nor referred to).	Humans are drawn or referred to as part of the ecosystem, but only implicitly (one or more human-related element is drawn or named, for example, a boat or house, etc.)	Humans are explicitly drawn or referred to as part of the ecosystem.	Draws or refers to something that shows the influence which humans have on the ecosystem.

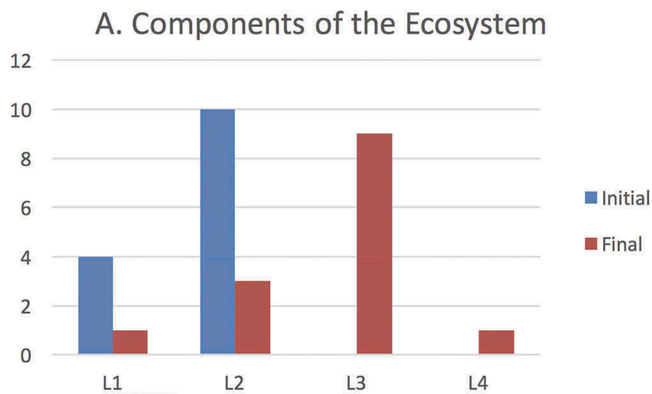

Figure 1. Frequencies for the levels of conceptual development observed in the initial and final posters in relation to dimension A, Components of the ecosystem.

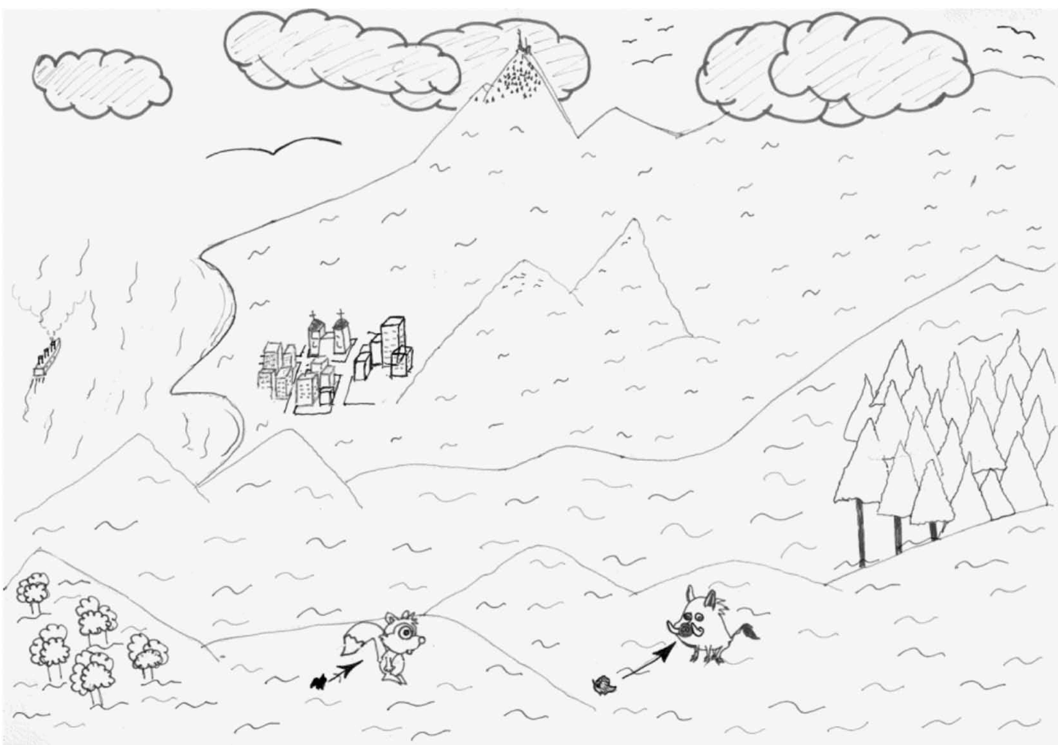

Figure 2. Initial poster from group 3.

Although these results are generally positive, they also suggest that many students still find it difficult to achieve the level of conceptual understanding associated with Level 4, since only five groups considered both plant and animal species in the aquatic and terrestrial ecosystem (see example in Figure 5).

As regards relationships within the ecosystem (dimension C), students initial level of knowledge was very low, with all the groups being at the first two levels (Figure 6) for all the sub-

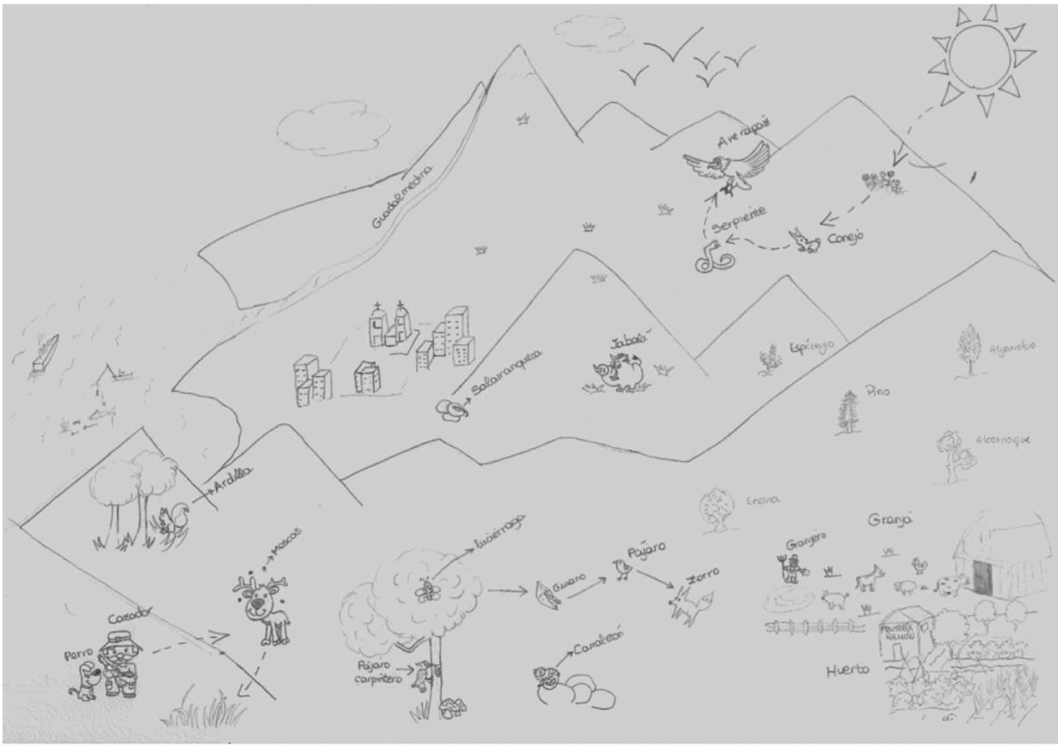

Figure 3. Final poster from group 3 (The labels are: Guadalmedina: Guadalmedina River; granjero: farmer; granja: farm; huerto: orchard; cazador: hunter; espárrago: asparagus; pino: pine tree; algarrobo: carob tree; alcornoque: cork oak; encina: holm oak; serpiente: snake; ave rapaz: raptor; conejo: rabbit; salamanquesa: gecko; jabalí: wild pig; ardilla: chipmunk; moscas: flies; perro: dog; luciérnaga: Firefly; pájaro carpintero: woodpecker; gusano: worm; pájaro: bird; zorro: fox; camaleón: chameleon).

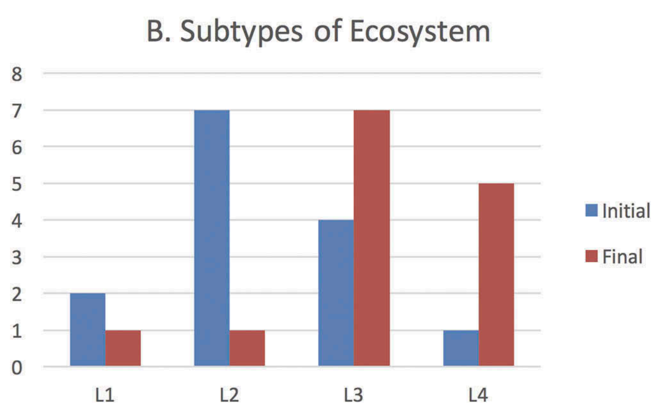

Figure 4. Frequencies for the levels of conceptual development observed in the initial and final posters in relation to dimension B, Subtypes of ecosystems.

dimensions considered (C1, C2 and C3), in other words, they either established no relationships (Level 1) or only did so implicitly (Level 2).

The progress shown by students in this case was very uneven. On the one hand, they continued to show considerable difficulty with respect to intraspecific relationships (sub-dimension C1), and 11 of the groups did not improve upon their initial level of understanding of this aspect (Figures 7 and 8). However, we observed notable progress with respect to

Figure 5. Final poster from group 1 (Hotel: hotel; farmacia: pharmacy; encina: holm oak; castaño: chestnut tree; alcornoque: cork oak; pino: pine tree; palmera: Palm tree; búho: owl; ardilla: cipmunk; lagartija: lizaard; culebra: snake; zorro: fox; jabalí: wild pig; cabra montesa: mountain goat; conejo: rabbit; águila real: golden eagle; camaleón: chameleon; murciélago: bat; erizo: hedgehog; ciervo: deer; golondrina: swallow; pato: duck; paloma: dove; delfín: dolphin; estrella de mar: starfish; atún: tuna; boquerón: anchovy; lisa: smooth fish; lenguado: sole; tortuga de mar: sea turtle; erizo de mar: sea urchin; morena: brunete fish; dorada goldfish; pez espada: swordfish; gaviota: seagull).

interspecific relationships (C2) and relationships between biotic and abiotic components (C3), with ten and nine groups, respectively, achieving the highest levels of conceptual development for these two sub-dimensions (Figure 5), producing posters in which they established explicit relationships of this kind (Figures 7 and 8)

Finally, and as regards the role of humans in the ecosystem (dimension D), students showed considerable progress in their knowledge (Figure 9). Specifically, by the end of the inquiry learning process, eight groups had achieved Level 4, producing posters in which they drew or referred to something that showed the influence of humans on the ecosystem (Figure 8), while a further three groups reached Level 3, explicitly drawing or referring to humans as part of the ecosystem. It should also be noted that all the groups showed progress in their understanding, improving by one, two or even three levels.

Conclusions and educational implications

In general, this study may serve as a platform for the design of specific learning activities for pre-service teachers about other scientific topics, with the dual aim of developing their systemic thinking and drawing attention to the educational potential of inquiry-based learning. It also illustrates how the way in which these kinds of activities are structured can help to build knowledge, in this case, regarding various aspects of the concept of ecosystem.

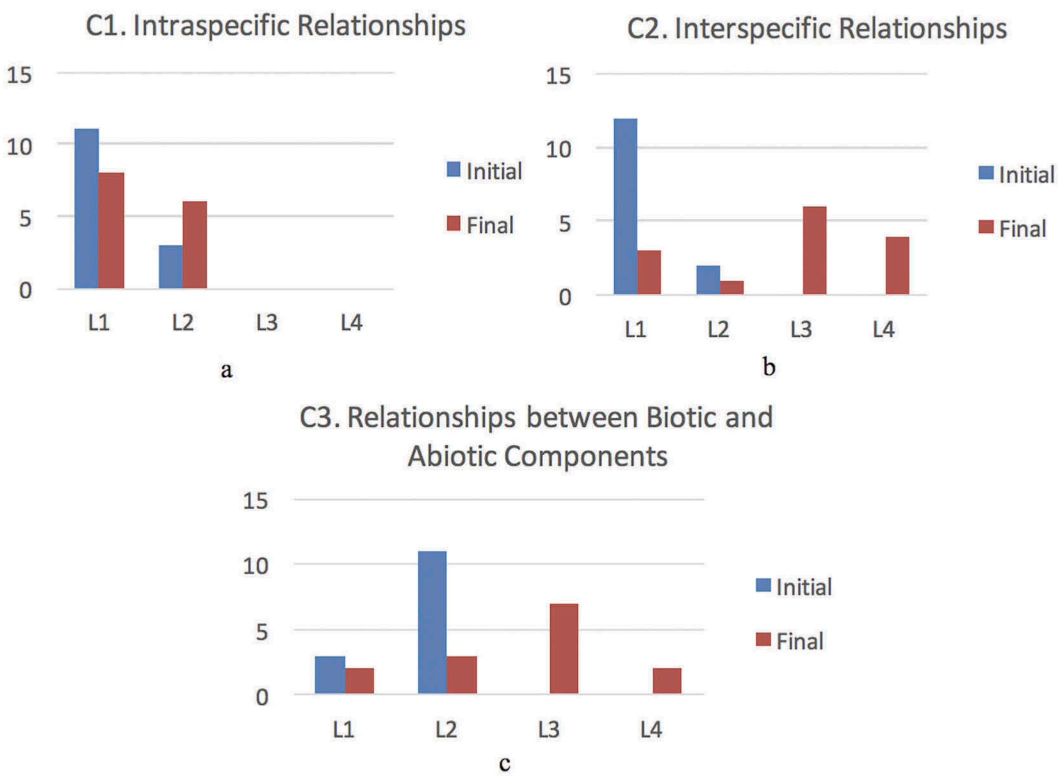

Figure 6. Frequencies for the levels of conceptual development observed in the initial and final posters in relation to dimension C, Relationships in the ecosystem.

The results show that students' progressed in their understanding of many of the aspects analysed. In our view, the fact that the task required them to consider a local natural environment helped them to appreciate the importance of developing their knowledge and the value of student-led inquiry in achieving this goal. Through this approach they gathered information that not only enabled them to identify processes and components of the ecosystem but also to relate these to one another. In particular, a significant advance can be seen in drawing abiotic components within the local ecosystem. However, classifying and identifying whether or not these ecosystem components are biotic or abiotic continued to be a problem for some students. This could be related to the need to have a higher level of abstraction and scientific knowledge to specify which are abiotic components and to be capable of drawing the ones corresponding to air, earth or water.

Furthermore, data points out a considerable progress made overall in understanding some of the relationships between biotic and abiotic components. Likewise, although the results show that most of the groups achieved a greater awareness of interspecific relationships, some students still found it difficult to identify plant and animal species in the aquatic ecosystem. That means that, although all the groups have recognized the marine aquatic subsystem within the Malaga ecosystem, the majority of them are not capable of recognizing and identifying producers and consumers of this ecosystem. In other words, it seems that there are certain difficulties in applying the basic theoretical model of an ecosystem to their closest reality. In this sense, and according to Bell-Basca et al. (2000), these difficulties could be based on the fact that society shows greater empathy and sensitivity towards the animal world than towards the vegetable world. So, there is a need to work from the first science educational levels with close examples and from the immediate environment to the students to promote the sensitivity and motivation towards knowledge of the ecological characteristics of their place of life.

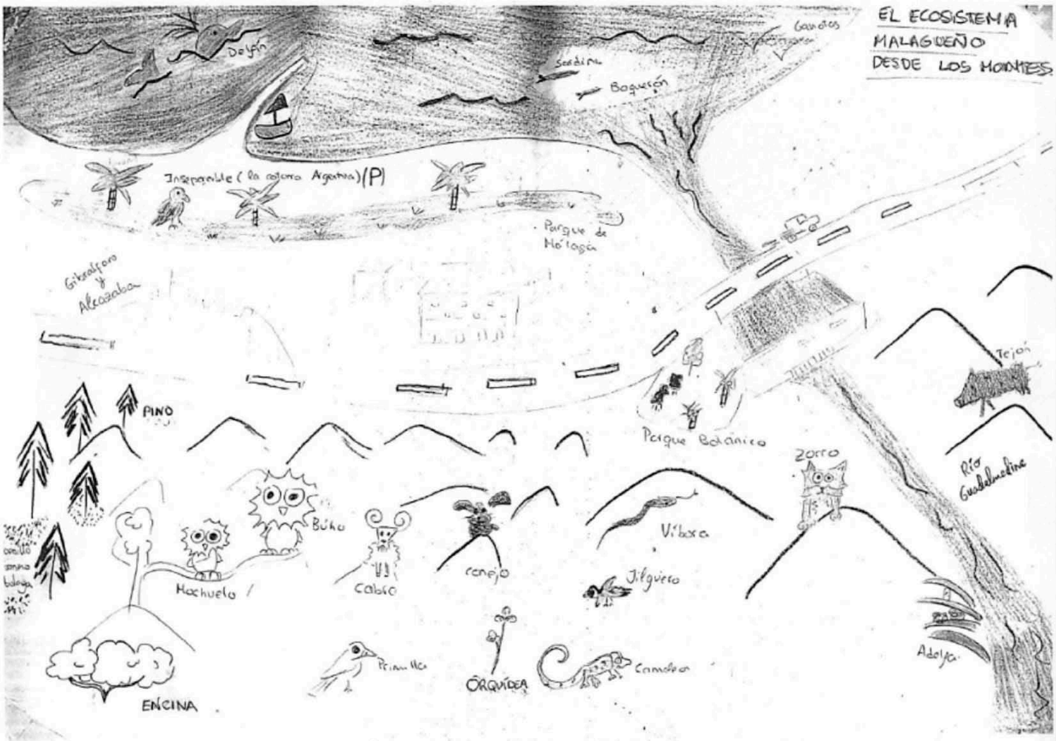

Figure 7. Initial poster from group 7 (Castillo de Gibralfaro: Castle of Gibralfaro; Alcazaba: Alcazaba Castle; parque de Málaga: park of Malaga; Río Guadalmedina: Guadalmedina River; Parque Botánico: Botanic Park; pino: pine tree; encina: holm oak; tomillo: thyme; romero: rosemary; aulaga: gorse; orquidea: orchid; adelfa: oleander. delfín: dolphin; sardine: sardine; boquerón: anchovy; gaviota: seagull; mochuelo: owl; buho: owl; cabra: goat; conejo: rabbit; jilguero: goldfinch; víbora: viper; zorro: fox; tejón: badger).

In addition, the participants made particular progress in their knowledge of the role of humans in the ecosystem, thus illustrating an improved ability to think in systemic terms and, therefore, to understand the interrelated nature of the aspects involved.

Given the above, we believe that students' ability to think in terms of systems should be enhanced through the use of guided inquiry processes that focus on the different interrelated aspects of interest and which set out the steps to be followed in each case: 1) expression of initial ideas and identification of points of agreement, discrepancies and queries in the form of hypotheses; 2) design of strategies for resolving discrepancies and queries and for comparing points of agreement; and 3) sharing acquired information in order to draw conclusions (Cañal, Pozuelos, and Travé 2005). We propose, therefore, that this framework be used to identify the components of the ecosystem, their location, the relationships they have with one another and the role of humans within such a system. In our view, a guided inquiry process that focuses on each of these aspects can foster a capacity for thinking that moves from the individual to the systemic level, thus favouring a shift from an anthropocentric to a biocentric viewpoint, one that considers humans as one species among many within the ecosystem (Gonzalez-García, Carrillo, and García-Alix 2015). This perspective may also help to highlight the educational value of using local natural environments as a learning resource, as well as encouraging an approach to teaching that overcomes the obstacles associated with the application of theoretical models (Hernández, Couso, and Pintó 2015), in this case regarding ecosystems, to real contexts.

Finally, in this study has been analysed the students' ideas through their drawings made by small groups. This form of collecting data represents an approximation to the students' mental models (Greca and Moreira 2002) showed though of application of a qualitative methodology on the content (Schreier 2012). However, it could be interesting in future research use another

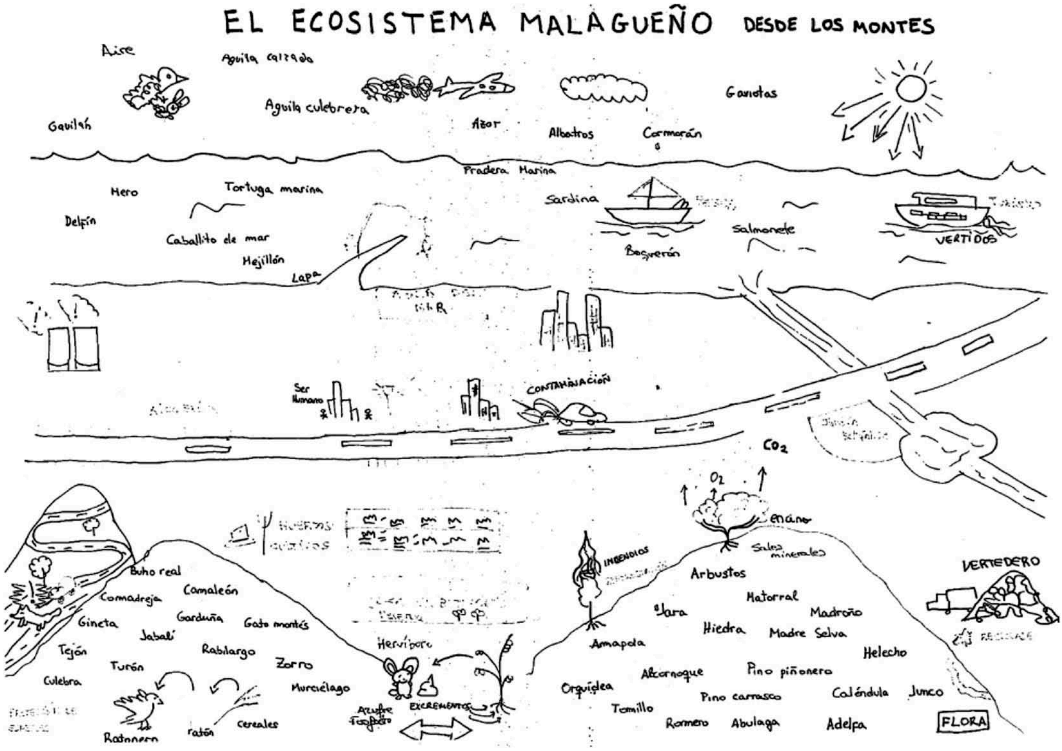

Figure 8. Final poster from group 7 (Aire: air; pradera marina: marine prairie; vertidos: waste; turismo: tourism; Alcazaba: Alcazaba castle; aula del mar: classroom of the sea; ser humano; human; contaminación: contamination; huertos: orchards; cultivos: crops; vertedero: dump; reciclaje: recycling; azufre: sulphur; fosfato: phosphate; herbívoro: herbivorous; incendios: fires; reforestación: reforestation; pesca: fishing; matorral: scrub; tomillo: hyme; romero: rosemary; arbustos: shrubbery; amapola: poppy; jara: rockrose; orquídea: orchid; hiedra: ivy; madroño: arbutus; madreselva: honeysuckle; helecho: fern; calendula: calendula; junco: rush; adelfa: oleander; gavilán: hawk; águila: eagle; azor: goshawk; albatross: albatross; cormoran: cormorant; gaviotas: gulls; mero: mere; delfín: dolphin; tortuga: tortoise; caballito de mar: seahorse; mejillón: limpet; lapa: mussel; sardina: sardine; boquerón: anchovy; salmonete: red mullet; buho real: royal owl).

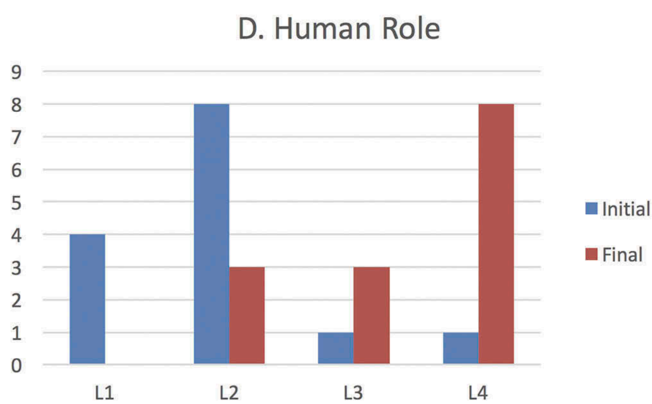

Figure 9. Frequencies for the levels of conceptual development observed in the initial and final posters in relation to dimension D, Human role.

complemented methods as a questionnaire that will show individual ideas of students of this issue. In addition, more time in the inquiry process of students could be necessary to get better results in the progression of ecosystem knowledge as such as understanding and applying of basic theoretical model of ecosystem within sub-ecosystem, given that learning progression of scientific knowledge is a slowly and complex process (Alonzo and Steedle 2008).

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