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Research Article

Examining the Effects of Using a Porphyrios-Tree Aided Constructive Teaching Approach with Pre-Service Social Studies Teachers to Develop Understanding About Ecological Interspecies Relationships *

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Abstract

This study aims to find out the effects on pre-service teachers of a constructivist teaching approach aided by use of a Porphyrios-tree. Use of a Porphyrios-tree is thought to be the basis of and most principled conceptual teaching tool to aid meaningful comprehension about concepts of interspecies relationships. The study has a quasi-experimental design and uses a single-group pre-test and post-test model. The study group consists of 3rd Grade Social Studies pre-service teachers who are studying in the Faculty of Education at a university in Turkey. The study has a two-tier application, the first of which is dedicated to conducting interviews with each participant for nearly 20 minutes in a suitable environment. Stage two is designed to conclude whether or not the responses from the individual or group interviews about the Porphyrios-tree drawings do help to resolve any misconceptions. A structured grid was used for data collection in these interviews. Data analysis was performed by analyzing the quantitative values obtained from the structured grid with SPSS 22.0. It was found out that pre-service teachers developed the most alternative conceptions in their learning about mutualism and commensalism. Also, after the application of Porphyrios-tree, the students' alternative conceptions about of "positive interaction (mutualism, commensalism)" was eliminated. More strikingly, the pre-service teachers' post-test scores are higher in all statements of the grid. Consequently, it is recommended to carry out further research with different variables to enlighten about whether the Porphyrios-tree is an effective teaching tool in other subjects.

Keywords

Interspecies Relations, Porphyrios Tree, Pre-service Teachers, Social Studies

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Human beings, living in the environment where they cause the unbalanced use of natural resources (Erten, 2005) and indirectly head for a fall, are, like other species, adversely affected by such problems. What is worse, such problems related to the unbalanced use of natural resources affect not only one specific country and people living there, but everyone who lives in any part of the world, regardless of language, religion, or race (Kıyıcı Balkan et al., 2005). At this point, it can be considered how important environmental education is for people.

On the one hand, environmental education transmits ecological knowledge; on the other hand, it enables the development of positive attitudes towards the environment together with gradual behavioral changes by individuals (Unterbruner, 1991; as cited by Erten, 2005). Environmental education emerges as the most effective way to bring up environmentally conscious and sensitive individuals; and preserve the existing species by solving environmental issues and being aware about the relationships between species (Wardle, 2016). In addition to environmentally friendly behaviors, environmentally conscious students are not indifferent to environmental degradation, neither are they egoist, or transform their personal gains into ambition (Erten, 2007) although they may hold some misconceptions about ecological information. Moreover, since those misconceptions are within integrity and reinforced by some everyday experiences, they tend to be resistant to modification and improvement (Wandersee, Mintzes & Novak, 1994). This situation may also negatively affect the student's learning about other concepts and contributed to a misunderstanding of the subject in focus (Palmer, 2001).

Nevertheless, it is known that pre-service teachers who are enrolled in Faculties of Education have misconceptions in their own fields of study (Ayas & Özmen, 2002; Akgün & Gönen, 2004; Aydoğan, Güneş & Gülçiçek, 2003). In this regard, we sometimes witness that educational systems fail to educate individuals to become fully equipped with professional knowledge. As a way of solving this problem and to make the teaching-learning processes more efficient, concrete tools and devices or visual materials can be integrated into ecological education. Although technology is not an omnipotent solution to overcome all educational problems, it must be remembered to educate highly-qualified teachers there is a benefit from using technology in educational systems (Gündüz & Odabaşı, 2004; Kirschhner & Selinger, 2003).

It must be recalled that student-centered learning is built on the theory that knowledge cannot be acquired directly by individuals; rather, students will need to discover and configure knowledge by means of their own activities. Therefore, it is seen that the best learning takes place through an individual’s relations with the concrete objects and friends around them (Charles, 2000). In constructivist learning, the individual processes the data obtained from all sources around them and transforms this information into unique knowledge. In this process, the individual is likely to acquire inaccurate accounts via unacceptable means, as well as reliable data from valid and reliable sources. Consequently, this may lead to alternative learning or misconceptions occurring in minds of individuals. Constructivist learning theory introduces many new approaches for externalizing and modifying misconceptions as a part of education (Akdeniz & Keser, 2002). According to a

constructivist approach towards teaching and learning, the teacher functions as a pole star showing the student the directions, rather than explicitly telling them where to go (Brooks & Brooks, 1999). Bearing this in mind, the main goal of this study can be said to be two-fold. First, the study aims to determine the misconceptions held by pre-service Social Studies teachers as a result of environmental education about interspecies relationships and by using the structured grid technique. Second, the study aims to find out effectiveness of constructivist teaching based on using a Porphyrios-tree to eliminate misconceptions. As a result of the study, it is expected to unearth pre-service teachers' current ecological misconceptions thanks to the structured grids. In addition, it is hoped that the use of extraordinary conceptual teaching devices such as the Porphyrios-tree would contribute to the correction of such erroneous ideas.

In this study, a Porphyrios-tree was used during the application process as a teaching tool. In fact, departing from Porphyrios tree, it might be wrong to say that we actually have clear data about the history of two-dimensional teaching graphical tools. Although concept network, mind map, and conceptual map stand out as popular devices of today introduced as an outgrowth of individual or collective studies by Tony Buzan and Joseph Novak since the 1970s, it would be unfair to the educational process to disregard the earlier periods. The Porphyrios-tree can be likened to many teaching tools used in the learning environment; especially two-dimensional diagrams. The main difference between these tools is that individuals learn to think about a concept at the same time in two dimensions. In other words, a Porphyrios-tree supports the connection of a concept with another concept by taking into consideration its features and examples. The first application with a Porphyrios-tree was performed by Haller (2002; cited from Yangın, 2013) in experimental (applied) and comparative form in Germany. Its Turkish equivalence was carried out by Yangın (2013, 2014) in two different studies with pre-service teachers. The fact that there is no study other than the aforementioned about the instructional effectiveness of a Porphyrios-tree seems to boost the importance of the present research. Although a Porphyrios-tree is used to determine pre-learning and eliminate the occurrence of misconceptions, if there are any, along with other frequently-used instructional materials (such as concept maps, conceptual changing texts, conceptual cartoons, etc.), a Porphyrios-tree has not been commonly employed in the learning environment so far. Therefore, as an applied study, this research is expected to help resolve the issues in this field. To this end, it was aimed to find out whether a Porphyrios-tree has any effects on the understanding of interspecies relations as a part of the Environmental Issues Geography lesson by 3rd Grade pre-service teachers who are majoring in the teaching of Social Studies. Furthermore, the related literature provides example studies using structured grids for determining misconceptions as seen during the data collection process (Bahar et al., 2009), therefore, the decision to carry out this research with the same method for detecting misconceptions occurred. In the literature, the most prominent advantages of this technique are listed as: the measurement of meaningful learning; and being an effective tool for revealing students' wrong cognitive formations, shortcomings and lack of knowledge within their knowledge network. For this purpose, data were collected by evaluating the learnings about "parasitism, competition, proto-cooperation (amensalism, predation), neutralism,

commensalism, mutualism, cannibalism, clustering, social life, sexual relations, colony forming, and groups" through a structured grid developed throughout the process. The structured grid was applied as both a pre-test and post-test, resulting in numerical data being analyzed to identify the values at which misconceptions change. On this ground, the research problem was put forward as follows: What misconceptions do pre-service Social Studies teachers hold about ecological interspecies relationships? Do Porphyrios-tree aided constructive practices help to eliminate the misconceptions held by pre-service Social Studies teachers' about the ecological interspecies relationships? In search of an answer for the research problem, the following sub-questions are suggested.

1. Do pre-service teachers hold any misconceptions about interspecies relationships according to the structured grids?

2. As a result of teaching about interspecies relationships by following the constructivist learning concept supported by use of a Porphyrios-tree:

2a. What are the pre-test scores of the misconceptions held by pre-service teachers about interspecies relationships?

2b. What are the post-test scores of misconceptions held by pre-service teachers about interspecies relationships and do the scores indicate an elimination of their misconceptions?

2c. Is there any significant difference between pre-test and post-test scores obtained from the pre-service teachers about their misconceptions based on the use of a Porphyrios-tree?

Taking into consideration the aforementioned, we expect the present study to prove useful in several aspects. First of all, environmental education in Faculties of Education might help to develop a more efficient and functional overall educational process. Secondly, pre-service teachers' perspectives about environmental education will turn positive thus making them more willing to learn about environmental phenomena. Furthermore, the education process and tools will be effective in eliminating the misconceptions held by pre-service teachers. Apart from these, the constructivist learning approach will confer several roles onto learners which will eventually improve their environmental consciousness and make them more sensitive to environmental problems. Also, an effective communication setting will be reached whereby certain criticisms regarding inhibited socio-psychological development of learners will be most likely to be overcome. It is also hoped that this research will shed light about how to increase the quality of environmental education in the classroom, since the use of a Porphyrios-tree is an uncommon instructional material which could diversify the understanding of teachers in the teaching of concepts.

Conceptual Framework

Nowadays it is important for research to be conducted in environmental education about the formation of conceptual hierarchies held by students about ecological subjects because recent studies show that in most areas of ecology, students face difficulties in perceiving concepts cognitively. Cognitive insights that are constructed incorrectly are considered to be an important factor that prevents

cognitive understanding since it prevents both the restructuring of newly learned information and also disrupts the integral meaning between the concepts (Bahar, 2003a). In this study, a Porphyrios-tree, was used as a constructivist learning device. A Porphyrios-tree, in fact, forms the basis of conceptual teaching tools and it dates back to the pre-Aristotle times. This visual material is largely similar to concept-map and cladograms. Concept-maps and cladograms are a two-dimensional graphical teaching tools that show the hierarchical relationship between super-ordinates and sub-ordinates in the form of propositions. In this material, students have to elicit the relationship between two specific concepts by means of a suitable action. As a matter of fact, the Porphyrios-tree requires learners to link the concepts within the framework of intrinsic attributes and scope the relationship substantively in an ascending or descending order, rather than simply associating one concept with another. In this respect, a Porphyrios-tree might prevent students from creating false systematic schemas by ordering a number of common and non-common attributes related to a conception. As a result, they may be ready to construct scientifically correct conceptual hierarchies.

Due to several reasons, students can forever sustain some misconceptions formed during their education life. One of these are alternative conceptions developed in the field of environmental education. In other words, students' erroneous ideas in the field of environmental education are also negatively reflected in the rest of their lives. It has recently gained considerable importance and become popular to investigate the scientific accuracy of students' conceptual hierarchies about ecology in today's environmental education programs. As a departing point, studies in recent years show that students suffer difficulty in understanding concepts across most areas of ecology. Knowledge developed by students which is contrary to scientific realities is called naive theories, preconceptions, misconceptions, or alternative conceptions; each constitutes an important obstacle in the learning process. According to the results of the studies done so far, students usually develop such complex and incorrect knowledge in their first years of school through their own interpretations or some inconsistent explanations made inside or outside of school (Bell, 1981; Bell & Barker, 1982; Driver, 1981; Gilbert, Osborne & Fensham, 1982). Misconceptions are often difficult to disclose because they are formed in learners' minds and are difficulty to directly observe. In the international literature, many methods and tools are being developed and implemented in order to reveal the mental structure of individuals in the best possible way, so as to determine the level of understanding and misconceptions (Köse, Coştu & Keser, 2003). Examples of such methods and tools can be listed as concept-maps, prediction-observation-description, drawings, word association, two-stage diagnostic test, Vee diagrams, interview, work sheets, and structured grid. A Porphyrios- tree is a teaching tool with different aims and structures to others known. Porphyri was the first person to reveal the Porphyrios tree.

Porphyri is a philosopher who lived between 232 and 304 AD. Believing that it is a pre-requisite for students to understand the five universal concepts for teaching Aristotle's "Categories" approach, Porphyri penned the work named Isagoge, which means "introduction" (Adsoy, 2012). The five universal concepts are examined in Isagoge: "genus, species, distinction, specific and relevance". The tree of Porphyrios

is a tree-shaped diagram where concepts are ranked by certain features and scope. According to Aristotle, in order to know an object, one must recognize the general concept to which the object is connected. For example, if one does not know about the concept of fruit, they cannot distinguish cherries as a kind of fruit. In addition, Avicenna stated his interest in this teaching tool and subject for his research. Avicenna suggests that some of the five universal concepts are recognized in a natural sense, some in a logical sense, and some others are recognized in a rational sense. He adds that at some moments, part of such understanding occurs before, during, and after plurality, respectively. Arguing that natural, logical, and rational consideration about the five universal concepts is associated with evaluation of species and kinds, the thinker told colleagues that he had adopted Porphyrios on this subject. Avicenna intends to explain the natural, logical, and rational scope of the five universal concepts in reference to examples of living creatures. In this regard, he discusses the living things in relation to species alone, not exemplifying the natural, logical, or rational scope of the other universal concepts (Adsoy, 2012). For example, take a person who tries to distinguish a bacterium from euglena in a Biology class; when they are asked to make comparisons at the species level, they tend to memorize the features and examples of each concept/set, and they often suggest information which is meaningless to them at that time.

In this context, it can be said that many students mistake concepts and connected features. Consequently, they configure incorrect cognitive structures. Yangın (2013) found out that university students make alternative conceptions while categorizing living things. They classify pine, fir, and spruce as seedless plants, while referring to seedless plants, such as ground pine and liverwort, as flowering plants. Despite the probability of an exhaustive list of reasons for the misclassifications occurring, the chief reason might be that students are not able to think substantively. Therefore, they cannot manage to meaningfully imagine a super-ordinate or characteristics of the super-ordinate.

Methods

This study has a quasi-experimental design using a single group pre-test and post-test model. The experimental model was preferred because it allows data generation to be observed under the direct supervision of the researcher (Creswell, 2009) with the aim of measuring the study variables (quantifiable qualities that can take different values) and highlighting the cause-effect relationships between these variables (Çepni, 2007). This model is important in environmental education and supports the teaching programs (Novak, 2003).

The current study uses a structured grid consisting of 16 boxes. The data were collected through experimental applications carried out during the research procedure. The study group consisted of 3rd Grade pre-service teachers who were studying in the Social Studies Teaching Program in the Faculty of Education at a university in Turkey during the Spring semester of 2016-2017 academic year. Experimental and control groups were not appointed because the aim is to conduct the study with a single group so that a holistic evaluation can made and only the alternative conceptions held by the application group were dealt with. Collected data were converted into digital form. Prior to the main implementation of the

research, a preliminary study was carried out with a group who had similar characteristics to the study group. To check the validity of the applications and materials used in the study, there were 3 experts who were interviewed. The experts came from the fields of measurement and evaluation, Social Studies teaching, Biology education. The practical steps of the study were carried out in two stages.

In the first step, as required by the study purpose, an interview was held with each student in a quiet place for approximately 20 minutes. Questions and answers during the interviews were recorded immediately by using a voice recorder. The interviews were carried out in 2 stages.

Stage 1: During this stage, 15 specific materials about interspecies and intraspecies relationships were selected which included photographs and short films. The selected materials target concepts such as parasitism, competition, proto-co-operation (amensalism, predation), neutralism, commensalism, mutualism, cannibalism, clustering, social life, sexual relations, colony forming, and groups. The photographs and films were shuffled on a desk during the interview and the students were asked to classify them first in a logical sequence according to positive and positive relations and then according to sub-concepts. Following that, the students were asked "Why is this concept covered as a positive relationship? "What other reasons are there?", and "Why didn't you cover these concepts under any of the groups?"

Stage 2: Here, the images and short films used during the previous stage about intraspecies and interspecies relationships were reshuffled and the students were asked to distinguish "positive" and "negative" relations. Later, two questions were addressed: "Why do you think these things show a positive relationship?" and "Why do you think these things show a negative relationship?" In addition to this, a Porphyrios-tree was introduced. The application lasted approximately 3 hours. During the application, the students were asked to present the Porphyrios-trees which were arranged individually and in groups for each of the intraspecies and interspecies relationships. In this scope, students were requested to re-answer the structured grid. It was followed by categorizing the answers given to the questions.

Participants

There are 24 pre-service teachers' who participated in the study. The participants were completing the 3rd Grade of Social Studies Teaching in the Faculty of Education at a university in Turkey. The research occurred during the spring semester of the academic year 2016-2017. All the participants went through a constructivist learning application based on the Porphyrios-tree. There are 42 students in the third year of Social Studies Teaching. In fact, all pre-service teachers were asked to be included in this study. However, 24 pre-service teachers continued to work voluntarily due to the fact that some of the pre-service teachers had a different study plans and did not want to participate in this study. In this respect, it can be stated that the student group included in the study is compatible with "appropriate sampling (easy access case sampling)", which is a non-random sampling method. In such a sampling method, the researcher selects a situation that is close and easy to access. Appropriate sampling or easily available case-sampling often involves researchers' time, money and labor, etc. It is used in cases where it is not possible to

use other sampling methods due to various limitations (Büyüköztürk et al., 2014; Yıldırım & Şimşek, 2006). In this aspect, it can be stated that the chosen sampling method provides speed and practicality to the research.

Data Collection

Structured Grid Test. In the study, it was first attempted to identify whether the students hold misconceptions about parasitism, competition, proto-cooperation (amensalism, predation), neutralism, commensalism, mutualism, cannibalism, clustering, social life, sexual relations, colony forming, and groups. Structured grids were used in individual and group interviews. In other words, structured grids were used to determine the misconceptions of pre-service teachers instead of using traditional interview questions.

Then, the study attempted to find out in which direction their current misconceptions tended to change as a result of using the Porphyrios-tree. For this purpose, a structured grid was used to determine the value of misconceptions during the pre-test and post-test. The structured grid technique was first used in the studies of Egan (1972; as cited by Bahar, 2003b) and later developed by other researchers (Johstone, Bahar & Hansell, 2000). The structured grid is a test used to test students' understanding of given subjects (Bahar, 2001; Hassan, Hill & Reid, 2004) and runs the memory capacity (Chen & Whitehead, 2009), regarded as an alternative to multiple-choice tests (Durmuş & Karakırık, 2006). This technique offers an interactive environment which can be devised by students together with their teachers and reveals the cognitive structure. Hence, the technique is referred to as structured grid or structural communication grid (Johnstone, Bahar & Hansell, 2000). Structured grids allow revealing the impact of students' cognitive styles (Bahar & Hansell, 2000), showing the level of knowledge, conceptual ties, or misconceptions and lack of knowledge on a particular matter (Bahar, 2001), and making logical decisions by students (Durmuş & Karakırık, 2006). This technique can also be used to determine the systematic misconceptions of a group of students (Reid, 2003; as cited by Chen & Whitehead, 2009). It is added that structured grid is a strong and flexible response evaluation technique (Johnstone & Ambusaidi, 2001).

Misconception Test (MT). In order to determine pre-service teachers' misconceptions about interspecies relationship in ecology, a "test of misconceptions" was developed. Test questions were prepared by using structured grids, which is an effective method for determining misconceptions, after reviewing studies about misconceptions related to interspecies relationships. The draft questions were then sent to 3 experts for their professional opinions. Following the corrections made in line with received opinions and suggestions, the test was thought to have a content validity. Lastly, the test was replicated and administered to the participants.

The form related to ecological interspecies relationships was prepared by preparing a structured grid. The structured grid here contains 16 boxes 10 questions in total. The grid was designed to for a maximum score of 100.

Structure of the Grid Used for the Misconception Test (MT). In the whole of the structured grid technique, which is a test consisting of rows and columns (Durmuş & Karakırık, 2006), the first important point is constituted by the structure

of the grid. The structured grid consists of boxes formed by the combination of rows and columns as shown in Figure 1. The structured grid consists of 12 boxes for primary school students, 16 for secondary schoolers, and 20 boxes for high school and tertiary education students (Johnstone, Bahar & Hansell, 2000). In this study, 16 boxes were prepared in relation to the concepts existing related to ecological interspecies relationships.

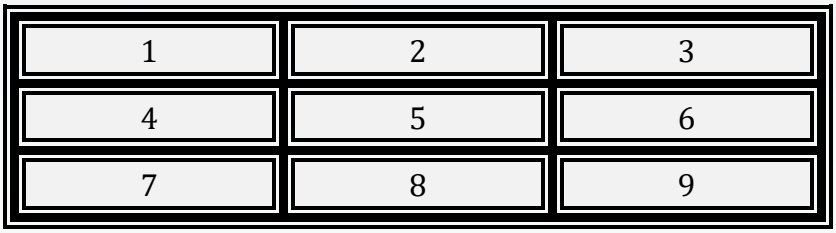

Figure 1. Overall structure of the structured grid technique

The Use of Structured Grid Technique. In this technique, the teacher prepares a question and places the possible answers in the box. Boxes with the correct answers are randomly distributed. Likewise, the next question and possible answers are randomly distributed into the boxes in the same grid. This is continued until the boxes are filled (Johnstone, Bahar & Hansell, 2000). Each box contains different types of answers or alternatives, such as texts, graphics, tables, or images. This helps teachers to make rich and objective assessment decisions (Durmuş & Karakırık, 2006). The students are asked to mark the boxes they think are most appropriate for the question addressed. In some cases, they are asked to place them in order of priority. This is the most important aspect of the structured grid because students have to choose the correct answers and then put them in order depending on the question. This feature of the technique differs from multiple choice tests as students cannot find the right answers by chance (Durmuş & Karakırık, 2006). There is no obvious correct answer because one or more boxes are selected to answer each question, and thus the chance of correct prediction decreases considerably (Johnstone & Ambusaidi, 2001). On top of that, the student knows how many options to choose in a multiple-choice test; whereas it is not the case in the structured grid technique. This can be mentioned as one of the strengths of the structured grid technique (Aydın, 2005).

Preparation of the Structured Grid and Scoring. In the structured grid, the following formula is applied in the scoring system and used during search for the appropriate boxes for each question:

C1 = Number of correctly selected boxes by the student

C2 = Total number of correct boxes

C3 = Number of incorrectly selected boxes by the student

C4 = Total number of incorrect boxes

(C1/C2) - (C3/C4)

In this formula, the scores range between +1, 0, and -1. In order to evaluate this score out of 10, it is first summed up with +1 to eliminate the negativity, and the score obtained is multiplied by 5 (Reid, 2003; as cited by Chen & Whitehead, 2009).

Structured grids can be considered as an objective technique by assessors as it allows obtaining the same result from the test regardless of the assessor (Çakmaklı, 2008).

Data Analysis

The measurement instruments were applied to the pre-service teachers as a pre-test. Their results were entered in SPSS 22.0 to find out whether they held incorrect learning about the related concepts. At that point, Porphyrios-trees were used with the aim of developing accurate and systematic understanding of particularly insufficient or erroneous learning since these trees are expected to establish logical contexts between concepts and sub-concepts. For this reason, data analysis was performed with a quantitative method. Quantitative data obtained from the structured grid were used to measure the change taking place between pre-test and post-test. Pre-posttest dependent t-test was performed for interpretation of the measured change. Besides these statistics, frequency and percentage calculations were used to test the changes in the pre-service teachers' misconceptions after the constructivist teaching occurred based on the Porphyrios-tree.

Results

In this section, pre-test and post-test scores obtained from the structured grid are applied before and after the constructive teaching. Results are given in Table 1 and Table 2, respectively.

Table 1
Descriptive Statistical Values Calculated by The Structured Grid for The Pre-Service Teachers' Learning About Interspecies Relationships Before the Application of a Porphyrios-Tree

	Statement	**1**		**2**		**3**		**4**		**5**		**6**		**7**		**8**		**9**		**10**	
	Option	**C**	**I**	**C**	**I**	**C**	**I**	**C**	**I**	**C**	**I**	**C**	**I**	**C**	**I**	**C**	**I**	**C**	**I**	**C**	**I**
Pre-Test	# of correct / incorrect boxes selected by student	2	57	12	23	16	21	9	23	11	32	2	40	12	31	21	14	8	20	10	24
	Total # of correct / incorrect boxes	2	14	5	11	3	13	2	14	2	14	2	14	8	8	6	10	2	14	1	15
	Total # of correct / incorrect boxes selected by student	48	336	120	264	72	312	48	336	48	336	48	336	192	192	144	240	48	336	24	360
	Average Score	4.360		5.0643		5.774		5.595		5.669		4.613		4.505		5.437		5.535		6.750	

When Table 1 is examined, it can be seen that the pre-service teachers hold the most erroneous ideas in relation with Item 1 in the structured grid, which is focused on "positive interactions [mutualism, commensalism]". Mutualism means compulsory common life in which both of the animals gain benefits; when they split up, both are damaged. On the other hand, commensalism provides unilateral benefit and means that the other party gets neither benefit nor harm from this relationship. It was found out that these two concepts had been learnt with significant errors by pre-service teachers during their previous educational experiences. However, the

last item represents the statement which yielded the highest score in the grid. This expression relates to the notion of "being in a relationship (male-female relations) in order to maintain the continuity of the generation and to preserve their offspring". As a response to this statement, the pre-service teachers could choose more accurate boxes on the structured grid compared to the other concepts. Hence, it can be suggested that the pre-service teachers do not suffer from any alternative concepts about the concept of male-female relationship.

Table 2
Descriptive Statistical Values Calculated by The Structured Grid for The Pre-Service Teachers' Learning About Interspecies Relationships After the Application of A Porphyrios-Tree

	Statement	**1**		**2**		**3**		**4**		**5**		**6**		**7**		**8**		**9**		**10**	
	Option	**C**	**I**	**C**	**I**	**C**	**I**	**C**	**I**	**C**	**I**	**C**	**I**	**C**	**I**	**C**	**I**	**C**	**I**	**C**	**I**
Post-Test	# of correct / incorrect boxes selected by student	26	25	56	11	38	10	25	12	21	19	22	18	78	15	56	9	22	4	16	14
	Total # of correct / incorrect boxes	2	14	5	11	3	13	2	14	2	14	2	14	8	8	6	10	2	14	1	15
	Total # of correct / incorrect boxes selected by student	38	266	95	209	57	247	38	266	38	266	38	266	152	152	114	190	38	266	19	285
	Average Score	7.951		7.684		8.130		8.063		7.406		7.556		7.072		7.219		7.819		8.964	

Post-test results in Table 2 show that the highest average score, as in the pre-test, was noted in response to the last test item; i.e. the notion of "being in a relationship (male-female relations) in order to maintain the continuity of the generation and to preserve their offspring". In other words, it can be argued that the pre-service teachers could reach a more accurate conception about male-female relationships in the post-test compared to the pre-test. Conversely, the lowest average score in the post-test was obtained from Statement 7. It implies that the pre-service teachers could record lower scores with "interspecies relations [neutralism, competition, mutualism, cooperation, commensalism, amensalism, predation, parasitism]" compared to the other concepts in the last test. However, since all scores range between 7.07-8.96, it is not considered to be a significant difference. It should be noted that in the post-test there was a positive change in the pre-service teachers' scores under all of the statements and concepts compared to the pre-test. As a consequence, it can be suggested that the pre-service teachers could substantially benefit from using the Porphyrios-tree to develop understand about the topic of intraspecies and interspecies relationships covered under population ecology, as well as in eliminating their misconceptions.

Table 3
Frequency and Percentage Values of Pre-Service Social Science Teachers' Responses to Population Ecology Before Application of The Porphyrios-Tree

Pre-Test and Post-Test Results from Structured Grid			
Concepts	Pre-Test $\overline{X}$	Post-Test $\overline{X}$	$\overline{X}$ Difference
1. Positive Interaction (mutualism, commensalism)	4.360	7.951	3.591
2. Negative Interaction (competition, amensalism, predation, parasitism, predator)	5.064	7.684	2.620
3. Grouping (colonies, groups, clustering)	5.774	8.131	2.357
4. Over-grouping (clustering, social life)	5.595	8.064	2.469
5. Division of Labor (colonies, social life)	5.670	7.406	1.736
6. Mutual benefit and no damage to both living species in case of splitting up (proto-cooperation)	4.613	7.556	2.943
7. Interspecies relationships (neutralism, competition, mutualism, cooperation, commensalism, amensalism, predation, parasitism)	4.505	7.072	2.567
8. Intraspecies relationships (competition, colonies, groups, clustering, social life, male-female relations)	5.438	7.219	1.781
9. No relationship between two species (neutralism, allelopathy)	5.536	7.820	2.284
10. Engaged in a relationship to maintain the continuation of the generation and to preserve their offspring (male-female relations)	6.750	8.965	2.215

Table 3 shows the pre-service Social Studies teachers' scores from 10 statements in pre-test and post-test, along with the difference between the first and last test. The differences between pre-test and post-test imply that using the tree of Porphyrios proved the most effective as it seemed to overcome the learners' erroneous or insufficient learning in relation with Statement 1 which refers to "positive interaction [mutualism, commensalism]". On the whole, when comparing the first and last test based on the average score, it can be seen that the score difference out of 10 points ranges from 1.736 to 3.591 in favor of the last test. In other words, the pre-service teachers achieved higher scores under all statements in the post-test corresponding to a higher number of correct answers. On the contrary, the lowest difference was noted under the ideas of division of labor (colonies, social life) (difference=1.736) and "intraspecies relationships [competition, colonies, groups, clustering, social life, male-female relations] (difference=1.781)". In this regard, it can be said that pre-service teachers are able to better analyze and internalize learning, and make more meaningful understanding about the concepts related to positive and negative interactions between living beings.

Table 4
Dependent T-Test Results of Pre-Test and Post-Test Scores by Pre-Service Social Studies Teachers

Test	N	$\overline{X}$	Ss	t	p
Pre-test	24	5.331	.7196	-14.352	.000**
Post-test	22	7.787	.5430		

Note: **at significance level of p<.01

Table 4 shows the pre-test and post-test mean scores from pre-service Social Science teachers about the answers given to all statements. Taking all of the 10 statements into consideration, the mean pre-test score was found to be 5.331 and the mean post-test score was 7.787. The dependent t-test indicates the differences between average scores from the two tests revealed significant differences in favor of the post-test ($t=-14.532$; $p<.01$). It can be inferred from the obtained values that the pre-service teachers' learning about various concepts including intraspecies and interspecies relationships under population ecology has progressed significantly, and their misconceptions have regressed considerably. In other words, use of a Porphyrios-tree proved to be beneficial for configuring concepts in a scientifically correct and sufficient way, such as "parasitism, competition, proto-cooperation (amensalism, predation), neutralism, commensalism, mutualism, cannibalism, clustering, social life, sexual relations, colony forming, and groups".

Discussion

This study was carried out with 24, 3rd Grade pre-service teachers. The pre-service teachers were majoring in Social Studies Education and enrolled in an Environmental Problems Geography course. The aim of the research was to determine and eliminate alternative conceptions related to the phenomena of intraspecies and interspecies relationships associated with population ecology. At the end of the first phase of the study, the use of a structured grid demonstrated that pre-service Social Studies teachers hold unempirical accounts about intraspecies and interspecies relationships. The misleading ideas are often developed during early years of schooling and persist into the following years, as seen in this example. However, it is hardly possible to set forth one exact cause for erroneous ideas because there are many living and non-living items that directly or indirectly affect learning within the education system. It can be asserted that the combination of these elements affects learning in a positive or negative way. An increasing number of studies have been carried out on alternative learning.

The findings obtained in the first phase of this study seem to be in conformity with and further support results from other studies in this field (Kumandaş, 2015; Önal, 2018; Sultan Kılıç & Dervişoğlu, 2013; Turan & Yangın, 2014; Ürey, Şahin & Şahin, 2011; Yüce & Önel, 2015; Yürüdür, Aksoy & Sönmez, 2013). The experimental phase, Stage two, was built around using the Porphyrios-tree technique. This technique bears a structure and procedure quite similar to concept-maps. At the moment, there are only inadequate theoretical explanations about this technique which allows students to produce concurrent thoughts at both a general and a specific level. The current study mainly aims to determine whether alternative conceptions, identified during the first stage, could be eliminated as a result of the studies carried out with the learners. After lessons given in one study group, positive changes were often recorded. Besides this, participants who could achieve accurate systematic placing provided logical reasoning based on use of the Porphyrios-tree. Although the pre-service teachers had misconceptions to a considerable extent, particularly about interspecies relationships at the earlier stage, they were observed to configure systematic structures through which they could propose predominantly correct scientific explanations at the end of the next stage. The

results are favorable for the Porphyrios-tree. The Porphyrios-tree has different properties than the teaching tools currently in practice. The most important of these features is that use of a Porphyrios-tree encourages students to think critically and reflectively. A Porphyrios-tree can be likened to a dichotomous concept classification key. With this feature, one concept can easily be associated with another and yield more accurate scientific generalizations. Yangın (2014) showed that use of a Porphyrios-tree positively affected the pre-service teachers' critical, creative, reflective and logical thinking processes. Based on this result, the pre-service teachers were expected to make sense of the concepts about inter-species relationships. As a result of these two-dimensional visual aids, pre-service teachers tied the concepts to which they were wrong in a highly accurate way with other related concepts.

Conclusion

The study findings show that pre-service teachers had the most errors as a response to Statement 1 during the pre-test. To put it more specifically, the students developed alternative learning about the concepts of mutualism and commensalism. On the other hand, the concept of male-female relations ended up with the highest score in the pre-test. In this statement, the students chose more accurate pieces on the structured grid compared to the other concepts. When the post-test results of the Porphyrios-tree are examined, the highest mean score is again found in male-female relationships. Still, considering the higher scores in favor of the post-test, it can be asserted that the students could attain more accurate learning in response to male-female relationships. However, the post-test yielded the lowest average score about interspecies relationships (neutralism, competition, mutualism, cooperation, commensalism, amensalism, predation, and parasitism). This result is not considered a significant difference since overall scores vary between 7.07 and 8.96. In the post-test, pre-service teachers were seen to record progress in all expressions and concepts compared to the pre-test. There was a more positive change. Therefore, it can be suggested that a Porphyrios-tree is quite an effective device to use in developing understanding about intraspecies and interspecies relationships and to cope with the misconceptions covered under population ecology.

Another result obtained in the study was that the difference between the post-test and pre-test are higher under Statement 1 than in the remaining statements. It can be suggested that the Porphyrios-tree proved more effective for developing students' conceptions about "positive interaction (mutualism, commensalism)" because it seems to have helped to resolve their misinformation or inadequate learning. In broad terms, in the grid, which is set at 10 as the maximum score, the difference of scores between the two tests range from 1.736 and 3.591 in favor of the last test. In other words, the pre-service teachers got higher scores for all items in the post-test. This is a positive result because the students could learn the topic and their misconceptions were largely eliminated.

The topics with the lowest difference were found as "division of labor (colonies, social life) (difference=1.736)" and "intraspecies relations (competition, colonies, groups, clustering, social life, male-female relations) (difference=1.781)". In light of the above, we can argue with comfort that pre-service teachers can solve the

positive and negative interactions between living beings more accurately, internalize learning, and make their learning more meaningful.

When evaluating the pre-test and post-test mean scores of the pre-service teachers about the answers given to all statements, the pre-test average score is seen to be 5.331 and the post-test average score as 7.787. According to results of the statistical tests, a significant difference was found between the pre-test and post-test mean scores in favor of the latter. The values demonstrate that the pre-service teachers' learning about various concepts, including interspecies and intraspecies relationship (which are taught in the scope of population ecology), progressed significantly and their misconceptions decreased considerably thanks to a constructive teaching process. In other words, use of a a Porphyrios-tree helped pre-service teachers to reconfigure, at a cognitively satisfactory and accurate level, an understanding about "parasitism, competition, proto-cooperation (amensalism, predation), neutralism, commensalism, mutualism, cannibalism, clustering, social life, sexual relations, colony forming, and groups".

Based on the results and conclusions of this research, which applied a Porphyrios-tree technique to eliminate false learning as an important obstacle in the learning process, we would like to suggest the following:

From the beginning of pre-school education, conceptual changes of students in different age groups and grades should be investigated and reasons for difficulties of understanding and misunderstanding faced by students should be explained. Another study can be conducted to find out whether visual tools used in identification or elimination of misconceptions would be as effective as a Porphyrios-tree. It should be investigated whether a Porphyrios-tree is effectively used in other subjects and at different levels, and the application procedures peculiar to this device should be determined.

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