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ARTICLE

Students' perceptions of the natural world and their attitudes toward ecological issues: What is the relationship between them?

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Abstract

This study examines the perceptions and attitudes of 234 Greek secondary school students regarding ecological issues arising from human intervention in food webs. The results of this study indicate that the following factors are crucial for students' attitudes toward environmental protection: scientific knowledge, perceptions of the relationship between humans and nature and personal motivations. It was found that those students who understand the interconnectedness of populations in food webs are able to evaluate arguments on an ecological issue and have positive attitudes toward environmental protection. However, students who have limited knowledge in evaluating arguments make decisions to solve environmental problems based on their perception of human-nature relationships. Thus, it has been shown that students who adopt an ecocentric or biocentric view sometimes adopt a negative or neutral attitude toward environmental protection because their incomplete knowledge leads them to misjudge the ecological impact of the proposed solutions. This study confirms that the development of values is best accompanied by the development of basic ecological knowledge. It also recognizes the usefulness of food webs as a means of revealing students' worldviews. Finally, the food web proves to be a specific indicator of the attitudes studied.

Keywords: Ecological knowledge; environmental education; beliefs about the natural world; attitudes; critical thinking

Introduction

One of the goals of education policy is to provide students with an understanding of ecosystem functions and pressures from human activities (Riess et al., 2022; UNESCO, 2019). However, it appears that students are unaware of the connections between human activities and the environment and often use nonscientific concepts to analyze environmental issues (Bayati, 2014; Gotwals & Songer, 2010). At the same time, students' limited environmental knowledge often leads them to rely on environmental myths, such as human independence from nature, and selected and filtered information when analyzing environmental issues. These beliefs may appear as opinions that students believe to be facts, and the likelihood of distinguishing myths or opinions from facts is very low without systematic guidance (Bayati, 2015; Gotwals & Songer, 2010; Kopnina & Cherniak, 2015).

However, in order to be environmentally aware, people must have a basic knowledge of environmental issues (Navarro-Perrez & Titball, 2012). Consequently, the question is whether scientific knowledge helps to raise citizens' awareness and develop their ability to make responsible decisions regarding environmental issues.

This study focuses on the above concerns and aims to shed light on students' attitudes toward important current ecological issues arising from anthropogenic interventions in food webs and related to biodiversity loss. In addition, this study examines whether secondary students' scientific knowledge of food webs not only helps them engage with environmental issues but also helps them identify possible pro-environmental attitudes toward these issues (Navarro-Perrez & Titball, 2012; UNESCO, 2019).

At the same time, a person's attitude toward different issues seems to be determined by their beliefs and values rather than objective knowledge (Nasibulina, 2015). Therefore, by analyzing students' arguments, this study examines the role of ethics in environmental decision-making. Specifically, this study examines how students perceive the relationship between humans and nature based on the following moral theories: (i) extreme anthropocentrism, which ascribes instrumental value to nature; (ii) moderate technocentrism, which expresses the belief that humans are capable of manipulating nature through science and technology; (iii) ecocentrism, which ascribes intrinsic value to systems such as ecosystems and the biosphere; and (iv) biocentrism, which ascribes intrinsic value to every individual, regardless of species (Kopnina & Cherniak, 2015).

Specifically, the research questions of this study are:

i. What are the environmental attitudes of secondary school students regarding critical ecological issues arising from human interventions in food webs?
ii. How do students view the relationship between humans and nature?
iii. Do students in the study have deeply held beliefs that are inconsistent with scientific data when analyzing environmental issues?
iv. Are secondary students' perceptions of the relationship between humans and nature and ecological knowledge potentially critical factors that can shape responsible decision-making and students' attitudes toward environmental protection?

Educational goals for sustainable development should be "*reflected in education policy, curricula, and training as a means to empower individuals to take informed decisions*" (UNESCO, 2019, p. 3). This paper explores young people's decisions on critical environmental issues related to biodiversity loss in one European country (Greece). It would likely be valuable to compare findings and approaches to these issues in other regions and contexts (Garrecht, Bruckermann & Harms 2018). Finally, the choice of the food web as a means to reveal students' worldviews and as an approach to examine the relationship between scientific knowledge and attitudes toward environmental protection seems original and relevant to the research questions.

Literature review

Ecological knowledge and attitudes toward environmental protection

Awareness of environmental issues "*includes not only formal but also non-formal education*" (UNESCO, 2019). However, a study of more than 25,000 citizens from 27 countries concluded that despite coordinated awareness programs directed at citizens of these countries over the past 30 years to protect biodiversity, 65% of respondents did not know what was meant (Navarro-Perrez & Titball, 2012). In addition, research (Prescott, 2016) shows that school curricula are characterized by the organization of school knowledge into individual school subjects. This traditional approach leads to fragmented and abstract school knowledge that makes it difficult for children to perceive the world as a system in order to develop a more ecologically sustainable worldview.

However, previous research (Littledyke, 2004; Perkins & Salomon, 1992) suggests that understanding a topic means that the learner can perform a variety of tasks related to the topic,

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including in contexts outside the original learning context, i.e., recognizing where and when that knowledge is useful. Indeed, limited research shows that ecological knowledge required to understand an environmental topic has a strong positive effect on attitudes toward that topic (Bayati, 2012; Giefer, Peterson, Chen, Gotwals & Songer 2019; Navarro-Perez & Tittbol, 2012). Furthermore, it is argued that while students can learn to engage in certain behaviors to meet teacher expectations, in order for these behaviors to have a solid foundation and be applicable outside of school, the development of values must be linked to an understanding of the complex issues surrounding environmental problems (Broom, 2017).

According to the Elaboration Likelihood Model or ELM (Petty & Cacioppo, 1986), how the receiver processes information or a message influences the ability to change an attitude. People with knowledge and skills are more likely to process the arguments of a message in a systematic and detailed way and draw conclusions that influence their attitude toward the issue at hand. People with low skills in processing the arguments of a message are more likely to have their attitudes influenced by factors related to the message, such as the reliability of the source, the attractiveness of the source, etc. The attitude change that occurs as a result of detailed processing of the content of the message is more substantial, lasting and more likely to resist further attempts to influence it.

Ecological knowledge – food webs

A good curriculum includes many important concepts, such as the topic of food webs, which represents the food relationships within a community (Smith & Smith, 2009). The Greek students between the ages of 14 and 16 who participated in the survey learned the concepts of food webs, food pyramids, energy flows in ecosystems, etc. in elementary and secondary school mainly through traditional teaching methods.

The interactions among populations represented in a food web can range from very simple to particularly complex. As relevant studies have shown (Bayati, 2014; Gotwals & Songer, 2010), students generally perceived the food chains in a food web as disconnected and used a food chain of their choice each time to convey the effects of changing one population on another. Populations that are not part of the same food chain or more distant populations are not perceived to be affected by each other, and the percentage of students who can make a correct prediction is lower.

Griffiths and Grant (1985) ranked the interactions among populations in a food web from simple to complex, and in each case assessed the hierarchy of skills required for students to make a correct prediction. Therefore, for each specific skill that students need to acquire to understand an ecological problem resulting from anthropogenic interventions in food webs, we were able to examine the relationship between this presupposed ecological knowledge and students' attitudes toward the corresponding ecological problem. For example, the more complex the interactions between populations in a food web, the lower the proportion of students who are able to understand the scientific aspect of the ecological problem in question (Bayati, 2014; Gotwals & Songer, 2010), and they may not be able to adopt an environmentally friendly attitude.

According to Heberlein and Black (1976), the more specific the indicator is to the behavior being studied, the better the predictive power. Typically, most researchers study general environmental knowledge that does not relate to the behaviors being studied (O'Flaherty & Liddy, 2018). This study shows that the food web is an appropriate tool to examine the relationship between ecological knowledge and attitudes toward environmental protection.

Beliefs, values and attitudes toward environmental protection

Previous studies in the field of environmental education (EE) (Ampuero et al., 2015; Navarro-Perez & Titball, 2012; Tuncay et al., 2012) indicate that students who are concerned with environmental issues and seek ecologically sound solutions are motivated not only by the domain

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of knowledge but also by an environmental awareness that requires respect, empathy and compassion for nature and all living things. It is therefore necessary to add a moral element to critical thinking, namely the role of morality (Nasibulina, 2015; Navarro-Perez & Titball, 2012). However, even when altruistic and social values are considered as primary motivations, people who care about the environment do not seem to be willing to make major sacrifices in their lifestyle. Thus, they engage in activities such as recycling, but not necessarily activities that impose a greater burden, such as driving less (Diekmann & Preseindoerfer, 1992; Herman, 2015). As described in cognitive dissonance theory (Festinger, 1957), it is commonly believed that we tend to avoid environmental issues because they conflict with or threaten some of our basic material needs.

Therefore, this study also examined whether people's perceptions of their interactions with the natural world (e.g., anthropocentric, biocentric, etc.) have an impact on students' responses to various ecological issues arising from human interventions in food webs.

Methodology

Sample

The sample of this study consisted of 234 students from twelve secondary schools in the city of Heraklion, Crete. The students were grade 10 students between the ages of 14 and 16. Since there was more than one grade 10 class in each school, it was decided to include only one class from each secondary school in the sample. Classrooms were selected through convenience sampling, as complete statistics on the grade 10 student population in the city of Heraklion were not available. A total of 12 classrooms were selected. The sample included girls and boys, 56 and 44%, respectively. Regarding the educational level of the family, 27.4% of the fathers and 24.8% of the mothers had a university degree.

Research tool

The research instrument used was a questionnaire to obtain multiple responses from a satisfactory sample size. The aim of the present study was to document the students' own reflections on ecological phenomena without formulating the terms in which the answers were given. Therefore, the use of scientific terms was avoided in most of the questions. In addition, the questionnaire contained several carefully worded open-ended questions that required students to apply their knowledge of food webs rather than just memorize information. This was necessary to elicit students' spontaneous thoughts about ecological phenomena.

The questionnaire was also designed to explore a range of different and hierarchical skills that students need to assess the ecological dimension of environmental problems. Students should initially refer to simpler "rules" such as predator-prey relationships, e.g., overfishing (see Appendix A – question 4), and to form similar combinations to predict more complex population interactions of a food web, e.g., habitat fragmentation (question 3). The questions designed to probe students' knowledge of the "food web hierarchy" were formulated based on Griffith and Grant's (1985, pp. 424, 427) instrument, which was tested for validity and reliability.

In addition, the questionnaire contained a total of 16 questions consisting of two parts: a closed-ended question (a knowledge test with multiple choices or an attitude question) and an open-ended question asking respondents to justify their choices. This allowed respondents to indicate the mindset that led them to make a particular choice. This study presents the responses of 234 students to seven of the sixteen questions (see Appendix A) that examined student attitudes toward biodiversity loss.

Survey results for the remaining nine questions, which examined students' ecological knowledge of food webs, have been previously published. Specifically, the Bayati (2012) presented

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the results of statistical analysis of the responses of the 234 students in the sample to the closed-ended questions to examine whether there was a relationship between required ecological knowledge and attitudes toward the particular ecological issue. A subsequent publication (Bayati, 2014) analyzed the knowledge and alternative perceptions of 234 secondary school students about food webs.

The questionnaire was first pilot tested with two 10-year-old secondary school classes to make necessary improvements. Some questions that proved difficult or misleading for the students were reworded. The researcher focused on the ease of completing the questionnaire and therefore made an effort to make the questions clear, small, simple and understandable. Based on the results of this pilot study and after the necessary corrections and changes were made, a new pilot evaluation of the questionnaire was conducted using the procedure described above (Cohen et al., 2007).

Both reliability and validity were ensured by the use of a sample capable of illuminating students' views on the environmental issues that were the subject of the study. In addition, student participation was voluntary, confidentiality of responses was assured and there was no interference with the data (Cohen et al., 2007).

Finally, the questionnaire was distributed on a normal school day by the researcher herself. The researcher explained to the adolescents that their assistance was important, that all their responses would be treated anonymously, that the questionnaire was not an examination paper and that their teacher would not participate. Filling out the questionnaire was covered in each class for one class period without the adolescents having any difficulties.

Methods of statistical analysis

The statistical analysis of the data was carried out with the statistical software SPSS 21.0, using the appropriate tools of descriptive statistics.

Classification of closed-ended questions

Responses to the closed questions were coded as follows: Category 3 (positive), Category 2 (neutral), Category 1 (negative) attitude toward environmental protection.

For example, in Question 1 (see Appendix A), the positive attitude toward environmental protection is the answer "I disagree," which was coded as Category 3. Sure, if the predators (snakes) are eradicated, the mice (prey) will increase. The mice need more food, so wheat consumption will increase and crops will be destroyed. The answer "I disagree" is the most environmentally friendly solution for all questions except question five and six and is coded as a positive attitude toward the environment. For example, for question six, the response "I agree" is coded as category 3 (positive attitude toward biological control). Statistical analysis of the closed-ended questions is used to examine students' attitudes toward environmental protection.

Classification of open-ended questions

The open-ended questions were classified according to the content analysis method described by (Cohen et al., 2007). Since content analysis strives for objectivity, the responses were classified into the same category in the same sense. The categorization was repeated frequently by the author at different points in time to ensure the reliability of the content analysis. Finally, in order for the classification system to be valid and effective, an attempt was made to create categories that were exhaustive and mutually exclusive, i.e., all units of analysis fell under the categories, but none of them were coded into two categories at the same time.

Students' responses to the open-ended questions allowed the researcher to explore adolescents' perceptions of ecological phenomena and individuals' relationships with the natural world, factors that likely shape responsible decision-making and students' attitudes toward environmental protection.

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Table 1. Distribution of students who have a positive attitude toward environmental protection (Relative frequencies)

Question	1 Extermination of a "dangerous" species	2 Introduction of a foreign species	3 Habitat fragmentation	4 Overfishing	5 Pesticide use	6 Biological insect controls	7 Hunting of birds of prey
Positive Attitude (%)	69.2	73.9	62.4	78.6	89.3	81.2	82.1
Negative Attitude (%)	18.8	13.3	12	11.1	4.3	5.6	8.5
Neutral Attitude (%)	12	12.8	25.6	10.3	6.4	13.2	9.4

Findings

The research results obtained from the analysis of the responses to the closed/open-ended questions provide us with the following data: first, students' attitudes toward environmental protection in relation to the environmental topics studied; second, students' perceptions of the relationship between humans and nature, followed by deeply held beliefs that contradict scientific data; and finally, the factors that influence their attitudes toward environmental protection.

Students' attitudes toward environmental protection: Research question 1

The statistical analysis of the closed questions shows, above all, that the students have a very positive attitude toward environmental protection (see Table 1).

Finally, the lowest percentage of positive attitudes toward environmental protection (see Table 1) is toward road construction, even if it means destroying part of the forest (62.4%, question 3).

Students' perception of the relationship between humans and nature: Research question 2

Responses regarding the relationship between humans and nature were classified based on ethical theories (see Table 2) and ranged from extremely anthropocentric to biocentric (Kopnina & Cherniak, 2015). Specifically, students held the following perceptions: i) Extremely anthropocentric: they asserted that humans can destroy the environment to satisfy their own needs and desires ii) Moderately technocentric: they seem to vacillate between the view that the planet and the creatures inhabiting it are of value to humanity and the view that they have intrinsic value iii) Ecocentric: They support that it is not right to destroy the ecosystem. However, they do not provide a sophisticated scientific explanation. iv) Biocentric: They state that all organisms should be protected regardless of their usefulness to humans.

It was also deemed necessary to introduce a new category, "Scientific ecosystemic," to capture perceptions based on detailed scientific explanations. In particular, the effects of human intervention on ecosystems are explained in scientific detail because all elements of the biosphere are interdependent and interact with each other. Students with a "Scientific ecosystemic" perception also understand that the environment is in a delicate balance that can be irrevocably disturbed by human activities and that it is not an inexhaustible resource for the satisfaction of human interests.

We have also included in the "Tautological" category those responses in which respondents simply express their ignorance without further interpretation (Table 2).

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Table 2. Students' perceptions of the natural world (indicative responses)

Categories	Indicative Answer
Tautological	*"I do not know how to answer"* (76th student, question 1).
Extreme anthropocentric	*"I agree because hunting is a fascinating sport"* (49th student, question 7) and *or "I agree because the deer is more beautiful. I am not interested in wild goats"* (232nd student, question 2).
Moderate technocentric	*"I'm not sure. Opinions differ because if tourists are very impressed, they will spend their money. On the other hand, the food for the animals is reduced"* (136th student, question 2).
Ecocentric perception	*"I do not agree because forest areas should not be entered"* (19th student, question 3).
Scientific ecosystemic	*"I disagree, because the weeds will disappear and as a result the population of wild goats, which are a rare species, will decrease and be threatened with extinction"* (191st student, question 2) and *"I disagree, because fish are small and need shrimp as food to grow. So, the fishermen do double harm: to the fish, which will die because they have no food, and to the shrimp, because they overfish them"* (149th student, question 4)
Biocentric perception	*"I disagree because I believe that animals are not for entertainment, they are just trying to survive"* (112th student, question 2) and *"It is not right that some animals have to die just because I want my comfort and convenience"* (178th student, question 3)

Table 3. Students' perceptions of the relationship between humans and nature (relative frequencies)

	Question (%)						
	1	2	3	4	5	6	7
Categories	Extermination of a "dangerous" species	Introduction of a foreign species	Habitat fragmentation	Overfishing	Pesticide use	Biological insect control	Hunting birds of prey
Tautological	2.1	6.8	4.3	9	5.6	12	9.8
Anthropocentric	32.5	13.2	12	12	6.4	6.8	26.5
Moderate Technocentric	8.5	6	21.8	3.8	2.6	2.6	2.1
Ecocentric	7,8	12	41.4	7.3	42.3	4.7	29.1
Scientific Ecosystemic	47	59.4	4.3	65.8	39.3	72.6	11.1
Biocentric	2.1	2.6	16.2	2.1	3.8	1.3	21.4

From the analysis of students' responses to the open-ended questions, it appears that the majority of the sample holds the scientific ecosystemic perception on most environmental issues (see Table 3).

In contrast, scientific ecosystem perceptions have the lowest percentages (see Table 3) in the cases of habitat fragmentation (4.3%, question 3) and hunting (11.1%, question 7). Thus, in the above ecological questions, students use a low percentage of their ecological knowledge to justify their choice of an ecologically acceptable solution. This result was to be expected. In fact, for the ecological knowledge questions, only 15.4% of the sample understands the impact of complete deforestation and only 10.3% recognizes the impact of a decline in the population of a superior predator on other organisms in the food web because most of these populations are not part of the same food chain, so they are not assumed to affect each other (Bayati, 2014).

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Table 4. Deeply held beliefs of students that contradict scientific data about the natural world (Relative frequencies)

	Question (%)						
	1	2	3	4	5	6	7
Categories	Extermination of a "dangerous" species	Introduction of a foreign species	Habitat fragmentation	Overfishing	Pesticide use	Biological insect control	Hunting of birds of prey
Organisms are useful or harmful	41	1.9				6	23.5
Nature promotes humans' welfare		7.3	31.8	15.8	11		4.7
Natural resources are inexhaustible		10.7					
Any human intervention is destructive to the ecosystem						4.7	

Deeply held beliefs that contradict scientific data accepted by students in the study: Research question 3

From the analysis of students' responses to the open-ended questions, it appears that the most common belief that contradicts scientific data about the natural world (see Table 4) is that organisms are characterized as useful or harmful to humans. For example, "*Too bad, because all the other animals I detest will reproduce, so we should not kill the hawks, we should kill everyone else*" (145th student, question 7). This prevents students from showing a positive attitude toward conservation, especially when it comes to eradicating a "dangerous" species (41%, question 1) and hunting birds of prey (23.5%, question 7).

In second place is a belief that contradicts scientific data about nature being used to promote human welfare (see Table 4), especially in the cases of road construction (31.8%, question 3) and overfishing (15.8%, question 4). For example, "*I agree because we need to make our lives easier*" (151th student, question 3) and "*I agree because fishermen can no longer feed their families*" (178th student, question 4).

In addition, students believe that natural resources are inexhaustible (see Table 4) if an alien species is introduced (10.7%, question 2). For example, "*I agree because weeds grow all the time so there is food for both animals*" (37th student, question 2). Students do not seem to have enough information about the problem of overgrazing, although it is a common phenomenon in Greek ecosystems.

The aforementioned deeply held beliefs that contradict scientific data about the natural world were the arguments of students who hold anthropocentric or technocentric perceptions. For example, the environmental myth that a species is considered dangerous was adopted by a student who expressed a moderate technocentric perception: "*I'm not sure because on the one hand snakes are dangerous to humans, on the other hand they eat mice that feed on wheat*" (90th student, question 1).

Finally, there is a nonobjective belief about the natural world – that any human intervention destroys the ecosystem (see Table 4) – in the case of biological control of insects (4.7%, question 6), as in: "*I disagree because they destroy the chain in nature*" (student 129). The above-mentioned nonobjective belief about the natural world were the argument of students holding an ecocentric or even biocentric view (see Table 6).

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Table 5. Distribution of students' perceptions of the natural world (absolute frequencies) and their attitudes toward environmental protection

Question	1	2	3	4	5	6	7
Perception		Anthropocentric					
Positive Attitude	29			4	5	10	42
Negative Attitude	44	30	28	24	10	6	18
Neutral Attitude	3	1					2
Total	76	31	28	28	15	16	62
	32,5%	13,2%	12%	12%	6,4%	6,8%	26,5%
Perception				Moderate Technocentric			
Neutral Attitude	20	14	51	9	6	6	5
Total	20	14	51	9	6	6	5
	8.5%	6%	21.8%	3.8%	2.6%	2.6%	2.1%

Students' perceptions of the relationship between humans and nature and ecological knowledge as possible determinants that can influence responsible decision-making and students' attitudes toward environmental protection: Research question 4

A negative attitude toward environmental protection is held by those who express an extremely anthropocentric perception in the corresponding open question.

However, there are also students who take an extremely anthropocentric view, but take a seemingly positive stance on the corresponding closed question. Thus, it can be seen (Table 1) that 192 students (82.1%) have a positive attitude and do not approve of hunting birds of prey. However, 42 students (17.9%) who hold the extreme anthropocentric view that snakes or mice are harmful take a positive stance on the corresponding closed question (see Table 5). For example, *'I do not agree, because if the hawks disappear, mice and snakes will grow'* (140th student, question 7).

If we also take into account that students may have answered randomly (especially the tautological answers), it is possible that students' positive attitudes belong to somewhat lower percentages than those listed in Table 1.

In the case of forest fragmentation, to justify their negative attitudes toward environmental protection (Festinger, 1957), students also argue that only part of the forest is being destroyed, for example: "*I agree because it will be easier for me to move. Besides, only part of the forest will be destroyed*" (28th student). The Bayati (2012) pointed out that the variables specific ecological knowledge and attitude were independent only in the case of habitat fragmentation for the construction of a road. However, we recall that only 15.4% of the students in the sample understood the impact of complete deforestation in the corresponding knowledge question (Bayati, 2014).

The results show that students with moderate technocentric perceptions (see Table 3) expressed neutral attitudes on the corresponding closed question (see Table 5), while they had conflicting views on their attitudes. These students seem to be undecided, for example: "*I am not sure because in theory it is wrong and we have no right to destroy the natural environment. However, if I lived in this area and there was a problem with the road network, I would probably agree*" (84th student, question 3).

Students who have an ecocentric or biocentric perception do not always take a positive attitude toward environmental protection (see Table 6) because their insufficient knowledge does not help them find ecologically sound solutions. For example, six of the fourteen students who fall into the two categories above are against biological control because they believe that any human

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Table 6. Distribution of students' perceptions of the natural world (absolute frequencies) and their attitudes toward environmental protection

Question	1	2	3	4	5	6	7
Perception		Ecocentric					
Positive Attitude	18	28	97	17	97		68
Negative Attitude						5	
Neutral Attitude					2	6	
Total	18	28	97	17	99	11	68
	7,8%	12%	41.4%	7.3%	42.3%	4.7%	29.1%
Perception		Biocentric					
Positive Attitude	5	6	38	5	9	1	50
Negative Attitude						1	
Neutral Attitude						1	
Total	5	6	38	5	9	3	50
	2.1%	2,6 %	16.2 %	2.1%	3.8%	1.3%	21.4%
Perception		Scientific	Ecosystemic				
Positive Attitude	110	139	10	154	92	170	26
Total	110	139	10	154	92	170	26
	47%	59.4%	4.3%	65.8%	39.3%	72.6%	11.1%

intervention in nature is destructive, e.g., "*I disagree because eventually there will be no more caterpillars*" (73rd student – biocentric perception). The other seven students took a neutral stance toward environmentalism, e.g., "*I do not know. I think caterpillars should be fed in some way, so caterpillars probably should not be eaten by lilacs for natural balance reasons*" (160th student-ecocentric perception). Only one student had a positive attitude toward environmental protection when asked about the related question. In addition, two students who held an ecocentric perception took a neutral stance on environmental protection in the case of pesticide use (see Table 6) because they believed that the birds starved after the pesticides wiped out the insects.

Finally, without exception, all students who have a scientific-ecosystemic perception (see Table 3), and thus have sophisticated ecological knowledge, have a positive attitude toward environmental protection (see Table 6). In fact, statistical analysis (Bayati, 2012) revealed a positive correlation – at a statistical significance level $\alpha = 0.001$ – between the ability of students in the sample to determine the impact of a sudden change in the size of a food web population and students' attitudes toward the resulting environmental problem.

Discussion and conclusion

The results of this study show that secondary school students' decisions and attitudes toward environmental protection are shaped by the following factors: Perception of the relationship between humans and nature, personal motivation and scientific knowledge.

The study shows that students who have limited ecological knowledge to evaluate arguments make decisions about ecosystem management based on their perception of the relationship between humans and nature. In this case, their attitudes toward environmental protection are most likely not stable (Petty & Cacioppo, 1986). Therefore, students who have an ecocentric or biocentric view sometimes adopt a negative or neutral attitude toward environmental protection.

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All students who held a moderately technocentric view took a neutral stance because they were characterized by a more complex way of thinking (Bright & Tarrant, 2002), usually without detailed scientific reasoning. All students with an extreme anthropocentric view expressed negative attitudes toward environmentalism (Kopnina & Cherniak, 2015). Deeply held beliefs that contradict scientific data are accepted by students with anthropocentric or technocentric views (e.g., that organisms are beneficial or harmful) or even ecocentric and biocentric views (e.g., that any human intervention is destructive to the ecosystem). Moreover, in some cases, there seems to be a mismatch between knowledge and attitude, and students are less pro-environment when it comes to environmental issues that are closely related to their lives, such as deforestation to build a road (Herman, 2015; Lavelle, Rau & Fahyc 2015). The above results can also be attributed to various other reasons. For example, curricula are characterized by a lack of interdependence and coherence, as many scientific concepts are very general and unrelated to environmental phenomena (Prescott, 2016). As a result, students do not acquire functional knowledge in school, i.e., knowledge that helps them understand the problems of daily life (Littledyke, 2004; Perkins & Salomon, 1992). In addition, evaluating an EE program is inherently difficult and often overlooked (Broom, 2017; Riess et al., 2022). Finally, the utility of food webs as a means of revealing students' worldviews is recognized.

On the contrary, this study shows that scientific knowledge is an important factor in evaluating different solutions and existing views to address an environmental problem, as suggested by limited research (Bayati, 2012; Giefer et al., 2019; Navarro-Perrez & Titball, 2012). Indeed, scientific knowledge appears to contribute to both students' critical thinking and stable, positive attitudes toward environmental protection (Broom, 2017; Petty & Cacioppo, 1986). All students who have advanced ecological knowledge and adopt a scientific view of the ecosystem consistently have positive attitudes toward environmental protection. This finding might suggest that knowledge of basic ecological concepts prepares students to analyze information in the context of ecosystem management decisions, even if they are initially unfamiliar with the details of a particular environmental problem (Humston & Ortiz-Barney, 2007). Similarly, it could be argued that a positive transfer of learning occurs for students who adopt the scientific view of the ecosystem (Perkins & Salomon, 1992; Riess et al., 2022). According to various studies (Garrecht et al., 2018), by participating in environmental projects that address complex current environmental problems, students improve their ability to apply critical thinking to find environmentally sound solutions.

The results of this study also support Heberlein and Black's (1976) view that the more specific an indicator is to the behavior under study, the better it predicts behavior. This study examined the individual specific skills students need to acquire (Griffiths & Grant, 1985) in order to understand an ecological problem resulting from anthropogenic interference with food webs, as well as students' attitudes toward the issue. The above observations reinforce the choice of the food web as an appropriate concept for examining the relationship between scientific knowledge and attitudes toward environmental protection. However, previous researchers have indicated that the relationship between knowledge and attitudes was not strong (Herman, 2015; Lavelle et al., 2015), although participants in these surveys with high levels of education were more likely to report participating in actions that promote pro-environmental behaviors.

In summary, this study shows that the food web is a key concept in ecology that encourages students to rethink their prevailing anthropocentric ideas about the value of organisms and to recognize their ecological value and the limits of ecosystem resilience. Therefore, when designing a curriculum EE, teachers should consider the basic scientific concepts needed to understand and explore the topic. Because environmental issues are both culturally and socially conditioned, addressing them requires a reexamination of preconceptions, perceptions and beliefs, as well as the adoption of a new system of ideas as opposed to the old (Nasibulina, 2015). This article suggests that by improving their ecological knowledge, students can revise their view of the Cartesian separation between humans and nature and recognize that every organism, including humans, is functionally and dynamically connected to the ecosystem. In the context of this general discussion, ecology education in general should be designed with expanded content that

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emphasizes not only the acquisition of scientific knowledge but also its application, including the development of students' critical thinking so that they are able to shape their values, beliefs and attitudes toward a more ecologically sustainable worldview.

In short, it is undoubtedly important for students to have a solid ecological knowledge in order to make ecologically sound judgments.

Limitations and recommendations for future work

The survey design was constrained by limited time and cost and by the need to obtain a sufficient number of responses from a satisfactory sample. Due to these limitations, the study was restricted to the city of Heraklion. In addition, due to its convenience, the sample of this study is not representative of all secondary school students, so the results cannot be generalized. Future studies with systematic samples are needed to determine if the results of this study can be confirmed. Future studies could also examine the perceptions of the relationship between people and nature by students from different regions, ethnicities, or age groups to determine if the general population has the same environmental attitudes and perceptions as in this study.

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Appendix

After each scenario (1-7), the question was: how do you judge this decision?

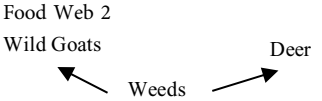
I agree - I disagree - I am not sure.

Edit your thoughts and choose your answer . . .

1. Farmers growing wheat in a plain decide to eradicate all snakes in the area because they scare people working in the fields.
   Food web 1

2. Wild goats, belonging to a rare species, live in a ravine that is a national park. The people decide to bring deer into the gorge to make it more impressive for the visitors.
   Food Web 2

3. The authorities in charge of road construction projects have decided to build a highway through a pine forest. In order for the road to be opened, a third of the forest must be cleared. You are a resident of the area and you have difficulty getting around because the existing roads are very small.

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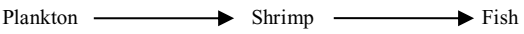
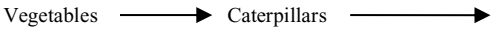
4. The fishermen of an island have decided to catch large quantities of shrimp, because the fish are too small to sell.
Food Web 3

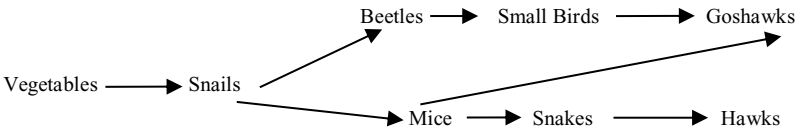


5. To control insects that destroy the crops they grow, people spray large amounts of toxic pesticides on the plants. Pesticides are not excreted by the bodies of plants and animals. In one region, crops were sprayed with pesticides. After some time, dead falcons were found in the area. Environmental organisations claim that the death of the falcons is due to the pesticides. What is your opinion on this?
Food Web 4
Plants → Insects → Small Birds → Hawks

6. Small herbivorous caterpillars threatened crops in a plain. The farmers decided to release ladybugs.
Food Web 5



7. The inhabitants of the same plain hunt hawks, which are now threatened with extinction.
Food Web 6



Author Biography

Irene Bayati is a primary education consultant in the Heraklion region of Crete. She is a graduate of the Department of Biology at the Faculty of Science, Aristotle University of Thessaloniki. She holds an MSc degree in "Teaching Science Faculty" from the University of Crete and a PhD in Education in the Cognitive Field "Environmental Education" from the Department of Pedagogy and Early Childhood Education of the National and Kapodistrian University of Athens. She received a scholarship from IKY (National Foundation for Scholarship) in the cognitive area of Environmental Education. She has organised a number of seminars, workshops and events on new teaching methods, sustainable education, environmental studies and pedagogy. She has been a member of scientific committees and a reviewer at international and panhellenic conferences. She participated in announcements and publications in international and panhellenic conferences, symposia, scientific meetings and journals on sustainable education.

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