

# The role of environmental education in compulsory education: The case of mathematics textbooks in Greece<sup>1</sup>

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*School plays an important role in the formation of children's positive attitudes towards the environment. Mathematics textbooks also play an important role in environmental education, because environmental problems have two distinct features: the quality and the quantity of environmental resources. It is well known that as students go higher in their education they often show a negative attitude toward mathematics. One possible reason for this is that mathematics contains many abstract concepts. Another reason is that students think that mathematics has nothing to do with their everyday needs. In this study research is conducted on the frequency of environmental topics in selected Greek mathematics textbooks. The results show that there are some environmental topics, but the way they appear does not help students forming positive attitudes towards the environment.*

Environmental education, Greek school curriculum, environmental topics,  
school programs, mathematics textbooks

## BACKGROUND

Increased concern about the environment in recent decades has paralleled the development of environmental education, and in particular has clarified its aims and purposes (Sterling, 1995). Both school and family, play important roles in the formation of children's positive attitudes towards the environment. Environmental education curricula may raise environmental literacy, and include knowledge that goes beyond an understanding of the environment. Environmental education should build concepts and awareness about the ways in which behaviour affects environmental literacy, knowledge and skills and a critical awareness of environmental action and skills. At an international conference in Greece (October 2000) entitled 'Environmental Education in the Context of Education for the 21st Century: Prospects and Possibilities', it was suggested that a curriculum should be designed to develop three types of literacy associated with the environment: functional, cultural and critical. Functional environmental literacy is basically book knowledge related to environmental and scientific concepts; cultural environmental literacy explores the reasons that society values the environment; and critical literacy encourages students

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to use functional and cultural environmental literacy to determine appropriate future action as citizens of the environments in which they live.

It is also important to consider and question which concepts students and interested observers should understand to be thought functionally and environmentally important. Cherrett (1989) has identified some important concepts such as ecosystem succession, energy flow, materials cycling, food webs, carrying capacity and species diversity. Other researchers have found that students bring many misconstrued or alternative conceptions to the science classroom and suggest that these need to be taken into account in curriculum design (Driver et al., 1994, Hlebowitsh, 1991, Sheldrick, 1991). Students often confound the meaning of words, for example, *weather* and *climate* (Spiropoulou et al., 1997), *heat* and *temperature* (Watts and Gilbert, 1985), words that are important in environmental education. Adults also have similar misconceptions about natural and environmental phenomena (Munson, 1994; Orr, 1992). Orr (1992) is concerned about the inaccuracies in teaching about the environment and the effect that these inaccuracies have on environmental literacy. He makes the connection between literacy and behaviour when he talks about the impact that environmentally illiterate adults have on the world, because these adults, even if they want to improve the environment, may not know how to because they lack basic knowledge about how the environment functions. We suggest that the same is true for students. Therefore, teachers are failing to develop environmental literacy because they are not incorporating environmental concepts or ecological principles into the subjects they are teaching.

Mathematics textbooks, together with other subject-specific textbooks, are didactic tools that play an important role in environmental education, because environmental problems involve not only the quality of air, water, land resources, material cycling, energy saving and other issues, but also their quantity. It is also known that students in mathematics classrooms, as they go higher in their education, tend to show an increasingly negative attitude toward mathematics. One reason for this phenomenon is that these classes contain an increasing number of abstract concepts. Another reason is that students think that these studies have nothing to do with everyday life needs and problems. According to James et al. (2000), when courses in mathematics, science and technology are well planned, students improve their conceptual skills. In the studies, where mathematics, science and other subjects are integrated, the effects of these on student success, show that students who gain mathematical knowledge, also gain scientific knowledge that is based on mathematics, and develop a preference for social- scientific activities.

Consideration is given to the fact that mathematics that is based on environmental topics and the ability to analyse and propose solutions to solve environmental problems encountered by students, influences the ways in which mathematical processes and abilities may affect success in science.

### **THE GREEK EDUCATIONAL SYSTEM AND ENVIRONMENTAL EDUCATION**

In Greece, there is a nine-year compulsory school system that is divided into two parts. Grades 1-6 are referred to as the primary school and Grades 1-3 of middle school are called Gymnasium. Until the early 1980s environmental education had an informal place in Greek schools. Education was conducted by teaching separate subjects in which environmental education was generally absent. Middle school time was divided into physics, chemistry, biology and mathematics lessons. The results were fragmented and learning was done by memorisation with little relation to everyday life.

Since the early 1990s, the system has changed. Environmental education has grown in many schools in Greece, and is now institutionalised in the Greek education system, through the enactment of *Law 1892, Article 111 /1990*. According to this law, environmental education is a process that leads to responsible individual and group actions with positive results to both the biophysical and sociocultural environments and assists with the development of critical thinking,

problem solving and effective decision-making skills. The purpose of this law is to increase awareness, change attitudes and behaviour, elucidate values, build commitments, provide skills, and encourage positive action towards the natural, social, technological and historical environments.

The commitment of the Ministers of Education from the country members of the European Union (1988) for action, promotion, and development of environmental education has been significant for its institutionalisation in Greece, in relation to the following: (a) the promotion of environmental education in all grades of education; (b) the consideration of the environmental education goals in the designing of school programs; (c) the importance of environmental education in teacher training; and (d) the need to supply schools with environmentally positive educational equipment.

Moreover, environmental education provides the school with a positive approach to society, because environmental education helps the entire process of education in the following ways:

1. *For students*, it teaches them to (a) learn how to learn, (b) improve their decision-making and problem solving skills, (c) develop their personal potential, and (d) act in a positive way to protect the environment.
2. *For teachers*, it enables them to (a) learn alternative teaching methods, (b) apply different teaching methods in the classroom, (c) become aware of students' potential, and (d) establish links between subjects.
3. *For curriculum planning*, it encourages students to (a) request a more student-centered educational program, (b) ask questions, (c) provide more time for students to think and act in a scientific way, (d) foster project-based learning in all school subjects, and (e) focus greater attention on environmental and health education.

Furthermore, focusing on environmental education enables the curricula to raise environmental literacy by incorporating knowledge that goes beyond an understanding of the environment. It also focuses on the many environmental themes and problems which should not be ignored, such as (a) climate changes and protection of the atmosphere, (b) protection of freshwater and marine environments, as well as the management and use of water resources, (c) an integrated approach to the planning and management of land resources by combating desertification and drought and by promoting sustainable agriculture and rural development, (d) combating deforestation, (e) focusing on energy flow and management strategies, (f) conservation of biological diversity and the management of fragile ecosystems, (g) environmentally sound management of toxic chemicals, cycling of materials and recycling of domestic waste, (h) understanding the relationship between the environment and technology. (i) studying science for sustainable development, and (j) protecting and promoting peace, improved human health, and combating poverty.

### **PURPOSE OF THE STUDY AND METHODS OF ANALYSIS**

In this study the aim was to investigate the frequency of environmental issues and topics in Greek mathematics textbooks used in the years of compulsory education. The main focus of the research study was to find answers to the following questions:

- a) How many environmental topics are found in the mathematics' textbooks?
- b) Which of the topics is regional, which national and which are global?
- c) Are any of the topics seen as anti-environmental? (That is to say, have they been developed without consideration of social or environmental needs?)

Data for this study were collected from nine different mathematics textbooks used in the Greek educational curriculum. The first step was to find out if there is any dissemination of environmental topics either in theory or in practical exercises in the textbooks. We used content analysis to ascertain this information, and following Bamboucas (1998), the unit is the book page

## RESULTS AND DISCUSSION

The relevant amount of environmental material in the nominated mathematics textbooks is presented in Tables 1 to 4 according to the level of the resource.

### *Primary School Mathematics textbooks*

The first and second grade textbooks, given in Table 1, contain many photographs or pictures with natural and environmental themes, such as health foods, flowers, birds, mountains, and forests. The third and fourth grade books have fewer pages with environmental photographs or pictures, and in the fifth and sixth grade books there is an increase in appropriate environmental material. Most of the illustrations are presented to help students learn about the environment and to help them calculate or count amounts of foods such as milk and, sugar that are important in the diet.

**Table 1. The relevant topics in the mathematics textbooks**

Grade	Number of pages		Number of Environmental topics	
	N	%	N	%
1st grade	328	100	78	23.8
2nd Grade	310	100	38	12.25
3rd Grade	234	100	7	3
4th Grade	267	100	7	2.6
5th Grade	263	100	15	5.7
6th Grade	264	100	21	7.5
Total number	1666	100	166	9.2

### *Middle school (Gymnasium) mathematics textbooks*

In the Gymnasium textbooks, presented in Table 2, environmental topics are included in both theory and practical exercises. There are no specific pictures or photographs and there is little numerical difference between these textbooks. Instead of pictures, there are diagrams or histograms which have environmental interest, such as population density, oil and food supplies, water pollution, or weather maps with information such as temperature and rainfall.

**Table 2. The relevant topics in the mathematics textbooks**

Grade	Number of pages		Number of Environmental topics	
	N	%	N	%
1st grade	313	100	15	4.8
2nd Grade	339	100	15	4.4
3rd Grade	275	100	10	3.6
Total number	927	100	40	4.3

### *Primary School Mathematics textbooks*

The next step is to select material that helps students to develop awareness and skills to allow them to become involved in solving environmental problems such as material recycling and energy saving. This material is classified in eight categories shown in Table 3.

### *Gymnasium mathematics textbooks*

The classification of environmental topics in primary mathematics textbooks, presented in Table 4, shows great diversity. Firstly, it gives an overall measure of the most beneficial topics such as plants, trees and forests, energy flow, and recycling materials. The topics are presented together

with pictures of deforestation, tables with fruit on them, butterflies and animals, examples of sustainable agriculture, water resources, and the consumption of petrol.

**Table 3. Classification of environmental topics in primary mathematics textbooks**

Environmental topics	Grade:	1st	2nd	3rd	4th	5th	6th	Total
Climate Changes								
Forests					4		1	5
Water resources			2					2
Land resources			1				1	2
Energy		1	7	1	3		2	14
Protection of biological diversity					1	1		2
Recycling			2		2		1	5
Environment and technology			2					2
Total number		1	14	1	10	1	5	32

**Table 4. Classification of environmental topics in Gymnasium mathematics textbooks**

Environmental topics	1st Grade		2nd Grade		3rd Grade	
	Theory	Practical Exercises	Theory	Practical Exercises	Theory	Practical Exercises
Climate Changes			2		1	1
Forest				4		1
Water		2				
Land		1				1
Energy	1	7	1	3		2
Protection of biological diversity				1	1	
Recycling material		2				
Environment and Technology		2		2		1
Total number	15		13 + 2 historical examples		8 + 2 historical examples	

### How many environmental topics are found in the mathematics' textbooks?

The information in Table 4 lists the environmental topics in Gymnasium mathematics textbooks that are presented in theory, practical exercises and as historical examples as follows:

There are four reports on the topic of climate change. Two reports show weather maps, one with data on air temperature measurements and the other with data on wind velocity. Other examples show vehicles which use highways, but without a reference on air pollution.

There are five reports on the topic of forest-plants. There are four references in the practical exercises on the felling of trees to open a fire-safety road, the construction of a square without any reference to tree re-planting, the calibration of the area in square metres without any reference to the contribution of trees, and the importance of green areas in urban locations.

There are two reports on the topic of water. There are two references in exercises concerning the cost of the construction of a water tank to supply water to three villages and the process of filling of a water tank from a tap without any reference to the serious problem of water shortage.

There are two reports on the topic of land and soil. There are two references on the use of pesticides that do not make any mention of the pollution and possible desertification of the soil or that point to the profit the farmers may gain if they utilise biological cultivation.

There are 14 reports on the topic of energy. There are seven reports on the use of petrol for the heating of homes or the consumption by new model cars, but with no reference to pollution issues. However, there is the suggestion that over-consumption would be harmful to the environment. There are four reports that discuss electric power bills and the percentage that is spent on electricity consumption, but there is a lack of any reference to issues of energy saving.

There are two reports on the topic of promotion and protection of biological diversity. The two references illustrate the percentage of plants and animals in the environment, one in the theory and the other in the practical exercise section.

There are two reports on the topic of recycling material. There are two references in the practical exercises. One illustrates the construction of a disposal system for waste water and the other describes the circulation of newspapers without any mention of paper recycling.

There are five reports on the topic of environment and technology. There are references in the practical exercises concerned with (a) the calculation of the quantity of material used in the painting of a school, (b) the calculation of the distance between three children using cell phones, (c) the construction of tall transmitting antennas without any discussion on the question of radioactivity, (d) the construction of a highway without any additional reference to the felling of trees, and (e) the construction of a factory without any mention of any kind of pollution that may be created by such an activity. Finally, there are four references to historical examples that do not have any relation to environmental issues.

### **Which of the topics is regional, which national and which are global?**

The second question concerns environmental issues that are presented in mathematics textbooks. For example, when concepts such as rivers, fields, built squares and built areas are presented, there is no mention of a particular village or town and the places referred to do not have any regional, national or global dimension. However, there are reports concerning the calculation of economical profit, areas of energy consumption, and other issues of national interest are discussed.

### **Are any of the topics seen as anti-environmental?**

In textbooks designed for Primary School and Gymnasium, many problems include an anti-environmental dimension. Some specific examples are: (a) water usage with a water tank that is filled from the main water supply instead of using collected rain water; (b) the use of a pump for watering of fields discusses the crucial problem of water shortage; (c) the use of natural resources including the over-consumption of fossil fuels, petrol and gas, for transportation and heating needs that shows no ecological awareness about the question of over-consumption of natural resources or issues concerning air pollution; (d) wastage of natural resources with the reference to a gas leak from a broken reservoir is used only as a vehicle to calculate the percentage of gas that is released into the environment; and (e) the use of pesticides, and the destruction of trees is mentioned so that the diameter of the tree trunks and the paving of a square may be calculated rather than a discussion about the replanting of felled trees or the biological restoration of used space.

## **CONCLUSIONS**

Therefore, the purpose and practice of environmental education involves gaining appropriate knowledge as well as developing skills in decision-making and strategies for implementing change rather than taking action. In this way environmental topics in mathematics textbooks are able to provide students with the opportunity to heighten awareness about natural, social, technological and historical environmental issues. Moreover, if societal needs and values are seen to be changing, education must consider this fact and provide opportunities for students to investigate both the quantity and the extent of environmental problems.

This study investigates the frequency of environmental topics in the mathematics textbooks. The results show that there are a number of environmental topics in both theory and practical exercises, but the way they appear does not help students to develop positive attitudes towards the

environment. The conclusion derived from the above information illustrates the existent preference for bio-diversity, since there are several reports concerning the flora and fauna without, however, referring to the subject of animal and plant extinction. Moreover, there are also many reports concerning particular types of trees that do not give sufficient attention to the dangers that forests face as ecosystems, such as deforestation and conflagration.

Furthermore, reports concerning the soil refer to the use of pesticides and the cultivation of vegetables and fruit, while there are eight reports on the availability of drinkable water, the use of water pumps, and the construction of water tanks. It is also notable that there are very few reports on recycling useful materials. Finally, there are several reports on petrol and oil consumption for transportation and heating, but only one report on ways of saving energy.

Some references made to issues such as animal extinction, the placement of solar-selector cells, the construction of water collectors highlight only the mathematical dimension of the exercise without drawing the reader's attention to environmental issues.

Our recommendation is that school-textbooks and other instructional materials should be peer-reviewed in the preparation stage so that input from scientists, economists and other experts in environmental studies may be developed and included at least in the Gymnasium and High Schools. Moreover, educators, textbooks writers and teachers should receive more substantive preparation in the natural sciences, economics, and mathematics, as the ICEE (1997) has recommended.

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