

CONTENT ANALYSIS OF ECOSYSTEMS AND GEOCHEMICAL CYCLES IN PORTUGUESE TEXTBOOKS

Análisis de contenidos de ecosistemas y ciclos geoquímicos en los manuales portugueses

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ABSTRACT: There are many studies in recent times, on the topic Ecosystems and geochemical cycles. We intend to analyze the didactic transposition of this topic in terms of textbooks from the Portuguese education system, in different periods. We analyzed textbooks of primary and secondary school about Environmental Studies, Natural Sciences, Biology, Geology and Geography, from the Portuguese Educational System, and even Social Studies, Chemistry, Biology, Natural Sciences, Geology, Geography and Ecology. Time I (1991-2000) has a more developed approach to the presentation of the subjects when compared with Time II (2000-2006). In the topic Ecosystems and geochemical cycles, the approach of the textbooks is essentially ecocentric. However our results lead us to question the quality of textbooks in relation to this topic, because not only it is necessary for an in-depth approach as well as how to include environmental education skills in textbooks so that they might be transmitted to future generations, and thus contribute to a better quality of life on Earth.

KEY WORDS: ecosystems and geochemical cycles; textbooks; education system.

RESUMEN: Son muchos los estudios, en los últimos tiempos, sobre el tema *Ecosistemas y ciclos geoquímicos*. Pretendemos analizar la transposición didáctica del tema *Ecosistemas y ciclos geoquímicos*, en los manuales escolares, en el sistema de enseñanza portugués. Fueron analizados manuales de ciencias naturales, ciencia de la

naturaleza, biología, geología y geografía, en el sistema educativo portugués y aun estudios sociales, química, biología, ciencias naturales, geología, geografía y ecología. En lo que se refiere a los manuales, constatamos que los del Tiempo I (1991-2000) se presentan más desarrollados en la presentación de los temas cuando se comparan con los del Tiempo II (2000-2006). En el tema *Ecosistemas y ciclos geoquímicos*, el abordaje de los manuales es esencialmente ecocéntrico. Sin embargo, nuestros resultados llevan a cuestionar la calidad de los manuales al respecto de este tema, porque no sólo es necesario tratarlo de modo más profundo, sino también se deben incluir en los manuales las competencias en educación ambiental para así poder transmitir-las a las generaciones futuras, y de este modo contribuir a una mejora de la calidad de vida en la Tierra.

PALABRAS CLAVE: ecosistemas y ciclos geoquímicos; manuales escolares; sistemas de enseñanza.

1. Introduction

THE EARTH HAS A GREAT ENVIRONMENTAL DIVERSITY in terms of and, consequently, a wide range of organisms, which are related to each other and to the environment in a very different way. According to Hjorth (2002, cit. Westra, 2008), one can consider three structural categories when seeking to understand the processes responsible for the abundance and distribution of organisms. Firstly, there is the structure corresponding to the abiotic factors with the respective distribution in time and space. Secondly, we have the structure corresponding to the entire population, with their distribution in time and space. The latter is considered the trophic structure, which corresponds to the flows of matter and energy. The term ecosystem emerged to define the set of these processes and their interrelationships. This term was first used by Tansley (1935), which referred to all abiotic and physical environments in a particular location (Westra, 2008). Historically, we can say that the first idea about ecosystem considered all organisms individually and species as part of a whole. Then came the idea that people considered themselves as dynamic units that responded to disturbance. Finally, the present idea focuses on the «motives and strategies of each of the players» that belong to the ecological stage (May & Seger, 1986). Over time, four main views about the concept of ecosystem (Westra, 2008) were considered, the following are presented: i) Holistic Vision - the beginnings of ecology, from 1920 on, in this vision the idea prevailed, in which the community (The term ecosystem was not yet used) was considered an organic unity, where developments occurred around a natural balance that kept it without any sign of disturbance, ii) Cyber Vision - in the 40's this vision developed from an interdisciplinary study involving the fields of control systems, electrical network theory, logic models and neuroscience. In this theory, the important thing is control and communication in biological and mechanical systems and their environment. Control is carried out through feedbacks which allow information flow. The essential point in this vision is not the components in the system, but the relationships between these components: regulation and homeostasis are the key concepts (Cannon, 1932 cit. Westra, 2008). According to Odum (1997), the behavior of ecosystems is the balance between the input and output of matter and energy; iii) Dynamic view - with the development

of evolutionary theory, during the second half of the twentieth century a more dynamic relation to the ecosystem emerged. The form, function and behavior of organisms develop in the course of an evolutionary process, through natural selection in a constantly changing environment. In this environment, fluctuations may occur around equilibrium but also gradual or sudden changes before a new environment emerges. In this vision, development is more important than balance. iv) Chaotic Vision - the interactions between all components of an ecosystem are not determined in advance, because the random factor is important. In addition to this, even deterministic processes, with their degree of freedom, can lead to chaotic behavior, as already proposed in the early twentieth century by Poincaré (1903). According to this theory, small changes in the initial state of an ecosystem can lead to completely different developments.

One of the interesting points when discussing ecosystems relates to the position of Humanity in them. Most ecologists argue that Humanity is part of the ecosystem and one of the major influences of Humanity on the ecosystem is reflected by its economic impact. Generally speaking, we can say that the value of the ecosystem can be divided, taking into account if it can be consumed or not (Westra, 2008; Begon *et al.*, 2007). For example, if we think of game then we characterize the ecosystem as consumable goods. If we think about bird watching, soil conservation we stand from the perspective of ecosystem that these are not consumable goods.

However, on the latest perspectives on the concept of ecosystem, dynamic and chaotic, it becomes clear that the people cannot anticipate all the ecological impact behavior, since the dynamic process involved is not predictable (Westra, 2008). In holistic and cybernetic perspectives Humanity is out of the ecosystem.

In Ecosystems, balance does not mean constancy, but fluctuations, since a possible balance is always dynamic. Although ecosystems have the resilience, i.e. the ability of the ecosystem to return to its initial state after being unstable, it is important not to exceed the limits of adaptation because it can lead to its destruction. Ecosystems thus have a tendency to resist change and remain in balance, in other words, the system adapts in dynamic equilibrium (Fernandes, 2007).

School is a social space and the location where things are made, said, and valued, that is, it is an example of what the society wants and approves. The concepts should be learned in practice, in everyday school life, contributing to the overall education of responsible citizens. According to Alarcão (2001), school has the responsibility of preparing citizens, but cannot be thought about only as a time of preparation for life. School is life itself, a place of living in society. According to Antunes (2002), the supports that form the basis of education are: learning to know, learning to do, learning to live together and learning to be.

Nowadays there is a great set of educational media available to teachers, from audiovisual to computerized, to entertaining ones. However, as stated by Roegiers & Gérard (1998), textbook is the one that remains by far the most widespread learning support, and undoubtedly the most effective. We can define as textbook (Lebrun, 2007: 2):

Any book or workbook that serve to understand and memorize knowledge which are explicit in programs written by relevant authorities and directed to students from different levels of education.

Due to the relevance of the textbook in our and in other countries education system, from its importance in curriculum development, to the issue of enhancing paths or even the fact it replaces teachers (Cabral, 2003; Vasconcelos e Souto, 2003), several studies have been made, in Portugal and internationally, that have focused on this teaching resource. Our work is included on a *product-oriented research*, in which we study, through the application of content analysis, the nature of knowledge included in textbooks, as well as the underlying values and conceptions. We intend to identify differences between two periods of the Portuguese educational system: Time I (1991-2000) and Time II (2000-2006).

2. Methodology

This study took place within the European research project BIOHEAD-CITIZEN (*STREP 506015 Priority 7 of FP6: Knowledge-based on Economy and Society*) entitled *Biology, Health and Environmental Education for better Citizenship* attended by the following 18 countries: five from the «old» EU (Portugal, France, Germany, Italy, Finland), seven who recently joined (Cyprus, Estonia, Hungary, Lithuania, Malta, Poland and Romania), and six countries of the *International co-operation* (INCO) (Lebanon, Tunisia, Algeria, Morocco, Mozambique and Senegal). We used part of the grid constructed by the project BIOHEAD-CITIZEN on «Ecology and Environmental Education», which were the result of a collective and international work carried out by researchers from all the countries involved in the project. For the grids construction, a sample of textbooks from all countries was analysed in a project meeting, and an initial version of the grids was built. Then, in each country, these grids were pre-tested on at least one textbook. The final version of the grids took into account the results of this pre-test (Caravita, 2008; Carvalho *et al.*, 2009; Tracana, 2009). This final grid was applied by each team in its country textbooks. The problem of subjective interpretation in this kind of qualitative analyse, was controlled by having two analysts applying separately the grids and cross-checking the findings afterwards (Carvalho *et al.*, 2011). In this article we will only mention the results obtained from the analysis of the Portuguese textbooks and specifically the study of *Ecosystems and geochemical cycles* (Carvalho & Clément, 2007). Thus, for the study of *Ecosystems and geochemical cycles* texts and images were analyzed, from textbooks about Environmental Studies, Natural Sciences, Biology and Geography, from the 1st grade (6 years old) to the 12th grade (18 years old). Textbooks were analyzed in two different periods of analysis, Time I: 1991-2000, and Time II: 2000-2008. In this analysis, we did a survey and record the number of occurrences and images according to the indicators that appear in the grids that are shown below (Tracana, 2009).

Table 1 shows us the indicators relating to the axle: complex versus linear, making it relevant to analyze ecosystem settings that appear in the textbooks, as well as the kind of environments that are described. After this initial analysis, we move to the analysis of ecosystem with respect to structural aspects (such as the type of ecological components that appear more often) and relational aspects (both as regards the plurality of relationship between the species and the inter- and intra-specific relationships that occur in ecosystems) present in textbooks.

That said, we noticed the importance that textbooks attribute to urban environments as ecosystems and to ecosystems' dynamics. This last item analyzed the functional description of ecosystems and the ecological changes that occur there, either alerting to issues of ecosystem balance, or looking at the human factors and catastrophic changes.

Axe: Complex vs Linear

Definition of Ecosystem	Ecosystem as a set of abiotic and biotic components	
	Ecosystem as interdependence and mutual influence among abiotic and biotic components	

Environments described in the book	Natural ecosystems (e.g. woods, river, oasis, pond, meadow,...)	
	Rural environment	
	Urban environment	
	Biomes	
	Earth	

Content (Themes, topics)	Indicators	Page number of Images	Figure number of Images	Occurences in text
DESCRIPTION OF ECOSYSTEMS <i>(If present in the book, select the best articulated description of an ecosyste. If not, make reference to the general description)</i>	<i>(Specify here which description of ecosystem you have selected for the analysis of structural and functional indicators)</i> Ecosysytem : (e.g. pond) Biome: (e.g.tropical forests)			
	Structural			
	Variety and plurality in the abiotic components (geological, chemical, climatic)			
	Variety and plurality in the biotic components (more than just one representative of each kind)			
	Mutual influence of biotic and abiotic factors			
	Humans are mentioned among the components			
	Relational			
	Plurality of <i>ecological relationships</i> that link species to their environment:			
	• A – alimentary (<i>Food, webs...</i>)			

	<ul style="list-style-type: none"> B - alimentary plus other relationships (<i>life cycle, rate of birth, nesting, spatial distribution, home range, etc.</i>) 			
	Interspecific and intraspecific relationships:			
	A - only trophic (<i>e.g. predation</i>)			
	B - trophic plus other kind of interactions (<i>e.g. symbiosis, parasitism, competition, social, etc.</i>)			
	Ecological roles of biotic components (<i>producers, consumers, decomposers</i>)			
Populations of species are mentioned				
URBAN ENVIRONMENT				
	Description as ecosystem			
	Variety of urban fauna and flora			
	Positive human interventions			
ECOSYSTEMIC DYNAMICS				
	Functional description of ecosystems			
	Flow of energy through ecosystem			
	Energy dissipation through trophic levels			
	Flow of matter			
	Cycles of chemical elements (O_2, CO_2, N_2, \dots) and water:			
	<ul style="list-style-type: none"> A - single linear paths 			
	<ul style="list-style-type: none"> B - multiple paths 			
	<ul style="list-style-type: none"> C - Links among paths 			
	Ecological changes			
	Equilibrium described as a dynamic condition of ecosystems			
	Concept of climax is explained in dynamic terms			
	Regulatory factors and processes (<i>feed-backs</i>) are mentioned (<i>specify</i>)			
	Daily and seasonal changes are considered as variables in ecosystems			
	Anthropic factor			
	Description of negative human impact			
	Description of positive human intervention			
	Catastrophic changes:			
<ul style="list-style-type: none"> A - natural 				
<ul style="list-style-type: none"> B - of human responsibility (<i>specify</i>) 				
Ecological dynamics of biosphere are considered (<i>specify</i>)				

FIGURE 1. Part of the analysis grid on the axis *Complex versus Linear*.

In Figure 2 we find the indicators that will allow us to characterize the axis: *Humans as owners vs. Humans as guests of nature*. In this axis we analyzed the issue conservation and management of nature, characterizing the motivation for conservation that appears in textbooks. This motivation can be just to preserve the aesthetic aspect for human pleasure, or preserve to prevent depletion of natural resources that are important to the economy, or preserve it to prevent ecological imbalances or else preserve to respect nature and all living beings. As we can see through these indicators, we have those that meet an anthropocentric position as well as those that meet an ecocentric position. However, Almeida (2007) also refers to biocentric perspective, and this breaks with the prospect of mere allocation of value instrumental to living beings.

Axe: Relationship of humans in respect to nature

Content (Themes, topics)	Indicators	Page number of Images	Figure number of Images	Occurences in text
<i>CONSERVATION and MANAGEMENT of NATURE</i>				
	<i>Motivation for Conservation</i> (Only if explicitly mentioned in the text)			
	To preserve a source of aesthetic pleasure for humans			
	To prevent exhaustion of natural resources important for economy			
	To prevent ecological dis-equilibrium			
	To respect nature and all living beings			

FIGURE 2. Part of the analysis grid on the axis *Humans as owners vs. Humans as guests of nature*.

3. Results

The topic *Ecosystems and geochemical cycles* is the third, among Pollution, Resource Use and Biodiversity, most mentioned in Portuguese textbooks. The approach to this topic, throughout education, is presented in Table 1. It appears that this appears more in programmes in Time I than Time II, with coincidence at the level of the following school years: 3, 5, 10, all in the area of Natural Sciences. Emphasis is given to the fact that this topic does not appear in any textbook of Geography.

	1º	2º	3º	4º	5º	6º	7º	8º	9º	10º	10º/11º	12º
T. I			X		X		X			X		X
T. II			X		X			X		X		

TABLE 1. Approach the topic *Ecosystems and geochemical cycles* in the programmes from Time I and Time II.

The current textbooks were selected, when possible, out of the most used ones in schools. Analyzed textbooks that include the theme *Ecosystems and geochemical cycles* are in table 2.

Time I (1996-2000)	Time II (2000-2008)
<ul style="list-style-type: none"> - <i>O Bambi 3</i> (Porto Editora, 1996) – 3rd grade - <i>Bioterra</i> (Porto Editora, 1996) – 5th grade - <i>Planeta Vivo – Ciências Naturais</i> (Porto Editora, 1996) – 7th grade - <i>Terra, Universo de Vida</i> (Porto Editora) – 10th grade - <i>Terra, Universo de Vida (Biologia) – 2ª parte</i> (Porto Editora, 1996) – 12 th grade 	<ul style="list-style-type: none"> - <i>Bambi 3</i> (Porto Editora, 2003) – 3rd grade - <i>Magia da Terra</i> (Porto Editora, 2004) – 5th grade - <i>Bioterra: Sustentabilidade na Terra</i> (Porto Editora, 2005) – 8th grade - <i>Terra, Universo de Vida – 2ª Parte</i> (Porto Editora, 2004) – 10th grade

TABLE 2. Analyzed textbooks in Time I (1991-2000) and Time II (2000-2008) referring to the topic *Ecosystems and geochemical cycles*.

The textbook from Time I that dealt in a more thorough way this theme is the one from 7th grade - *Planeta Vivo Ciências Naturais e Terra* and Time II is the one from 8th year *Bioterra: Sustentabilidade na Terra*. Chart 1 shows various quantitative data relating to the number of pages, number of images, ratio images /page, and the distribution of images into three categories: macroscopic illustrative, those representing data and images which demonstrate the conceptualization that appears in the textbooks analyzed.

		1.º SC		2.º SC		3.º SC		High School		Total
		3.º	5.º	7.º (S)	8.º	10.º (S)	12.º			
T I M E I	N of pages	2	11	65	-	5	31	114		
	N of images	5	28	114	-	5	50	202		
	ratio images / page	2,5	2,5	1,7	-	1	1,6	-		
	macroscopic illustrative image	-	23	58	-	1	21	103		
	Image with empirical data	-	-	-	-	-	17	17		
	Image with conceptualization	5	2	38	-	4	6	55		

T I M E II	N of pages	10	28	-	74	10	-	122
	N of images	27	67	-	167	9	-	270
	ratio images / page	2,7	2,4	-	2,3	0,9	-	-
	macroscopic illustrative image *	6	56	-	112	1	-	175
	Image with empirical data **	-	-	-	-	-	-	-
	Image with conceptualization ***	10	-	-	15	2	-	27

S – Science

* Macroscopic illustrative image: are the macroscopic figures without being from the microscopes

** Image with empirical data: are those that show the graphs and data tables

*** Image with conceptualization: are those with a concept map

CHART 1. Relationship between the number of pages on *Ecosystems and geochemical cycles* and the number of images and their distribution among the three main categories: illustrative, with empirical data and images with conceptualization.

The average number of pages for this topic is 57 on Time I and 61 on Time II, with a wide variation between them as it can be observed in the analysis of Table 1. Although T. II encompasses one less textbook than T. I, dedicated to this topic, the number of pages dedicated to it is superior, suggesting that currently the authors give it more consideration.

The macroscopic illustrative images are the most frequent, both in the textbooks of Time I (103) and Time II (175). Images showing quantitative data are rare. Only 12th grade Biology textbook presents them on Time I (17 images). The images that illustrate conceptualization about the theme appear in large numbers only in textbooks that discuss this topic with greater comprehensiveness, as the 7th grade of T. I and the 8th grade of T. II (Figure 1). The latest textbooks, from Time II, show a greater number of images (270), meaning a greater attention to the iconic aspect, thereby making the textbook more appealing either to the student or to the teacher, one should note that this last one is the responsible for its choice. One of the common aspects to all years of schooling and both Times is that the selected historical retrospective on this topic does not appear in reference. In addressing the topic *Ecosystems and geochemical cycles* we focus our analysis on two axes: «complex versus linear» and «human as owners versus human as guests of nature.»

In the study of axis «Complex Linear versus» we addressed the following points: *i) definition of Ecosystem, ii) type of environment, iii) structural aspect, iv) description of the ecosystem, v) ecosystem dynamic.*

With regard to how the ecosystem is defined in textbooks, we noted that at the level of the 3rd grade, there isn't any *definition of ecosystem* in the textbooks studied. In the following grades, we found that the ecosystem concept had a growing complexity from the 5th grade to the remaining grades (7th and 8th, 10th and 12th). The notion, in the 5th grade, is that the ecosystem as *a set of abiotic and biotic factors* while in other grades the emphasis is on *interdependence and*

mutual influence. It is interesting to note that although in Time II this topic does not appear in the 7th grade, as it appears in Time I, the definition of ecosystem is the same in the 8th grade textbook, which allows us to see that there was a transfer of content from the 7th to the 8th grade in recent Times.

By analyzing *the type of environments* that are referenced in the textbooks, we found that, except for the 3rd grade of Time I, *natural environment* is the one that appears in all grades. The type of environment (rural, urban, biomes or Earth) that appears in textbooks is another topic, which is a part of our analysis grid (Figure 1).

In Time I, there isn't uniformity in the type of environments mentioned above; there even is an increase of complexity in the type of environments associated with the ecosystem, because the environment Earth only appears in the 12th grade. Another aspect to be highlighted at the level of Time I is the notion of *rural and urban environment* (7th grade) associated with an ecosystem that does not appear in any other grade. In the latest textbooks there is uniformity regarding the type of environments, concerning the ecosystem and that refers to the *natural environment and Earth* (5th, 8th and 10th grade). In terms of the 8th grade *biomes* appear as one of the environment types described to an ecosystem.

Another important factor in the analysis of the concept of Ecosystems and geochemical cycles concerns their structural aspect (Figure 1): abiotic components; biotic components, and the Humans as a component of the ecosystem.

Once again, it shows an increase in the complexity of content as we move forward in education. For example, at the level of 3rd grade, it is only mentioned, and only in T. II, the aspect of plurality of biotic components. In the remaining grades are mentioned *abiotic components*, *mutual influence of abiotic and biotic* as well as the *Humans* being referred as a structural component of the ecosystem. An important aspect, which should be highlighted in this analysis, is the fact that only the *Humans* is referred to as an *ecosystem component* in textbooks from T. II (8th and 10th grade). Generally speaking, we can say that the greatest number of textual occurrences refers to the factor *mutual influence of abiotic and biotic components* in both Time I and Time II, there is, of course, certain exceptions like the 7th grade (IT) and 8th grade (T. II).

In addressing the item *relationship* established in an ecosystem (*plurality of ecological relationships between species and interspecific, intraspecific relationships, ecological rules of biotic components and species populations*), we noticed that there is no such uniformity among the grades as it has been observed in the cases above. In this item, it is on the 5th grade that there isn't any reference, in Time I nor in Time II. Another aspect to be highlighted is the fact that in the textbooks of Time II, there are more references to this item and mainly in the 8th grade. We cannot forget that this textbook is exclusively dedicated to the theme of ecology. The results show us that comparing *intraspecific and interspecific relations*, it is in the textbooks for the 7th grade (T. I) and 8th grade (T. II) that most textual occurrences appear, noticing once more an uniformity between the 7th and 8th grade, as previously mentioned. With regard to more advanced grades (10th and 12th grade) references regarding this item are not significant when compared with previous grades (7th and 8th grade). The same is true when we study the case of *ecological rules and species populations* as previously referred. If we look at textbooks

as a whole (Table 3), we find that interspecific and intraspecific relationships are more referenced in textbooks (232 total occurrences) in contrast to the plurality of ecological relationships between species, with 103 total occurrences.

	Plurality of <i>ecological relationships</i> that link species to their environment:				Interspecific and intraspecific relationships:								Total
	Alimentary (Food, webs...)		Alimentary plus other relationships		Only trophic		Trophic plus other kind of interactions		Ecological roles of biotic components		Populations of species are mentioned		
	T	I	T	I	T	I	T	I	T	I	T	I	
T. I	49	18	0	0	12	5	20	15	39	11	20	8	217
T. II	26	10	0	0	7	6	24	2	13	5	42	3	138
Sub-Total	75	28	0	0	19	11	44	17	52	16	62	11	
Total	103				232								

TABLE 3. Distribution of occurrences, text and images, the *plurality of the ecological relationships between species and intraspecific, interspecific relationships*, in textbooks from Time I (1991-2000) and Time II (2000-2008).

With regard to the plurality of ecological relationships, textbooks only present food relations, not giving emphasis to other relations such as life cycle, spatial distribution among others. This shows that the textbook has a deficit on this issue. The ecosystem seen as *urban ecosystem* (Figure 1) only appears in the textbooks analyzed, with a textual occurrence and with an image or otherwise it is not even addressed. There is then a reference to its description in the 7th grade (T. I) and 8 grade (T. II) and reference to the *variety of urban fauna and flora* in the 7th grade (T. I) and 10th grade (T. II). This shows that the urban ecosystem is not relevant when studying the various types of ecosystems, even seeming that it is not considered as an ecosystem because it is a city.

The *dynamics of ecosystems* is another item that we examined, and for this we addressed the functionality of ecosystems, as can be seen in Figure 1.

We found that in textbooks from the 3rd and 5th year, in both Times, the functional part of the ecosystem is not addressed, only being from the 7th grade (T. I) and 8th grade (T. II) on, which comes to reinforce that as we advance in education, the contents become more complex. Again is at the level of the 7th grade (T. I) and 8th grade (T. II) that a larger number of textual occurrences related to this issue appear, where *energy transfer, the energy dissipation and matter transfer* are referred. It should be stressed that only in the 8th grade (T. II) textbook, a mention of *cycles* (carbon, water) appears, although there are only two textual occurrences. This shows that these textbooks are deficient in terms of the understanding about the functioning of an ecosystem.

When we look at the *ecosystems dynamics* on the one hand, we look at the *functionality of the ecosystem*, as referred to above, and on the other hand to *ecological changes* (Figure 1), which address human interference in the ecosystem, as well as catastrophic changes.

When analyzing the *ecological changes*, a topic within the *dynamics of ecosystems*, we noticed that at the level of the 3rd grade (T. II) only a reference to *dynamic equilibrium* appears. In the 5th grade textbook references to *anthropocentric factors* appear, however only one occurrence and an image in T. I and T. II respectively, which is not significant. In reviewing the textbooks from the 3rd basic cycle of education (7th of T. I, and 8th of T. II) and Secondary education (10th of T. I and T. II, and 12th of the T. I), we found that in the 8th grade textbook (T. II) there are more occurrences as well as a greater number of analyzed factors involved in the major theme, which is the *ecosystems dynamics*. It should be stressed that at the level of the 8th grade textbook (T. II) a great emphasis on *human* impacts on the ecosystem is given, both for its positive intervention and its negative intervention (which is markedly higher). For example, in the 12th grade great importance to *ecosystem dynamics* is not given, because only three occurrences appear at the level of *concept of climax*, leaving all other aspects without any reference. The issue of ecosystems dynamic is of great importance to realize the way of its operation. However, as noticed above, this issue is not very often referenced in the textbooks that we studied, presenting itself as a failure at the level of content. Again, this reinforces what was said previously, for the failures in content.

In the analysis of the axis Human as owners *versus* Human as guests, we approached the *motivation for conservation* (Figure 2), given the following items: *To preserve a source of aesthetic pleasure for humans; To prevent exhaustion of natural resources important for economy, To prevent ecological dis-equilibrium, To respect nature and all living beings.*

We found that the textbooks from the 3rd grade (T. I and T. II), 10th grade (T. I and T. II) and 12th grade (T. I) show no reference to this aspect, both in terms of image and in terms of textual occurrences. At the level of the 5th grade, in both Times, the only reference that appears to *respect for nature and living beings*, as well as in the 7th grade textbook (T. I) with only one textual occurrence in this case. Finally, in the 8th grade textbook in Time II, there are references concerning all items, being the least representative *prevent the extinction of natural resources important to the economy*, with only one occurrence. In this textbook, the utmost importance to *prevent ecological imbalance and respect nature and all living beings* is given. These results highlight, as the most important aspect, respect for nature and all living things as motivation for nature conservation.

4. Discussion

In the textbooks that address the topic of *Ecosystems and geochemical cycles*, we found that Time II has more pages and pictures dedicated to it, although in this analysis period there is one less textbook. This may be indicative of the fact that these textbooks develop this theme more than the textbooks of Time I. In relation to images, the opposite happens in relation to other issues, since the ones from Time II have more images meeting the results found by Silva Carneiro (1997) and Martins (1997), who found that the textbooks used a decade ago had fewer images, in comparison with the most recent ones.

The existence of a large number of images makes the textbook more appealing either to the students that study by them, or to the teacher who was a part of the selection of textbooks at school. It is important to highlight that textbooks convey either ideological or epistemological values either in an explicit or implicit way, and incorporates a large set of messages «hidden» in the textual explanation and images (Jacob, 1988). We emphasize that the description of contents, about this issue, shows a clear distinction between ecology (i.e. the description of ecological components, their relationships and processes in the «natural» world) and environmental issues (i.e. the description of the effects produced in natural world, by humans).

A relevant aspect, which is common to the topics analyzed above, is the absence of historical question. The lack of historical perspective leads to the descontextualization of facts and phenomena, which are illustrated in this topic, leading to a failure to promote a comparative analysis, or even the search for a relationship between other facts and events in cultural human development.

The concept of *ecosystem*, although not explained in the 3rd grade, appears in a growing complexity as education develops. This is in accordance with the capacity of grasping the concepts, which develops with age. It starts as being defined as a mere set of factors and ending with the explanation of their interconnections, since in nature what we see is a set of interdependent relationships.

A common aspect in the analysis of this axis is that it is at the level of the 7th grade (Time I) and 8th grade (Time II) textbooks, that there are more textual references and images. This meets what has been previously discussed, when we referred to the fact that the transition of curricula from Time I to Time II, this issue was no longer addressed at the level of the 7th grade and passed to the 8th grade. It should also be highlighted that the curriculum for the 8th grade is, all of it, dedicated to contents of Ecology, which in turn was implemented in the corresponding textbook, as we can see from its analysis.

One issue analyzed in the topic *Ecosystems and geochemical cycles* was the notion of *Urban Ecosystem*, which was treated in a very narrow way, which seemed to indicate that when it comes to ecosystems we are only referring to so-called «natural» ecosystems, not considering cities as an ecosystem with its abiotic, biotic factors and their interconnection. Therefore, we can say that the ecosystem concept is presented in a reductionist approach.

Yet, in this axis, three important points have to be considered: the structural aspect of the ecosystem, the functional aspect and dynamics of ecosystems. Of them all, the functional aspect was the most covered in all textbooks under consideration. The authors of the textbooks attributed greater importance to food chain relationships that were established between the different species and the environment, as well as the inter-and intraspecific relationships, and within these references to populations of existing species in this environment were essentially highlighted.

An important point which shows a general failure of textbooks has to do with the lack of conceptualization of certain ecological phenomena, which leads to a simplistic treatment of certain facts. Since our objective is to analyze the issue of EA to the citizenship education of our students, we found that the textbooks are faulty eg little or no reference to regulatory processes that take place at the level of ecosystems as a result of disturbing natural phenomena, failure at the level of

definition of certain concepts such as resilience and robustness of an ecosystem. The balance of the natural system should be treated as a metaphor, a model rather than a fact (Zimmerman & Cuddington, 2007). According to Caravita and colleagues (2008), although the ecological sciences have a «robust» tradition in the field of life sciences, many of the ecological problems situated in specific contexts, call for a multidisciplinary approach through the synergy between science experts and social sciences experts. As long as we do not address ecology from a holistic point of view, we'll always have a simplistic and reductionist view of ecosystem.

In recent decades, Humanity has been changing ecosystems worldwide, not only in order to find what they need, such as food, water, minerals, oil, among others, but fundamentally diverting natural resources to meet the cultural metabolism of developed societies. The difficulty of finding a compromise between the protection / preservation of the integrity of the environment and the requirements of human economic development is stated in terms of a stereotypical complaint about the destructive presence of humans on Earth (Caravita *et al.*, 2008). In this perspective we analyzed the motivations for the conservation of ecosystems that textbooks under study conveyed.

Among these motivations for conservation, we analyzed: *save to preserve the source of aesthetic pleasure of humans*, *save to prevent the depletion of important natural resources to the economy*, *save to prevent ecological imbalances* and *save to respect nature and all living beings*. From our study two positions towards nature emerged: the anthropocentric position and the ecocentric position. We noted, in textbooks, that little consideration was given to this issue, since only in the 8th grade (Time II) there was a higher number of occurrences, the most representative were the defenders of a position of preserving nature, advocating an ecocentric conceptualization. We can thus say that these textbooks placed humans as guests and not owners. However, although the few occurrences are from ecocentric positions, we cannot say that a great emphasis to this situation is given.

5. Conclusion

Textbooks are essentially about ecological content, giving little emphasis to the perspective of environmental protection in order to increase students' behavior changes, attitude changes, inclusion in social groups that are connected to the protection of the environment. The way the textbooks treat this concept, give us more detailed information about the possible problems of its didactical transposition such as we find in the work of Peña and Quílez (2001).

These results show that if we want an education facing sustainability, which is recommended in official documents, textbooks should be improved in order to introduce more and better information about sustainability and promote citizenship. Although ecological sciences have a tradition rooted in the field of sciences of life, many of the ecological problems call for an intervention, through synergies between the natural sciences and the social sciences, which is not reflected in the textbooks.

We find therefore that there is an urgent need to improve the textbooks, not only in Portugal but also in several other countries involved in this study. Adding

great problems of our time may contribute to children and young people becoming participative adults and concerned about the reality that surrounds them.

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