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ECOSYSTEMS AND GEOCHEMICAL CYCLES IN PORTUGUESE TEXTBOOKS OF TWO HISTORICAL PERIODS

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Abstract: The present study intends to analyse the didactic transposition of the topic Ecosystems and Cycles, in national programmes and textbooks of the Portuguese education system in the period between 1991 and 2006. The changes during this period in the "national Portuguese curricula" and respective "competencies" were identified from primary up to the secondary school level (12 years of schooling). Their respective contents were analysed in order to identify topics where Ecosystems and Cycles were addressed in the national programmes. From this analysis, respective textbooks of Environmental Studies, Natural Sciences, Biology, Ecology, Geology and Geography, Social Studies and Chemistry where Ecosystems and Cycles where the topic of Ecosystems and Cycles was present were analysed. Results showed two periods: Time I (1991 – 2000) showing more developed approach to the presentation of the subjects as compared with Time II (2000 – 2006). The textbooks approach is essentially ecocentric and focused in knowledge contents. It was concluded that in addition to the need of improving some contents, approaches concerning environmental education skills are a matter that need to be taken into account in textbooks so that students can be active citizens regarding environment issues and thus contribute to a better quality of life on Earth.

Keywords: Ecosystems, Geochemical Cycles, Textbooks, Education system

INTRODUCTION

The Earth has a great environmental diversity, with a wide range of organisms, which are related to each other and to the environment in very different ways. 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. There is a structure of the abiotic factors and a structure of the entire population, both with their distribution in time and space. The latter is considered the trophic structure, which corresponds to the flows of matter and energy. An interesting point, when discussing ecosystems, is related to the position of humans in the trophic structure and the humans in nature. Most ecologists argue that humans are part of the ecosystem and one of their major influence on the ecosystem is reflected on the economic impact. Generally speaking, one can say that the value of the ecosystem can be estimated, taking into account whether it can be consumed or not (Begon et al., 2007; Westra, 2008).

Nowadays there is a great set of educational media available to teachers, from audiovisual to on-line products, including entertaining products. However, as stated by Gérard & Roegiers (1998), textbook is the one that remains by far the most widespread students'

learning support, and undoubtedly the most effective one. Due to the relevance of the textbook in the education system of many countries, with its importance in curriculum development and support for teachers preparing their lessons (Cabral, 2003, Vasconcelos e Souto, 2003), several studies have been made internationally, as well as in Portugal, that have focused on this teaching resource (e.g. Bernard et al., 2008; Castéra et al., 2008; Carvalho et al, 2008; Clément et al., 2008; Carvalho et al., 2011; Tracana & Carvalho, 2012; Tracana, Ferreira & Carvalho 2012; 2014a, 20124b) . In the present work it was intended to identify differences in the approaches about the topic Ecosystems and Cycles in two historical periods of the Portuguese educational system, Time I (1991-2000) and Time II (2000 - 2006). Content analysis was applied to investigate the nature of knowledge included in textbooks, as well as the underlying values .

METHOD

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*" including 19 countries (Carvalho, 2004; Carvalho & Clément, 2007). A grid for textbook analysis on the topic "Ecology and Environmental Education" was constructed by researchers from all the countries involved in the BIOHEAD-CITIZEN project consortium (Tracana, 2009). The present work focus on the part of this grid on the subtopic "Ecosystems and geochemical cycles".

Texts and images of Portuguese textbooks were analysed. They were textbooks from the 1st grade (6 years old) to the 12th grade (18 years old) of the following subjects: Environmental Studies, Natural Sciences, Biology and Geography. Textbooks of two different periods were analysed, Time I: 1991-2000, and Time II: 2000-2008. In this analysis, an examination and recording of the number of occurrences and images was carried out, following the indicators that appear in the grids of analysis.

Figure 1 shows the indicators concerning the 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.

RESULTS

Regarding how the ecosystem is defined in textbooks, we noted that at the level of the 3rd grade, there is not any *definition of ecosystem* in the studied textbooks. In the following grades, the ecosystem concept had a growing complexity from the 5th grade to the subsequent grades: 7^{th} and 8^{th}, 10^{th} and 12^{th} grade.

In the 5th grade, the notion is that the ecosystem is *a set of abiotic and biotic factors* while in other grades the emphasis is given to the *interdependence and mutual influence*. It is interesting to note that although in Time II (T.II) this topic does not appear in the 7th grade, as it appears in Time I (T.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.

An important aspect, which should be highlighted in this analysis, is the fact that only the Humans are 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. However, there are some exceptions like in the 7th grade (T.I) and 8th grade (T.II) textbooks.

Content (Themes, topics)	Indicators	Page number of Images	Figure number of Images	Occurrences in text
DESCRIPTION OF ECOSYSTEMS *(If present in the book, select the best articulated description of an ecosyste. If not, make reference to the general description)*	*(Specify here which description of ecosystem you have selected for the analysis of structural and functional indicators)* ***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 *ecological relationships* that link species to their environment:			
	• **A** – alimentary *(Food, webs ..)*			
	• **B** - alimentary **plus** other relationships *(life cycle, rate of birth, nesting, spatial distribution, home range, etc.)*			
	Interspecific and intraspecific relationships:			
	A - only trophic *(e.g. predation)*			
	B - trophic **plus** other kind of interactions *(e.g. symbiosis, parasitism, competion, social, etc.)*			
	Ecological roles of biotic components *(producers, consumers, decomposers)*			
	Populations of species are mentioned			

Figure 1. Part of the grid of analysis of BIOHEAD-CITIZEN project, showing indicators for structural and relational aspects.

Concerning the plurality of ecological relationships (Table 1), textbooks only present food relations, not giving emphasis to other relations such as life cycle, indicating that textbook have a deficit on this issue. Comparing Time I with Time II, it becomes clear that Time I has generally more occurrences in text and images than Time II, except in text

concerning *Trophic and other kind of interrelations* and *Populations of species images* on *Only trophic* (Table 1).

Table 1: Distribution of textual and images Occurrences of the plurality of ecological relationships between species and the relations inter-specific and intra-specific in textbooks from Time I and Time II

	Plurality of ecological relationships between species				**Inter- specific relationships , intraspecific**								**Total**
	Food		**Food +**		**Only trophic**		**Trophic and other kind of interrelations**		**Ecological rules of the components**		**Populations of species**		
	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**								

The ecosystem seen as *urban ecosystem* only appears in the textbooks analysed, 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.

DISCUSSION AND CONCLUSIONS

In the textbooks that address the subtopic of *Ecosystems and geochemical cycles*, we found that Time I has more pages and pictures dedicated to it. This may be indicative of the fact that these textbooks develop this theme more than the textbooks of Time II. It is important to take into account that the textbooks transmit either ideological values as epistemological ones, either explicitly or implicitly, and incorporates a large set of "hidden" messages in text and displayed images (Jacob, 1988). The contents show a clear distinction between ecology (*i.e.* the description of ecological components, their relationships and processes in the world, "natural") and the Environmental Affairs (i.e. the description of the effects produced in the natural world, by man). The absence of historical perspective does not allow the contextualization of facts and phenomena and so hampers comparative analysis or relationships between facts and events in human cultural 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.

At the level of the 7th grade (Time I) and 8th grade (Time II) textbooks, are more textual references and images. This is in agreement with what we 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.

An aspect analysed in this topic, Ecosystems and Cycles, was the notion of Urban Ecosystem, which was treated in a limited way indicating that the study of ecosystems only refers to the so-called "natural" ecosystems, not considering the cities as an ecosystem, with their biotic and abiotic factors in interconnection. Therefore, we can say that the ecosystem concept is presented in a reductionist view. The functional aspect was the most discussed in all textbooks. The textbook authors attributed greater importance to food relation established between the different species and the environment, as well as to relations inter- and intra- species, and within these enhanced essentially references to existing species populations in this environment.

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 promoting 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 whatsoever reflected in the textbooks.

These results show that there is a need to improve the Portuguese textbooks by adding relevant social problems of our time that may contribute to make children and young people more participative in environmental problems surrounding them, not only at their early ages but also in their future, when being adults.

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