Ecological systems and environmental problems in science textbooks between simplification and complexity

A cross-cultural study on secondary school manuals

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As countries around the world face complex environmental and social issues, there is a growing recognition that education has a key role to play.

It is critical that we help students understand how our individual and collective behaviour affects the environment, and how environmentally responsible lifestyles can contribute to healthy, sustainable ecosystems.

Environmental education is a vital tool that helps young people understand the nature and complexity of environmental challenges and builds their capacity to take appropriate action

Environmental education is education about the environment, for the environment, and in the environment that promotes an understanding of, rich and active experience in, and an appreciation for the dynamic interactions of:

- the Earth's physical and biological systems;
- the dependency of our social and economic systems on these natural systems;
- the scientific and human dimensions of environmental issues;
- the positive and negative consequences, both intended and unintended, of the interactions between humancreated and natural systems.

Environmental education enables students to develop the knowledge and skills they need to be environmentally active and responsible citizens and to apply their knowledge and skills cooperatively to effect long-term change.

To support student learning, teachers are encouraged to develop the knowledge, skills, and perspectives that will enable them to teach confidently about environmental issues and expose students to varied points of view.

Because environmental education is an integrative undertaking that allows for teaching across disciplines, educators also need the skills to link approaches and content from various disciplines to help students understand complex environmental issues and guide them towards environmental literacy.

Objectives of the study

Many questions therefore underlie our study:

It aims at checking the place that ecology and EE have in science textbooks, at assessing how the exposition of the contents reflects the development of ecological sciences, mainly whether they take into account the widely shared recommendations to the educational systems that are stated in the documents of international conferences and organizations, such as the Agenda21 and that are backed by scientific arguments in the literature (Sauvé, 1997; Goffin, 1998; Mortari, 1998; Falchetti & Caravita, 2005)

Obviously, the educational practices in the school classes are in the teachers': they decide the role of textbooks in the learning environments.

Anyway, textbooks are one possible "look-out" for gaining information on teaching, also considering that they reflect the kind of didactical transposition of science to which the prevalent culture of the country gives credit (Chevallard, 1989).

Methodology

We designed grids for the analysis of text and images of the textbooks to find out to which extent:

(1) The complexity of the ecosystems and their working is simplified in the exposition and schematizations;

(2) The textbooks support the development of a systemic approach to and a dynamic interpretation of local and global cases dealing with polluting agents and related environmental problems;

(3) The implicit conceptions are instantiated in the images that illustrate the environments and in the exposition of emblematic examples of environmental issues;

(4) The authors are sensitive to ideas of environmental identity, promote reflexive thinking on the specific nature of the human relationship with the environment;

(5) The approach to the complexity of environmental issues is dogmatic, non-historical, scientist and relies on linear causality.

This paper focuses on **ecosystems and cycles (EC) and pollution (Po)** and it will report only the data about the presence of two out of four conceptions that have been targeted by the entire analyses, that is: **Complex vs. linear and relationship of humans in respect to nature**.

The complex vs. linear view was characterized as follows when instantiated in EC or in Po:

(1) Webs vs. chains of ecological components;
(2) High number and diversity of components of the ecological webs vs. stereotyped simplification of their components;
(3) Functional vs. structural description. A functional perspective highlights factors, variables, constraints;
(4) Inter-dependence among the components vs. one-way relationships;
(5) Presence vs. absence of feedbacks, retroactions, cycles;
(6) Time scales consideration, reversibility of processes vs. “here and now” descriptions;
(7) Interpretation of events from systems as emergent from co-factors, from parallel processing vs description/explanation of events deterministically caused.

Interpretation of events as emergent from systems of co-factors, from parallel processing vs description/explanation of events deterministically caused, results of linear chains of causes.

The conception of the relationship of humans in respect to nature was characterized in terms of viewing humans as owners of nature and environment in opposition with humans as guests of the Earth together with other living beings. We outlined it as follows:

(1) Humans as part of nature vs. humans as observers;

(2) Planet as a resource for humankind vs. planet as a resource shared with other living beings;

(3) Emphasis on the attainment of economical aims vs. social, cultural, ethical, aesthetical aims;

(4) Humans only considered to be an external source of pressures, pollution and destruction vs. humans as users and responsible managers of resources;

(5) Human benefits vs. ecological benefits considered in the evaluation of the impact, costs, priorities;

(6) Emphasis on risks, catastrophes, problems vs. balanced information about problems and about possible solutions;

(7) Unlimited trust in science and technology solutions vs. principle of precaution, on one side, and citizen's participation, on another side.

Results

Conception complex vs. linear

1. Sub-topic ecosystem and cycles (EC)

We cannot claim that the descriptions of ecosystems is presented in an oversimplified way in the exposition of textbooks, either in the Italian either in the Moroccan books, but we can certainly state that the structural aspects are more articulated than the relational and the dynamical ones, either in the text and in the images.

Most importantly, the textbooks' view of ecology is rather superficial and incomplete.

What we did not find treated in the content of the manuals is a long list that mainly points out the absence of detailed illustration of concrete, contextualized examples of ecological phenomena that avoids simplistic treatment of facts.

We will underline in particular some of the deficiencies that have negative consequences on the construction of "scientific" citizenship.

Very rarely are mentioned or described:

• processes of regulation that take place at the ecosystems or at micro-ecosystems level as a consequence of natural (even cyclic) perturbing factors;

• ecosystems at life limits that can well illustrate the interplay between ecological and biological factors;

• variables and conditions that modify and modulate the ecological events.

• Discussion on the role that ecosystems' size and level of complexity may have, but also time, severity and persistence of perturbing factors are an important content.

• The concepts of resilience, of robustness of ecosystems should be defined.

• The "balance of natural system" should be treated as a metaphor, a model rather than a fact (Zimmerman & Cuddington, 2007).

The illustration of emblematic concrete (successful and unsuccessful) cases of management of ecosystems, of wildlife conservation might improve the comprehension of the controversial control of anthropic factors.

Different kinds of empirical data produced by scientific studies, the use and meaning of statistical analysis, the possibilities offered by the application of new methodologies like simulation, should be essential components of the information conveyed by the manuals to make more intelligible the role of ecology as science in the interpretation of ecosystems' changes and in the management of the environment.

In the majority of the examined textbooks, the issue of pollution is treated in a fragmentary way, as an added “call of attention” often in relation to the description of the environmental components or to human body affected by dangerous agents.

An organic exposition, that highlights and defines concepts necessary for a deep understanding of the phenomena and relevant for facilitating generalizations, is lacking.

Surprisingly, in higher respect to lower secondary school, the exposition of the environmental issues does not attain higher levels of information and does not consider their complexity in a more articulated way.

Analyses of the factors, the drawbacks that influence the success of concrete interventions for controlling or preventing pollution are lacking.

The relation between potential solutions and contextual features is never highlighted.

The participation of people, the role of local expertise are never mentioned.

The limits of available knowledge, the new frontiers of research and the arguments raised in the scientific debate are never or rarely considered.

Reference to plurality of perspectives and theoretical frames, to their consequences on the choice of methodological approaches, argumentation about the origin of the disagreements in interpretation and in the design of solutions, instantiate epistemological values that are crucial in EE to prevent dogmatic attitudes and to make citizens more acceptant of the approximation to satisfying solutions when many trade-offs have to be evaluated in the complex problems that characterize most of the ecological issues.

Conception relation of humans respect to nature

We can only summarize some general conclusions and comments about the implicit *conception* of human-environment relationship that is conveyed by these manuals.

The conflict of interests between humankind and nature takes the shades of a philosophical dilemma.

The difficulty of finding a compromise between the protection/preservation of environmental “integrity” and the demands of the development of human economy is stated in terms of a stereotyped complaint about the destructive presence of humans on the Earth.

The attitudes conveyed by analyzed textbooks might be classified into the following types:

- fatalistic,
- blaming (“man is guilty”!),
- responsibilizing,
- objectivizing (“interest of environment are also the interest of the human species”),
- optimistic and mainly based on trust in the progress of science and technology.

Thus, the appeal to a generic responsibility of humans substitutes the identification of real cases, the pointing out of specific responsibilities of agents, the highlighting of concrete policies that might be explored at different levels in the organization of a society: economic, social and political.

The neutral informative style of the exposition buries any emotional implication under a veil of neutral, reassuring and pretended rationality.

Conclusion

What can we gain from the comparison between the outcomes of the textbooks' analysis in these two countries?

Slight differences can be pointed out. The most outstanding conclusion is that, regardless of obvious cultural differences and differences in the environmental contexts, the topics of ecology and pollution are treated in a very similar way.

We have also observed that the types of pollution, the kind of events that are considered and the accidents that are illustrated are often the same in the Moroccan and in the Italian textbooks.

Even images and schematizations tend to be similar.

In both countries the majority of the figurative images point out the “bad deeds” of humans. Some of the images that show a less aggressive interaction of humans with their environment concern cases in foreign, and sometimes exotic countries.

We must conclude that a globalized approach to EE is prevailing on the attention to the construction of students' environmental identity

This approach is in contrast with the aim of EE.