Genetically Modified and Transgenic Organisms: a study focusing on 9th grade Portuguese textbooks

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1 - CONTEXT OF THE RESEARCH

School science education should promote the development of informed, critical, active and responsible citizens by approaching socio-scientific controversial issues.

By dealing with such issues, science education may raise students' motivation and engagement in learning and understanding the physical and natural world and foster the development of their cognitive, social, moral, ethical and emotional abilities, as well as their capacity to take informed decisions.

The production and use of genetically modified organisms (GMO) and transgenic organisms (TO) are among the most controversial socio-scientific issues of our times and it's the incidence of this study.

2 - RESEARCH OBJECTIVE

The objective of this study is to find out how six 9th grade Natural Sciences textbooks that are in use in Portuguese schools approach the GMO and TO issues.

3 - THEORETICAL FRAMEWORK

The teaching of controversial socio-scientific matters such as GMO and TO:

- focuses on themes and concepts needed to promote reflection on non-consensual issues of students' daily lives
- promotes critical thinking and decision-making on controversial subjects by students
- Is targeted to the social, cultural, moral, ethical and environmental factors in which the students are inserted
- fosters the inter-relationships between science, technology, society and environment

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It can lead to informed, critical, active and responsible citizens

An appropriate way for textbooks to deal with controversial socio-scientific matters:

- works as a teaching tool for teachers
- captures and promote students' motivation and interest in everyday issues and social responsibility
- promotes reflexion and critical thinking
- promotes the search for scientifically accepted knowledge
- develops cognitive, social, moral, ethical and emotional capacities
- promotes the use and development of students' prior knowledge
- promotes students' understanding of the relevance of scientific knowledge

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Forms scientifically knowledgeable and responsible citizens

Recent research studies on GMO and TO suggest that:

- the theme is hardly approached in schools
- students hold a variety of alternative conceptions on those issues
- school textbooks which deal with those issues do not do it in the best way

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The teaching approach may make a difference to overcoming students' alternative conceptions

4 - RESEARCH METHODOLOGY

Science Textbooks (ST) analysed

Six science textbooks (ST), 2017 editions, were analysed.

They chosen because they are currently been used in Portuguese schools.

Procedures of data collection and analysis:

- Selection of the textbooks contents to be analysed
- Development of a checklist from another checklist available in literature
- Definition of dimensions and sub-dimensions, partly based on the literature and partly based on the textbooks content
- Content analysis according to the dimensions and sub-dimensions of the checklist
- Data collected based on the categories of analysis: presence or absence of the sub-dimension

Dimensions of analysis focus on three types of issues:

- ***Conceptual:*** the GMO concept; the TO concept; the relationship between GMO and TO; production of GMO and TO; GMO and TO legal framework; and advantages and risks of GMO and TO production and use
- ***Methodological:*** types of activities presented; demands of the activities in terms of students' engagement; and potential of the activities for students' conceptual change promotion
- ***Graphical*:** types of illustrations; relationship with illustrations and text; and relationship of illustrations and students' alternative conceptions on the issues that are at stake

5 - FINDINGS

Table1
Concepts of GMO and TO in Science Textbooks

Dimensions related to Conceptual Issues	Sub-dimensions	Natural Sciences textbooks					
		ST1	ST2	ST3	ST4	ST5	ST6
GMO concept	Refers the concept of GMO	√	√	√	√	√	√
	Refers the acronym of GMO	√	√	√	√	√	---
	Refers the meaning of the GMO acronym	---	√	√	√	√	---
	Gives a correct definition of GMO	---	---	√	---	√	---
TO concept and its relation with GMO	Presents the concept of TO	---	---	---	---	---	---
	Present the concept of GMO as a synonim of TO	---	√	---	---	---	---
	Distinguishes correctly GMO from TO	---	---	√	---	√	---
GMO mentioned in the Textbooks	Mentions cereals (corn, soy, rice)	√	√	---	---	√	√
	Mentions vegetables (potato, pea, tomato)	---	---	---	---	√	---
	Mentions fish (salmon)	√	---	---	---	---	---
	Mentions bacteria (escherichia coli)	√	---	---	√	√	---
	Mentions virus (Pexa-Vec)	√	---	---	---	---	---
Production of GMO and TO	Explains based on the recombinant DNA	---	---	√	√	√	---
Advantages and risks of GMO and TO production and use	Mentions Health advantages	---	√	---	---	√	√
	Mentions Economic advantages	---	√	---	---	√	√
	Mentions Environmental risks	---	√	---	---	---	√
	Mentions Health risks	---	---	---	---	---	√

Table 2
Methodological approaches used by Textbooks

Dimensions related to Methodological issues	Sub-dimensions	Textbooks					
		ST1	ST2	ST3	ST4	ST5	ST6
Types of activities presented	Paper and pencil activities	√	√	√	√	---	√
	Roleplaying	---	---	---	---	---	√
	Group work with discussion	---	---	√	---	---	---
Demands of the activities in terms of students' engagement	High engagement of students	---	---	---	---	---	√
	Medium engagement of students	---	---	√	---	---	---
	Low engagement of students	√	√	---	√	√	---
Potential of the activities for students' conceptual change promotion	Able to promote conceptual change	---	---	√	---	---	√

Table 3
Graphical approach used by the Textbooks

Dimensions related to Graphical isues	Sub-dimensions		Textbooks					
			ST1	ST2	ST3	ST4	ST5	ST6
Types of illustrations	Real photographs		√	√	---	√	√	√
	Drawings-like photographs		√	---	---	---	√	---
	Photographs combined with other elements		---	√	---	√	√	√
	Flow chart		√	---	√	√	√	---
Relationship between illustrations and text	Illustrations are related to the content	Explicitly mentioned	√	---	---	---	√	---
		Not explicitly mentioned	√	√	√	√	√	√
	Illustrations are not related to the content	Simply add new information	---	---	---	---	---	---
		Work as a background to beautify the page	---	√	---	---	√	√
Relationship of illustrations and students' alternative conceptions on the issues that are at stake	Susceptible of promoting the formation of alternative conceptions about GMO and TO		---	√	---	√	√	√
	Susceptible of promoting the construction of scientific correct ideas about GMO and TO		---	---	---	----	√	---
	Neutral		√	---	√	---	----	---

6 – CONCLUSIONS, IMPLICATIONS AND RELEVANCE TO SCIENCE EDUCATION

The findings show that:

- *Conceptual issues:* textbooks deal with the concept of GMO an TO but they do no relate them; they hardly deal with the production of these organisms and rarely provide examples of GMO and TO; they tend to focus more on the advantages of GMO and TO then on their risks. The European and the Portuguese legal framework relative to these organisms is not considered.
- *Methodological issues:* textbooks tend to describe the content and give few activities for students to do, most of which are of the paper and pencil type. Only one textbook presents a team work activity to be followed by a discussion and another textbook presents a roleplaying activity.
- *Graphical issues:* the illustrations used are rarely explicitly mentioned in the text and are often prone to reinforce or induce alternative conceptions.

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The science textbooks analysed are not dealing appropriately with socio-controversial matters like GMO and TO

Therefore:

- Science textbooks need to be carefully analysed to be improved on what concerns to GMO and TO teaching.
- Teachers need to go far behind what textbooks suggest if they are to use GMO and TO to form scientifically knowledgeable and responsible citizens.
- They may need to find ways of developing their competences on these issues.

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