HISTORY AND NATURE OF SCIENCE IN BRAZILIAN PHYSICS TEXTBOOKS: SOME FINDINGS AND PERSPECTIVES

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Abstract

There is agreement in Brazilian and international science teaching community concerning the relevance of teaching history and notions of nature of science at high-school level. Influenced by academic researches, history of science and concepts about nature of science were included in Brazilian scientific curricula during the last decade. Indeed, textbooks play an important role in science education, and usually are the main didactic tool used by teachers and their pupils, having a big influence on the nature of science taught at classrooms. The present paper analyses how and which kind of history appears in some of the most popular Brazilian physics textbooks, focusing on the concepts concerning the nature of science conveyed by these historical narratives. Generally, these books present pseudo-history, which reinforces myths about scientists, misleading teachers and students on their understanding of the nature of science. Finally, we discuss some perspectives and actions towards the improvement of the quality of historical and philosophical contents in textbooks.

Introduction

Usually science teachers pay almost exclusive attention to explicit scientific contents such as concepts, results, formulae and experiments, while they usually leave aside discussions on history of science and nature of science. Such discussions could clarify some aspects of scientific theories that are unclear for students in addition to improve the comprehension of NOS. To teach about NOS opens several new possibilities for science teaching, including influences of historical and cultural contexts; to dismiss some famous scientific myths, to show that currently scientific knowledge is not a definitive truth and is liable to change (Matthews, 1994; Martins & Silva, 2001). Thus, in this perspective, the classroom work with topics and lessons on HPS can contribute to promote a more cultural and contextualized scientific education, favoring a broader understanding of scientific concepts and also notions about how science operates and its relationship with society (Matthews, 1994; McComas et al, 1998).

Nowadays, textbooks play a crucial role in education, particularly in science education, since it is the tool in the relation among the taught contents, teachers and pupils. Thus, it is

important not only to research on the potential of the use of the history of science in education and the importance of teaching on the nature of science (NOS), but also how those ideas are conveyed in textbooks. The present paper analyses how history of science is presented by some of the most popular physics textbooks used in Brazilian high schools. We also take into account the notions about NOS nourished by these historical narratives. Finally, we discuss some perspectives and actions towards improving the quality of historical and philosophical contents in Brazilian textbooks.

Pseudohistory and scientific myths

If, on one hand, historical-philosophical aspects contribute to promote science teaching, on the other hand, its absence and, above all, its misuse generates distorted views on the nature of science. Some historical narratives nourish common views about NOS, which are based on empirical-inductive conceptions and convey the idea that science is constituted of irrefutable truths produced by geniuses (Martins 2006). Those incorrect views on NOS very often are the result of the poor quality of historical and philosophical contents in education. The history of science in secondary education and culture is distorted and oversimplified, it is the so-called "pseudohistory", which main feature it to reinforce common sense stereotypes about what science is and how scientists work (Whitaker, 1979; Allchin, 2004).

Pseudohistory inflates the drama of scientific discoveries, selects few main characters, reads the past in terms of current standards, erases mistakes and contingencies, and portrays critics of "heroes" as silly and irrational. As consequence, pseudohistorical narratives oversimplify the process of science, making it seem that current ideas and theories were inevitable, ignoring the historical context, and suppressing uncertainty from science. Thus, the "scientific truth" is reached as far as the proper method is followed.

Usually, pseudohistorical narratives have a structure that emphasizes aspects such as 1. monumentality: scientists are heroes, with no character flaws; they never err. Their discoveries happen in an instantaneous insight. 2. Idealization: narratives are oversimplified, so that the complexity of scientific enterprise is lost, influences of social and scientific context ignored, "right" contributions highlighted and errors dismissed. 3. Affective drama: profound persistence, heroes versus adversaries, scientists fighting against enemies of truth, etc. 4. Moral of the story: if you have an extraordinary intellectual power, follow the proper scientific method, be persistent and ignore mundane influences, you reach the truth! (Allchin 2003; Allchin 2004).

HPS and NOS in Brazilian textbooks

Brazil, like other Latin American countries, is committed to promote educational reforms aiming at overcoming its significant educational deficit. The Minister of Education has organized the Secondary Education Reform Project in 2000 as part of a broader social development policy that attaches priority to actions in the field of education. One of the tasks of this reform was to set up the National Curricular Parameters (PCN), which, among other issues, emphasizes the social and cultural contextualization as necessary: recognizing Physics as a human construction; teaching aspects of its history and its relationship with cultural, social, political and economic context; recognizing the role of Physics in the production system, understanding the evolution of technology and its dynamic relationship with the evolution of scientific knowledge.

How and which kind of history appears in some of the most popular Brazilian physics textbooks? We answer this question focusing on concepts concerning the nature of science brought by historical narratives. In order to research the historical and epistemological contents and approaches of Brazilian physics textbooks for secondary education, we analyzed sixteen edited didactic collections, from the 1980s up to 2006. Analysis was carried out considering quantity as well as quality of historical contents. The presence of pseudo-history, scientific myths and description of the "scientific method" were also considered.

This paper takes into account the three main categories of analysis defined as: 1. how historical materials are found in didactic collections; 2. ideas about NOS induced by historical contents; 3. quality of the historical information presented. The findings are summarized at table 1.

In the first category, there are three subcategories: 1.1 total absence; 1.2 isolated presence in introductory sections, complementary texts at the end of the chapters or in boxes; 1.3 contents diluted, so that the historical and philosophical contents pervade the text along with formal presentation of theories, concepts, definitions and equations of a common physics textbook.

When analyzing the ideas about NOS induced by historical contents in textbooks, we emphasized those related to scientific methodology taking into account three different subcategories: 2.1 implicit references to the scientific method, where its steps are dispersed along the text; 2.2 by explicit references, that is, when the textbook discusses scientific procedures calling them "scientific method" or "experimental method"; 2.3 by the nature of scientific endeavor discussed as a human construction, emphasizing the contributions of many researchers and the inexistence of a method that assures scientists to reach the same results accepted nowadays.

Regarding the quality of historical narratives presented in textbooks, there are four subcategories: 3.1 excessively simple history, characterized by only dates and short bibliographical notes on the scientists and some of their most famous scientific results; 3.2 Whig historical

accounts, where the old ideas are taken as mistakes and the current ideas as the truth; 3.3 presence of pseudo-history and the reinforcement of popular scientific myths; 3.4 historical contents have satisfactory quality, complement the understandability of scientific subjects, and transmit proper NOS notions.

How historical contents appear			NOS			Quality of historical information			
1.1	1.2	1.3	2.1	2.2	2.3	3.1	3.2	3.3	3.4
	A		A			A	A	A	
	B			B			B	B	
C									
	D	D		D			D	D	D
	E			E		E	E		
	F	F		F			F		F
	G							G	
	H	H			H				H
	I	I			I				I
	J			J		J	J	J	
	K				K		K	K	K
	L					L	L		
	M					M	M	M	
	N		N				N	N	
	O			O		O	O	O	
	P	P			P		P		P

Table 1. Summary of HPS and NOS conveyed in textbooks

Table 1 shows that in the category (1.1), excepting collection C, all the analyzed collections brings historical contents presented in "boxes" and specific sections, such as in historical introductory or complementary texts in chapter ends (1.2). In five collections (D, F, H, I and P) we also notice an overlapping with classification 1.3, since in some subjects the historical content was presented diluted along the main text. Regarding the views on scientific method conveyed by those collections, nine out of the thirteen collections brings ideas about it; among them seven make explicit references to "scientific method" or "experimental method" as a set of rules that assure the scientific knowledge.

Only four collections (H, I, K and P) explain science as a complex enterprise, with no secure methods to be followed; and highlight the influences of humanistic and external factors. For instance, about the scientific method we can quote:

"Although it is common to talk about a scientific method, composed of a series of procedures that would make possible new discoveries, it is unlikely that any scientific discovery has strictly followed such method. The idea that hypotheses and theories arise from the facts or

experiments is not true. Which facts? Which experiments? The choice of some facts or the performance of some experiments indicates that, indeed, hypotheses and theories already existed. In other words, experiments are set or facts are observed in accordance with some theoretical framework previously formulated […]. Thus, a new theory can give to a trivial current fact, as solar eclipses, an exceptional importance. This is the case of the solar eclipse that, in 1919, brought dozes of scientists from many different countries, among them Einstein, to Sobral, a city in Ceará State. This was a privileged place to observe the eclipse. Their goal was to test if light experiences gravitational attraction. This phenomenon had just been predicted by Einstein in his General Theory of Relativity" (Gaspar 2004, p. 12)

Concerning the quality of historical information, there is not a clear pattern, but we can say that the majority of collections resume the historical contents on dates, names and timelines. Their approaches have strong Whig influence and there are much more pseudohistorical narratives, than transposition of good historical studies. Those contents reinforce the popular scientific myths spread on students, teachers' imaginaries.

Final remarks and prospective

The present analysis of Brazilian physics textbooks books for secondary level education shows that it is not rare to find quite simplistic historical discussions that transmit common misconceptions about NOS, with explicit reference to scientific method. In addition, the Whig approach and the reinforcement of popular myths about famous scientists and episodes are also frequently found in those physics textbooks.

However, some recent collections convey more sophisticated contents and discussions concerning history of science and nature of science. The improvements found in those collections may be interpreted as a direct influence of recent Brazilian educational programs, such as the National Curricular Parameters (2000) and the National Program of Textbooks for Secondary Education (2005).

PCN suggests that, among other issues, NOS must be taught together with specific contents; while the National Program of Textbooks evaluates textbooks distributed in Brazilian public schools taking into account many criteria of quality, including how history and philosophy of science are addressed. We believe that such evaluation forces authors and publishers to improve the quality of specific, methodological and didactical contents of textbooks.

References

ALLCHIN, D.: 2003, Scientific myth-conceptions. *Science & Education* 87 (3), 329-351.

ALLCHIN, D.: 2004, Pseudohistory and pseudoscience. *Science & Education* 13 (3), 179-195.

GASPAR, A.: 2004, *Física – Série Brasil*. São Paulo: Editora Ática.

MARTINS, R. A., A maçã de Newton: história, lendas e tolices. *In* Silva, C. C. (Ed.) *Estudos de história e filosofia das ciências: subsídios para aplicação no ensino.* São Paulo: Editora Livraria da Física, 2006.

MARTINS, R. de A. & SILVA, C C.: 2001, Newton and colour: the complex interplay of theory and experiment. *Science & Education* 10 (3), 287-305, 2001.

MATTHEWS, M. R.: 1994, *Science teaching - the role of history and philosophy of science*. New York: Routledge, 1994.

McCOMAS, W. F.: 1996, Ten myths of science: reexamining what we think about the nature of science, *School Science and Mathematics* 96(1), 10-16.

McCOMAS, W. F., ALMAZROA, H. and CLOUGH, M.: 1998, "The nature of science in science education: an introduction", *Science & Education*, 7, 511-532.

WHITAKER, M. A. B.: 1979, History and Quasi-history in Physics Education. *Physics Education* 14, 108-112 e 239-242.

Appendix 1 – Analyzed textbooks

A: **Alicerces da Física** – volume 1 (6ª ed., 1993)

Authors: Carlos Tadashi Shigekiyo, Kazuhito Yamamoto, Luiz Felipe Fuke.

Publisher: Saraiva. São Paulo, SP.

B: **Aulas de Física** – volumes 1 (7ª ed., 1996), 2 (6ª ed., 1997), 3 (16ª ed., 1995)

Authors: Nicolau Gilberto Ferraro, Paulo Antonio de Toledo Soares, José Ivan Cardoso dos Santos.

Publisher: Atual. São Paulo, SP.

C: **Bases da Física –** volumes 1 (1ª ed., 1981), 3 (1ª ed., 1982)

Authors: Francisco Ramalho Júnior, Gerson Herskowicz, Valdemar Scolfaro.

Publisher: Moderna. São Paulo, SP.

D: **Curso de Física –** volumes 1 (3ª ed., 1992), 2 (3ª ed., 1993), 3 (2ª ed., 1986)

Authors: Beatriz Alvarenga Álvares, Antônio Máximo Ribeiro da Luz.

Publisher: Harbra. São Paulo, SP.

E: **Estudos de Física –** volumes 1, 2 (2ª ed., 1982)

Authors: Paulo Toru Ueno, Issao Yamamoto.

Publisher: Moderna. São Paulo, SP.

F: **Física** – volumes 1, 2, 3 (1ª ed., 2002)

Authors: Fernando Cabral, Alexandre Lago.

Publisher: Harbra. São Paulo, SP.

G: **Física** – volume 1 (1ª ed., 2002)

Authors: José Antonio Fernandes de Freitas, Mirko Daniel Cencic.

Publisher: unknown

H: **Física** – volumes 1, 2, 3 (1ªed., 2000)

Author: Alberto Gaspar.

Publisher: Ática. São Paulo, SP.

I: **Física - Série Brasil** – volume único (1ª ed., 2004)

Author: Alberto Gaspar.

Publisher: Ática. São Paulo, SP.

J: **Física –** volume único (2ª ed., 1994)

Authors: Djalma Nunes Paraná.

Publisher: Ática. São Paulo, SP.

K: **Física** – volume 4 (1ª ed., 2005)

Authors: Álvaro Csapo Talavera.

Publisher: Nova Geração. São Paulo, SP.

L: **Física Básica** – volume único (2ª ed., 1990)

Authors: Nicolau Gilberto Ferraro, Paulo Antonio de Toledo Soares.

Publisher: Atual. São Paulo, SP.

M: **Física Clássica** – volumes 1, 2 (2ª ed., 1981) 3, 4, 5 (1ª ed., 1985)

Authors: José Luiz Sampaio, Caio Sérgio Calçada.

Publisher: Atual. São Paulo, SP.

N: **Física na Escola Atual** – volumes 1, 2, 3 (1ª ed., 1993)

Authors: Miguel Augusto de Toledo Arruda, Ivan Gonçalves dos Anjos.

Publisher: Atual. São Paulo, SP.

O: **Fundamentos da Física** – volumes 1 (5ª ed., 1991), 2 (6ª ed., 1994), 3 (5ª ed., 1993)

Authors: Nicolau Gilberto Ferraro, Paulo Antonio de Toledo Soares, José Ivan Cardoso dos Santos, Francisco Ramalho Júnior.

Publisher: Moderna. São Paulo, SP.

P: **Universo da Física** – volumes 1, 2, 3 (1ªed., 2001)

Authors: José Luiz Sampaio, Caio Sérgio Calçada.

Publisher: Atual. São Paulo, SP.

Education in Science, History of Science, and the Textbook -. Necessary vs. Sufficient Conditions. Interchange, 20 (2), 71-80.Â This paper argues that some kind of historical perspective is a conditio sine qua non in the teaching of physics. Without a proper historical perspective the student will not experience physics as the living, human endeavour it is; in addition, the historical-exemplaric approach is often beneficial also to the technical and conceptual aspects of physics education by offering a deeper and more critical look at particular physical problems. However, the relationship between physics and history of physics is intrinsically problematic in that the lessons to be learned from history are often counte History and nature of science in brazilian physics textbooks: some findings and perspectives. Cassiano Rezende Pagliarini, Cibelle Celestino Silva. 2007. Historisch orientierter Physikunterricht (Teaching physics with history). D. HÃ¶ttecke. S. MikelskisSeifert & T. Rabe (Hrsg.), Physikmethodik.Â Understanding and Developing Science Teachers' Pedagogical Content Knowledge. Jeffrey John Loughran, Amanda Berry, Pamela Joy Mulhall. 2006. What EuropeansReally Think (and Know) about Science and Technology. R. Hodge. Science in School, issue 3, Winter 2006: 71-77, http://www.scienceinschool.org/2006/issue3/eurobarometer/ (17.04.2007). 2006. VIEW 2 EXCERPTS. Surprisingly, for a physicist, his favorite book of all time was Charles Darwinâ€™s The Origin of Species. SchrÃ¶dingerâ€™s 1944 book What is Life?, although not entirely original, had a profound effect on the future of genetics and molecular biology. SchrÃ¶dinger wrote that the gene was an aperiodic crystal â€“ a code script for life. His book inspired a number of scientists â€“ including three of the main players in the discovery of DNAâ€™s structure â€“ Francis Crick, James Watson and Maurice Wilkins â€“ to pursue research in that field. Paul Dirac. Lived 1902 â€“ 1984.