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How Biology textbooks of two different socio-cultural contexts may contribute to students' scientific literacy

Dissertation

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presented by:

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1. Summary

A main goal of science teaching is to provide the basis for students to become scientifically literate citizens. In the context of daily classroom practice, textbooks are potentially powerful tools to support the achievement of this goal, though their adaptation to the most recent epistemological paradigms is often delayed and they may even convey inadequate views of science and technology. An international comparative study of textbooks therefore investigated the messages conveyed and sought to identify sociocultural influences. Thus, four sub-studies were completed:

The first sub-study (A) analysed the scientific literacy concept (SL), with the identification of the requirements to reach scientifically literacy. Within the broad spectrum of this concept, the understanding of science and technology was subdivided into three frameworks: (i) *Nature of Science* (NoS), (ii) *Nature of Scientific Inquiry* (NoSI) and (iii) *Relationships between Science, Technology Society and Environment* (STSE issues). The potential of textbooks to provide SL was elaborated, as were misconceptions that can represent obstacles to the acquisition of a fair image of science.

In the second sub-study (B), a set of criteria for supporting both a qualitative and a quantitative science textbook analysis was extracted in order to: (i) determine how textbooks approach STSE issues – students' understanding of STSE issues is considered a cornerstone of SL – and (ii) identify the potential presence of decontextualized and socially neutral views of science (DSNVS), a known relevant misconception. Additionally, the suitability of the criteria was proven, by comparing the content relating to genetics of two Bavarian Biology textbooks for the 11th grade. In this context, the necessity of the addition of the dimension "T" (for technology) was recognised, in order to elucidate the interplay between science and technology (therefore, the misconception was renamed *decontextualized and socially neutral views of science and technology:* DSNVST).

In the third sub-study (C), four Portuguese textbooks, two for the 9th and two for the 12th grade (corresponding to Bavarian grade 11), were compared, both horizontally (i.e., inside a school grade) and vertically (between school grades). The analysis focussed on the potential influence of the sociocultural context, on the selection of STSE content, on the discourse used, as well as on the concepts and potential misconceptions about science and technology displayed by the textbooks.

In the fourth sub-study (D), two 9th and two 11th grade Bavarian Biology textbooks were compared with two 9th and two 12th grade Portuguese ones. Some clear differences between both nationalities appeared when the sociocultural context of each country was characterized. Factors determining the differences displayed by the textbooks, both in terms of the approach to STSE issues, as well as of the indicators of the misconception DSNVST were also identified.

2. *Zusammenfassung*

Ein wesentliches Ziel naturwissenschaftlichen Unterrichts ist es, Grundlagen für die Entwicklung von Schüler/innen zu wissenschaftlich gebildeten Bürger/innen zu legen. In der alltäglichen Umsetzung im Klassenzimmer stellen hierfür Lehrbücher potentiell bedeutsame Unterrichtsmittel dar; allerdings werden sie oft an neueste erkenntnistheoretische Paradigmen verspätet angepasst und vermitteln darüber hinaus sogar manchmal unzureichende Ansichten von Naturwissenschaft und Technik. Eine internationale Vergleichsstudie von Lehrbüchern sollte daher die darin vermittelten Botschaften untersuchen und mögliche Einflüsse des soziokulturellen Kontexts aufzeigen. Dazu wurden vier Teilstudien durchgeführt: Die erste Teilstudie (A) umfasst die Analyse des naturwissenschaftliches Grundwissens (nGW) einschließlich der Ermittlung von Voraussetzungen hierfür. Innerhalb des breiten Spektrums dieses Konzepts wird das Verständnis von Naturwissenschaft und Technologie in drei Verstehensbereichen abgebildet: *Natur der Wissenschaft* (NdW), die *Natur der wissenschaftlichen Untersuchung* (NdwU) und die *Beziehungen zwischen Wissenschaft, Technologie-Gesellschaft und Umwelt* (WTGU-Themen). Das Potenzial von Lehrbüchern zur Förderung von nGW wurde herausgearbeitet, sowie Fehlvorstellungen, die den Erwerb einer adäquaten Sicht von Naturwissenschaft behindern können.

In der zweiten Teilstudie (B) wurde eine Reihe von Kriterien zur Unterstützung einer qualitativen und einer quantitativen wissenschaftlichen Lehrbuchanalyse extrahiert, um: (i) zu bestimmen, wie Lehrbücher mit WTGU-Themen als zentralen nGW-Aspekten das Verständnis von Schülern beeinflussen, sowie (ii) das mögliche Vorhandensein einer „dekontextualisierten“ und sozial neutralen Sicht von Naturwissenschaften (DSNVS) als eine bekannte Fehlvorstellung identifizieren zu können. Die tatsächliche Eignung der vorab identifizierten Kriterien wurde durch den Vergleich genetischer Lerninhalte in zwei bayerischen Biologie-Lehrbüchern für die 11. Jahrgangsstufe belegt. Dabei wurde die Notwendigkeit eines Einbezugs der Dimension “T” (für Technologie) erkannt, um das Zusammenspiel von Naturwissenschaft und Technik zu klären (daher Umbenennung der Fehlvorstellung in DSNVST).

In der dritten Teilstudie (C) wurden vier portugiesische Lehrbücher, zwei für die 9. und zwei für die 12. Jahrgangsstufe (entsprechend der bayerischen Jahrgangsstufe 11), sowohl horizontal (d.h. innerhalb der gleichen Jahrgangsstufe) als auch vertikal (zwischen den Jahrgangsstufen) verglichen. Ein besonderes Augenmerk wurde auf den möglichen Einfluss des soziokulturellen Kontextes für die bewusste Auswahl des WTGU-Inhalts gelegt, auf den verwendeten Diskurs sowie auf die gegebenen Konzepte und mögliche Fehlvorstellungen zu Naturwissenschaft und Technik.

In der vierten Teilstudie (D) wurden vier bayerische Biologie-Lehrbücher, jeweils zwei für die 9. und zwei für die 11. Jahrgangsstufe mit vier portugiesischen verglichen, ebenfalls zwei für die 9. und zwei für die 12. Jahrgangsstufe (entsprechend zur bayerischen Jahrgangsstufe 11). Bei der

Charakterisierung des soziokulturellen Kontexts jedes Landes wurden eindeutige Unterschiede zwischen den beiden Sprachräumen identifiziert und darüber hinaus Faktoren für die Unterschiede benannt sowohl im Hinblick auf den Ansatz der WTGU-Themen als auch der Indikatoren der Fehlvorstellung DSNVST bestimmen.

3. Detailed summary

This section comprises an introduction to the problems relating to science curricula that motivated the research, and to the literature concerning the concept of *scientific literacy* (SL) as an important goal of science education. The influence of sources of information about scientific research, and the corresponding role of textbooks as potential sources, is discussed. Furthermore, evidence for textbooks being vehicles of distorted views of science is presented. It is followed by a discussion about the science that should be taught and how visions of science influence the perspectives of science education. The focus of the present research is STSE issues in respect of genetics and was selected in view of the importance of the topic for SL.

The influence of the sociocultural context in the science curriculum as well as in public and individual views of science are approached. The influences of these factors on science teaching and therefore on textbooks are inferred. Finally, the choice of a cross-cultural textbook analysis and comparison of Germany and Portugal is explained, and the research questions and objectives of the study are presented.

3.1. Introduction

Science and technology (S&T) interact constantly with our daily lives, and media increasingly make scientific information available to the public (Brossard & Shanahan, 2006; Lewenstein, 2001). However, this information seems to be unintelligible to the vast majority of people. Therefore, science educators should provide all students with the background enabling them to be aware of what triggered certain research, how knowledge was achieved, what this achievement represents, and how it may positively or negatively affect individuals, society and the environment. In this sense, Osborne and Dillon (2008) pointed out the importance of SL in science education, irrespective of the students' professional future.

3.2. Science curricula: Problems and challenges

Several voices (Osborne & Dillon, 2008; Rocard, Csermely, Jorde, Lenzen, Walberg-Henriksson, & Hemmo, 2007) called on educators to rethink science education, extending it beyond factual knowledge in order to fit it to the modern world and to meet the needs of all students. Fensham (2002) criticized attempts to enrich the curriculum by simply adding Nature of Science (NoS) or

Science-Technology-Society (STS) material to an already excessive body of scientific content, while (Zeidler, Sadler, Simmons, & Howes, 2005; Sadler & Zeidler, 2004; Bell & Lederman, 2003) ignoring ethical considerations as prerequisites to any discussion of SL for all citizens. As representations of S&T being placed in curricula are shaped by scientists' activities and by the social and political context in which they develop (Rudolph, 2003), and since the transposition of scientific ideas results from the interaction between knowledge, values and social practices (Quessada & Clemént, 2007), we consider it legitimate to assume that the ideas having emerged from the epistemological debate surrounding the *views* of science and how it should be conveyed to students also might be affected by these constraints.

3.3. Scientific literacy: The Literature

The term SL became a recognized educational term connected with the contemporary educational goal of Science for All (UNESCO, 1983), and nowadays it represents the main goal of science education (DeBoer, 2000; Hodson, 1998). However, a consensual meaning has not yet been reached and several definitions of SL have been proposed since then. Definitions vary according to the historical and political contexts (Turner, 2008), and are based on interest groups (Laugksch, 2000) or on economical, utilitarian, cultural, democratic, or even moral arguments (Millar, 2002; Osborne, 2000; Thomas and Durant, 1987). Among them, two major labels prevail (Turner, 2008): NoS and STS, which, together, converge to the concept of "*civic* SL" (Miller, 1998). From that perspective, these two domains comprise the knowledge that citizens should be aware of as a requirement for understanding and judging scientific and technological advances. According to Schwartz and Lederman (2008) however, epistemological views of science involve two separate yet overlapping concepts: one's view of scientific knowledge as a way of explaining the NoS; and one's view of the processes through which that knowledge is acquired, constructed and justified - nature of scientific inquiry (NoSI). Some authors contend that students' understanding of the scientific research (involving both NoS and NoSI) is increased by allowing them to engage in authentic science (Gaskell, 1992; Turner & Sullenger, 1999; Scharfenberg & Bogner, 2010). Although for different reasons, the arguments above support the thesis that understanding the nature of scientific enterprise from the internal perspective and its methods contributes to SL. Nevertheless, recent studies point out that students' attitudes towards socio-scientific issues are determined more by ethical assumptions than by their understanding of the "methods of inquiry" or by the "nature of science" (Turner 2008). Halfway between these two positions, the Rocard report (Rocard, Csermely, Jorde, Lenzen, Walberg-Henriksson & Hemmo (2007), which, despite emphasising inquiry-based methods, highlights the understanding of the interactions between science, technology and society as a pre-requisite for acquiring "science literacy". A shift in science education appears to be occurring as goals are being set beyond the internal perspective of science, crossing the boundaries of the subject-focussed scientific community. The relationship between S&T, as well as their positive and negative repercussions in society and the environment, have been gaining increased prominence, assuming the designation of *Science, Technology Society and Environment* (STSE) issues (Aikenhead, 2002; Turner, 2008). The domain of knowledge prevails in the definitions of SL, but other dimensions embracing more than knowledge are included by several authors. In our perspective, a scientifically literate citizen should be capable of, at least, a superficial understanding of the "happenings" in all scientific and technological domains. Coinciding with the conception of SL of Miller, our view of SL can be defined as being the knowledge of, and about, S&T that, together with personal experience and cultural values, contributes to the development of attitudes and behaviours required for a participative citizenship (Figure 1).

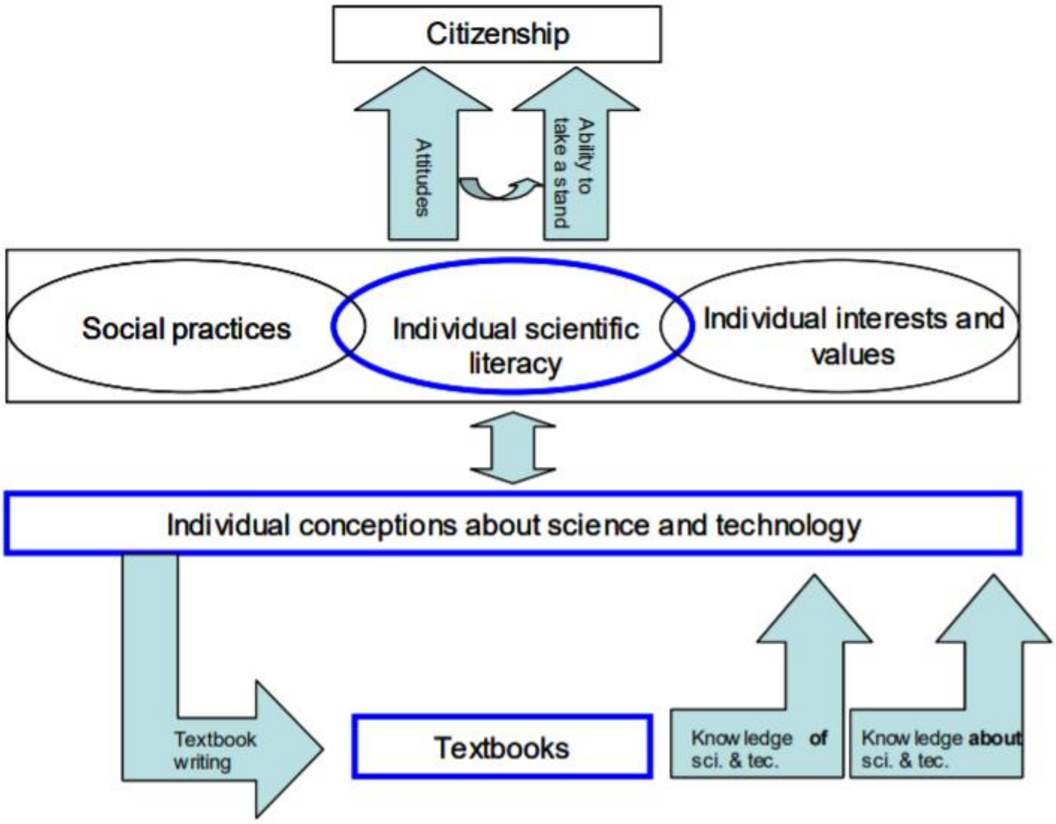

Figure 1 - Schematic representation of the concepts involved in the present work

3.4 Sources of information about scientific research and the role of textbooks

The media are the prevailing sources of new information about scientific research for the common citizen, and teaching of science should prepare students for a critical interpretation of the news conveyed by the media, and also promote the construction of personal opinions about daily socio-scientific questions (Millar & Osborne, 1998). Nevertheless, despite its potential importance to SL, little is known by common citizens about the content of media reports (Zimmerman, Bisanz, Bisanz, Klein & Klein, 2001).

There is a time lag between the publication of advances in scientific and academic journals and their announcement in the general media. Furthermore, news is shaped by journalists' interpretation of scientific reports, without a description of the processes behind the reported achievements (Wellington, 1991). An equivalent delay (Quessada & Clemént, 2007) and erosion occurs between the descriptions of research disclosed by the original sources of scientific knowledge and their appearance in textbooks (Zimmerman, Bisanz, Bisanz, Klein, & Klein, 2001). Despite this limitation, science textbooks are referred to by several authors (Chiappetta, Fillman, & Sethna, 1991; Hodson, 1996; Leite, 2002) as powerful resources for teachers and students alike. In parallel with the mere presentation of achievements of S&T, they also offer both teachers and students the opportunity to work out the way in which they have been achieved. Through a balanced combination of extensive reports and brief references to illustrative events, textbooks can help students realise how scientific knowledge was generated, how it evolved and how it established itself. Textbooks should provide adequate and reliable material supportive of discussions of both classical and contemporary socio-scientific issues in the classroom, such as genetics, gene technology and nuclear energy. Additionally, addressing contemporary socio-scientific issues may confront teachers and students with questions that frequently have moral and ethical implications. This is a valuable strategy for preparing citizens to face problems that can be perceived and judged from different perspectives and involve values (Hamm, 1992; Gaskell, 1992; Vaz e Valente, 1995; Kolsto, 2001; Aikenhead 2002; Reis, 2008). This kind of material should facilitate the conveyance of correct ideas about S&T, thus representing a step towards lessons promoting SL. However, even though the incorporation of socio-scientific issues into the curricula may seem to be an international trend, most textbooks still fail to include insights from social science (Morris, 2014).

3.5. Distorted views of science in science textbooks

As explained in the previous chapter, studies in this domain were undertaken by several researchers (e.g., Abd-El-Khalick, Waters & Le, 2008), but, in our opinion, a method capable of providing a holistic overview of the same reality is still absent. Along with concerns for the promotion of scientific understanding in the broader sense, many scholars draw attention to both the lack of information about S&T placed in textbooks, and the incorrect ideas displayed by them (e.g., Chiang-Soong & Yager (1993), Rosenthal, 1984). Incorrect ideas can represent filters or even barriers to the achievement of SL in students. They can induce and cement distorted views that interfere with the construction of a fair image of science as a body of knowledge, as well as with the comprehension of scientists' work and of the role of S&T in our lives (e.g., Aguirre et al., 1990; Carter, 2007). At first glance, compliance with the requirements of SL can be surveyed by looking for absent or incorrect ideas about S&T. However, in our opinion this method misses an important point: There is evidence that incorrect ideas and the absence of correct ones, do not appear in isolation or at random. Instead, their occurrence is interconnected with other ideas, occurs according to certain patterns, and reveals distorted views of S&T (e.g., Gil-Pérez et al., 2005). Seven distorted views of science prevail in the literature (Fernández, Gil, Carrascoa, Cachapuz & Praia, 2003) which coincide with those found by Fernández (2000) in his analysis of current science teaching practice. Based on the descriptions presented by Gil-Pérez et al. (2005), a correspondence can be observed between the seven distorted views of S&T and the three domains that together represent the knowledge about science to be acquired by citizens, namely, NoS, NoSI and STSE issues. This correspondence suggests that each of the described distorted views is rooted in a misunderstanding of one or more of the three domains of knowledge. Therefore, we drew attention to the importance of carrying out textbook analysis in order to raise consciousness of the fact that naive and distorted ideas about S&T are still conveyed by textbooks. In our view, such a global analysis should be based on seven sets of criteria defined from the lens of the seven distorted views proposed by Gil-Pérez et al. (2005), in order to detect indicators of these views. Results should also be analysed by verifying the compliance of textbooks with groups of criteria that indicate if, and to what extent, distorted images of S&T are displayed by the analysed textbooks. This procedure has the advantage of not only showing the position of textbooks relative to SL according to the three domains, NoS, NoSI and STSE issues, but also of emphasizing aspects that require improvement.

In further work, we narrowed the scope of our research by focusing on the simplistic *decontextualized and socially neutral view of science* (DSNVS). This misconception assumes particular relevance as, according to Gil-Pérez et al. (2005), it underlies the other six distorted views of S&T. In this view, science is either exalted as being the absolute source of progress in society or, alternatively, S&T (perceived as applied science) are presented as being solely responsible for environmental degradation, and therefore are to be rejected. That is, DSNVST ignores the responsibility of other agents of decision (Fernández et al., 2003; Stinner, 1995), disregards the efforts of S&T in solving problems that affect humanity and scientists' concern for the potential risks deriving from their own activity (Kolstø, 2001; Fernández et al., 2003). An adequate approach of STSE issues in classrooms provides an opportunity for students to identify their own distorted ideas and to replace them by correct ideas about S&T.

3.6. What ideas about science and technology should be taught?

The STSE domain, in particular, represents for many authors a shift from the positivist view of science to "a post-positivist vision for science education" that considers science within its "social, technological, cultural, ethical, political, [and] environmental" contexts (Pedretti & Nazir, 2011, p. 602). However, it still remains questionable which ideas about S&T students should be made aware of. Osborne, Duschl and Fairbrother (2002) reported considerable consensus found in their Delphi study (Osborne, Collins, Ratcliffe, Millar, & Duschl, 2003). However, conflicting science views may still persist among educators, the scientific community, and epistemologists (Blachowicz, 2009; Harding & Hare, 2000).

3.7. Visions of science and perspectives of science education

A variety of arguments, including economic, utilitarian, cultural, democratic and moral (Millar, 2002; Osborne, 2000; Wellington, 2001), have been proposed for educating students towards SL. These seem to derive from underlying visions of science. Roberts (2007) argued for the existence of two visions of science that generate different conceptions of SL, and therefore determine different curricular options. Vision I is underpinned by traditional views of science education as it sets the acquisition of knowledge and scientific skills by students as the goal of science education. Vision II is consonant with humanistic perspectives of science education (Aikenhead, 2006), viewing science both from the contexts in which scientific ideas and processes evolved, and from their role in society. The present surveys are guided by Robert's Vision II of science, & technology and, therefore, by the democratic argument for SL.

3.8. SL and STSE issues in genetics

Introducing STSE contents in classrooms has often been recommended as a method of confronting students with controversial socio-scientific issues, including those with moral and ethical implications (e.g., Gaskell, 1992; Kolstø, 2001). Particularly in such controversial aspects as human genetics & genetic engineering, decision-making may lead to moral dilemmas (e.g., gene therapy and cloning). Genetics and gene-technology are essential contents in biology curricula (e.g., Bavarian Ministry of Education [BME], 2004a, 2004b, Galvão et al., 2001 and Mendes, Rebelo & Pinheiro (2004).) and affect important domains of human life, such as reproduction, health and nourishment, as well as the environmental balance. Moreover, they also include controversies concerning genetic processes and products (Bauer & Gaskell, 2002). For these reasons, we consider genetics to be an appropriate field for surveying the approach to STSE issues of textbooks.

3.9. Socio-cultural context and the science curriculum

Science textbooks have been suggested as a means to convey the notion of the "social context of science" (Green & Naidoo, 2008, p. 249). However, they may convey distorted views of S&T

(Calado, Scharfenberg and Bogner, 2015) deriving from public and individual misconceptions. Perceptions of the “impact of S&T on individuals and society” may vary substantially between different nations (Miller, 1998, p. 205). Local political decisions may be in conflict with educationally driven research findings concerning the inclusion of STSE issues into curricula (and learning materials). Epistemological views are also significant as they also seem to condition beliefs about science teaching (Höttecke & Silva, 2011). A community’s perception of S&T might influence its expectations of science education, while the influence of these factors may lead to particular STSE syllabi and, consequently, to particular science textbook profiles. For instance, Bencze & Carter (2011) found frequent statements in political documents urging school systems to prepare students to “compete in the global economy” (p. 651), thus contradicting the concerns of promoting a science education towards SL.

3.10. Transferring S&T views in science education

3.10.1. Public S&T views

Several studies have viewed science as a socio-cultural construct (Aikenhead, 1996; Hodson, 1998, Jenkins, 1992), and public S&T views seem to derive from a combination of “cultural traditions, practical experiences, school learning and messages from the media” (Costa, Ávila & Mateus, 2002, p. 43). Knowledge about science and understanding of the relationship between science and the other STSE spheres determine individual views, which, together with personal experience and cultural values, might contribute to the development of a participative citizenship (Calado & Bogner, 2013). The science curriculum, however may influence one´s view of science, as curriculum designers determine syllabus orientations consciously, by selecting and emphasizing some issues, while neglecting or excluding others. In addition, the language selected is affected by the prevailing ideology (Knain, 2001). Therefore, either explicitly or implicitly, the narrative construction of S&T events is influenced by the corresponding socio-cultural context (Lakin & Wellington, 1994). Despite the necessary caution in avoiding simplistic cause-effect relations, knowing public attitudes in a particular context might help to interpret the S&T views displayed by textbooks.

3.10.2. Individual S&T views

In spite of the multidisciplinary character of curriculum design teams, some curricular documents display misconceptions about S&T (Calado, Scharfenberg & Bogner, 2015). Additionally, although the textbook writers are supposed to follow the official pedagogical recommendations, evidence points out that a re-contextualization “creates space for changing” (Ferreira & Morais, 2013, p. 5). Textbook writers (mostly teachers) transfer their own views to textbooks. As teachers also seem to retain their own socially and culturally defined beliefs (Hollingsworth, 1989), and as their epistemological S&T views condition their beliefs about science teaching (Höttecke & Silva, 2011), it is to be expected that teachers as textbook writers will transfer their conceptions of teaching and of learning to the pedagogical orientation of textbooks (e.g., Aguirre et al., 1990; Carter, 2007). School textbooks are therefore, together with teachers, transmitters of social models, and might contribute to the improvement of students' interests in, attitudes towards, and images of, science (Christidou, 2011).

3.11. Socio-cultural context and science teaching

Perceptions of the "impact of S&T on individuals and society" vary substantially among different nations (Miller, 1998, p. 205). Local political decisions about what knowledge is of most value to a science curriculum are very likely driven by economic criteria and may conflict with educationally driven research findings concerning the inclusion of STSE issues into curricula (Aikenhead, 2007). Additionally, they might also be influenced by distorted S&T views of decision makers (Calado, Scharfenberg & Bogner, 2016). The way a community perceives S&T might influence its expectations of science teaching (Höttecke & Silva, 2011), and may define particular STSE syllabi and particular STSE textbook profiles.

Additionally, there might be as many sciences as there are contexts and cultures (Harding, 1998), resulting in a *cultural common sense notion of science* (Weinstein, 1998). Public S&T views seem to derive from a combination of "cultural traditions, practical experience, school learning and media messages" (Costa, Ávila & Mateus, 2002, p. 43). Therefore, textbook writers, mostly teachers (Markert, 2013), are likely to hold similarly distorted views as the general public (Yates & Marek, 2013), which might be transposed to textbooks in the process of re-contextualization (Ferreira & Morais, 2013). Assuming that teachers' S&T views condition their beliefs about science teaching (Höttecke & Silva, 2011), teachers will transfer their conceptions of science teaching to the pedagogical orientation of textbooks (e.g., Aguirre et al., 1990; Carter, 2007).

3.12. Cross-cultural textbook analysis

Based on these assumptions, cross-cultural textbook analyses are of considerable interest, as they may reveal both good practice and aspects requiring improvement in the compared contexts. International comparisons of biology textbooks demonstrated interactions between scientific knowledge and values (Selmaoui, Agorrama, Kzamia, Razoukia, Clément & Caravita, 2012). In certain cases, implicit ideological messages, conveyed by representations of social conditions and beyond the messages of scientific content, were found (Castéra, Sarapuu, & Clément, 2013), which may have ethical, cultural, and social implications (Clément & Castéra, 2013). Regarding STSE issues in genetics and gene technology, cross-national analysis may help in raising consciousness about different perspectives and different ways of conceiving the content of science learning materials and lead to broad-mindedness in the design of science education programs, in syllabi development and in textbook writing.

3.13. Germany and Portugal: Divergent perceptions of S&T?

Germany and Portugal have different historical backgrounds to the development of S&T and the relationship between S&T and the social sphere. Germany is rather special in terms of civic participation in debate about genetic STSE issues, attitudes towards biotechnologies, and media communication concerning S&T (Eurobarometer, 2006; Hansen, 2006; O' Mahony & Schäfer, 2005; Peters, Lang, Sawicka & Hallman, 2007). During the 1980s (Weber, 2009) and 1990s (Kohring 2002), one of the longest-standing debates in Germany concerned biotechnology and genetic engineering in Europe (Hansen 2006), with active public participation in decision making (Bauer & Gaskell, 2002). Contrary thereto, in Portugal, public opinion displays high optimism towards technology and high acceptance of GM organisms (GMO; Kurzer & Cooper, 2007).

Differences may predominantly depend on stronger or on weaker scientific and technological systems (Gonçalves & Castro, 2009). Germany is as a very industrialized country at the post-industrial stage (Bonoli, 2006) that has a long tradition of molecular and cellular biological research and a strong industry for biotechnological products (Torgersen et al. 2002), while Portugal is regarded as a late-industrializing country (Fontes & Novais, 1998; Pepinsky, 2013) with incipient experience in the field of genetic engineering (Fontes & Novais, 1998).

Evidence showed that the greater the scientific knowledge, the more positive the attitude to science; however, an ambivalent attitude, with readiness to criticism, has also been observed (Ávila, Gravito & Vala, 2000, Bauer, 2009). Positive attitudes are strongly related to the length of schooling, in particular to the highest school grades (Costa, Ávila & Mateus, 2002) and both countries contrast in this respect. The long tradition in S&T, as well as public schooling, might also explain Germany's longer and Portugal's shorter traditions in the communication of science to the public (Gonçalves & Castro, 2009). German co-existence of both catholic and protestant religions may foster a plurality of opinions (O'Mahony & Schäfer, 2005), while the sceptical views of science may be explained by the collective memory of the eugenicist program that raised the level of (media) communication in the field of human genetics (O'Mahony & Schäfer, 2005). In contrast, Portuguese people were for many years subjected to authoritarian politics that disregarded public interest, discouraged capabilities in decision-making (Gonçalves et al., 2007) and prevented the development of a powerful and organized civil society (Roberts 1995). Even though controversies related to STSE issues have also shaken the Portuguese society, they were triggered by a more sensationalist and less informative media that might have influenced public conceptions of science (Reis & Galvão, 2004). Therefore, we hypothesize that these two socially and culturally different communities display different attitudes towards S&T and consequently, to science education, that should be recognisable in biology textbooks.

4. Research questions and objectives of the study

4.1. Sub-study A

A Reflection on Distorted Views of Science and Technology in Science Textbooks as Obstacles to the Improvement of Students' Scientific Literacy

The questions that guided our research were the following:

- What literature is available concerning the concept of SL?
- How does the concept of SL relate to distorted views of S&T?
- To what extent do biology textbooks contribute to SL or constitute obstacles to its achievement?

In view of these questions, we defined the objectives of our first sub-study A as follows:

(i) To reflect about the concept of SL, while recognizing the prevalence of the domains known as Nature of Science (NoS), Nature of Scientific Inquiry (NoSI) and Science-Technology-Society-Environment issues (STSE issues);

(ii) To highlight the potential of textbooks to promote the understanding of S&T and their interplay with society and the environment;

(iii) To discuss how distorted views of S&T (misconceptions), consciously or unconsciously conveyed by textbooks, may constitute obstacles to that understanding;

(iv) To point out how the detection of those distorted views in textbooks may help in determining the extent to which a textbook may contribute to SL.

4.2. Sub-study B

To What Extent do Biology Textbooks Contribute to Scientific Literacy? Criteria for Analysing Science-Technology-Society-Environment Issues

Following the reasoning of the previous study, we carried out sub-study B, which consisted of an empirical survey. The main goal remains to bridge two perspectives of the same paradigm: (i) The ideas about S&T that should be taught to students in order to foster SL, and (ii) the inadequate ideas that might follow to misconceptions about S&T, that is, to demonstrate that an inadequate and/or an incipient approach of ideas about S&T by textbooks-convey distorted views about these entities that might constitute obstacles to students' SL. However, for practical reasons, such as the complexity of these subjects and time constraints, we restricted our work to STSE issues and surveyed for the occurrence of the *decontextualized and socially neutral view of science.*

The questions that guided the research were the following:

- Do textbooks explicitly and/or implicitly provide teachers and students with a suitable support of information about STSE?

- Do textbooks stemming from the same socio-cultural context, and based on the same guidelines, differ essentially concerning the STSE issues discussed. Is DSNVS, explicitly and/or implicitly, conveyed by textbooks?

Our specific objectives were twofold:

(i) to develop a set of criteria for textbook analyses in order to examine how two German textbooks address STSE issues in the context of genetics and to detect indicators for confirming or disproving the presence of the *decontextualized and socially neutral view of science*;
(ii) to apply, qualitatively and quantitatively, these criteria to genetics and gene technology contents within two German biology textbooks and to identify differences regarding these issues.

4.3. Sub-study C

To What Extent does Genetics Content in Textbooks Contribute to Scientific Literacy Analysis of Science-Technology-Society-Issues in Textbooks

us to the following research questions:
- Does our set of criteria for analysing STSE issues in textbooks reveal a similar usefulness when applied to a different sociocultural context?
- Are textbooks in an inclusive educational system, where diversity is privileged independently of learners' particular needs, conceived to provide education for citizenship? Or are they more focused on preparing future scientists and technologists?
- Are prevailing public views of science reflected in textbooks?

We analysed the contribution of Portuguese natural sciences and biology textbooks to students' SL, in the manner in which they approach STSE issues, both by seeking ideas that help to understand STSE interactions, and by looking for ideas or deficiencies indicating distorted views of S&T.

Our specific goals were to:

i) Examine the extent of STSE content in Portuguese natural sciences and biology textbooks for middle and secondary schools;
ii) Identify the presence of inadequate S&T ideas, especially DSNVST, as a barrier to the achievement of students' SL;
iii) Examine syllabi and guidelines and include several social studies in order to isolate the view of S&T under study;
iv) Infer possible relationships between misconceptions displayed by textbooks and the constraints imposed by the sociocultural milieu, in terms of communication between S&T settings and the general public S&T, such as historical background, socioeconomic development and values.

4.4. Sub-study D

Science-technology-society-environment issues in German and Portuguese biology textbooks: influenced by the socio-cultural context?

Motivated by our previous results (of sub-studies B and C), we decided to compare Portuguese and German biology textbooks both for the secondary (9^{th} grade) school and for the higher secondary school 11^{th}/12^{th} grades, in order to answer our research question:

- How do textbooks from countries with a different sociocultural background regarding STSE issues in genetics and gene technology differ?

We hypothesize that Portuguese and German textbooks differ in terms of the choice of STSE content, the discussions employed, and the concept of S&T, therefore reflecting the socio-cultural contexts. Our objectives were:

- to identify potential differences in the way to which German and Portuguese textbooks approach the STSE issues, related to genetics and gene technology, with the intent of relating such differences with the corresponding educational policy; and
- to compare the textbooks in terms of DSNVST indicators and to establish possible linkages between them and the corresponding socio-cultural background.

5. Methods

Our study is classified as Product Oriented Research, with emphasis on the textbook as a product (Cabral, 2005).

5.1. Design of the study

The first sub-study (A) consisted of a survey of the literature relating to the above referred research questions and objectives. Based on this survey and subsequent reflections, we performed sub-studies B, C and D, which consisted of empirical research, as follows:

We developed a set of criteria for textbook analysis and applied them to a small sample, in order to test their suitability (sub-study B). Subsequently we applied the tested criteria to a both a national comparison of textbooks for different school cycles (sub-study C), and an international comparison of textbooks for corresponding grades (sub-study D). All sub-studies had in common the subject of the analysis (the chapters relating to genetics and gene-technology in biology and natural sciences textbooks), the methods followed and the set of criteria applied.

5.2. Sample

The provenance of the sample is justified as follows: Firstly, Germany and Portugal represent two realities at different evolutionary stages with respect to S&T. Secondly, they have been confronted by two different public experiences concerning the relationship between society and genetics and gene technology issues. Thirdly, we chose these countries for practical reasons, because the authors know the corresponding educational systems.

5.2.1. Sub-study B

We analysed two randomly selected 11th grade biology textbooks for the *Gymnasium* as a university-preparatory secondary school (Bavarian Ministry of Education [BME], 2016) from two different publishers - textbook A and textbook B.

5.2.2. Sub-study C

We analyzed four Portuguese textbooks (student versions) for the 9th and 12th grades, as the textbooks most adopted in the school year 2013/2014 for our subjects and school grades. The textbooks represent two publishers. Pair One: 9th grade natural sciences textbook P9-1 and 12th grade biology textbook P12-1; Pair Two: 9th grade natural sciences textbook P9-2 and 12th grade biology textbook P12-2.

5.2.3. Sub-study D

For this survey, we compared German and Portuguese science and biology textbooks. The German sample comprised the four textbooks for the *Gymnasium* as a university-preparatory secondary school (BME, 2016): Two for the 11th grade, which had been analysed in the sub-study B, and the two for the 9th grade, stemming from two different publishers and randomly selected German biology textbooks - G9-1, G11-1 and G9-2, G11-2. The Portuguese sample was the same we used in sub-study C, and was selected from amongst the most adopted textbooks in the school year 2013/2014. The textbooks were also from two different publishers: the natural sciences textbook P9-1 and the biology textbook P12-1, as well as, the natural sciences textbook P9-2 and the biology textbook P12-2. We chose German 9th and 11th grade biology textbooks (G9/11) and Portuguese 9th natural sciences and 12th grade biology textbooks (P9/12) because these grades approach genetic and gene technology contents at a similar level.

5.3. Criteria development

While developing our criteria, we alternated between deductive and inductive methods (Patton, 2010) according to their appropriateness. The considered consensual sets of ideas about science (McComas & Olson, 1998; Osborne, Collins, Ratcliffe, Millar, & Duschl. 2003), though not representing a suitable framework for our textbook analysis, provided ideas that guided our development of criteria.

In order to define our criteria, we carried out a literature survey which consisted of analysing documents derived mostly from the epistemological debate and from research in science education. We then extracted from the literature the ideas that we assumed to be likely observable in textbooks and excluded unlikely ones. Six criteria were defined, each representing one sub-domain of the STSE relationships, and refined in sub-criteria (26, altogether) in order to provide observable units.

The first author initially applied these first-round sub-criteria definitions to randomly selected parts of one of the analysed textbooks (in the first survey designated textbook A). The definitions of the sub-criteria were iteratively applied and refined in order to reduce subjectivity and to increase accuracy. Finally, an external reviewer, a biology in-service teacher, completed the validation test (interpersonal comparison).

5.4. Textbook analyses

Textbooks' statements were analysed by identifying the co-variation between text and context (Knain 2001). Doing so, we inferred the ideas about S&T that matched our criteria and we recorded them. With regard to the reliability of our statement categorization, in the sub-study B we carried out a second intra-rater categorisation and an inter-rater categorisation, computed Cohen's Kappa coefficient (Cohen, 1968) and obtained reliability scores for the intra-rater reliability of Kappa as 0.93 and for the inter-rater reliability of Kappa as 0.76. In the sub-study C, we repeated this test and obtained Kappa values of 0.94 (intra-rater reliability) and of 0.77 (inter-rater reliability).

We proceeded by combining our qualitative content analysis with a quantitative frequency analysis (Pingel, 2010). The content analysis allows differentiation between explicit and implicit statements. We also took eloquence into account. However, this differentiation was only taken into account as a qualitative qualifier and not as a quantitative one, all statements being equally weighted. We examined potential contingencies between criterion frequencies and the analysed textbooks by computing adjusted Pearson's contingency coefficients C (Pearson, 1904). We applied the same method in our three empirical surveys.

6. Results

6.1. Sub-study B

The analysis of the German textbooks A and B provided 718 STSE statements within the genetics and gene technology chapters. Textbook A supplied significantly more statements than textbook B. In both textbooks, we found statements for at least 25 sub-criteria. Textbook A lacked the sub-criterion *global environmental impact*, and textbook B the sub-criterion *different sources of information* (Table 2 in paper 2). Generally, criteria and sub-criteria frequencies significantly differed between the two books, with adjusted Pearson's contingency coefficients pointing to different textbook profiles.

Textbook A focussed on the criteria *science and technology events* and their *contextualization* as well as *decision-making processes*, while textbook B focussed on the criteria *interplay between science and technology* and *science and technology as means to solve societal problems*. At the level of sub-criteria, we only found differences for the *criterion science and technology as a means to solve societal problems*. In summary, both textbooks supplied teachers and students with a considerable basis for generally raising understanding of the complex STSE relationships, although lacking relevant information. On the other hand, despite being compliant with the same state guidelines, they seem to follow considerably different orientations.

6.2. Sub-study C

We identified 1019 STSE statements in the four Portuguese textbooks. They complied with all the six criteria and at least 26 sub-criteria in each textbook. We discuss the main differences and/or similarities vertically between P9 and P12 as well as horizontally between P9-1/-2 and P12-1/-2, in order to draw inferences about the differential investment in students' SL in the middle school and in the high school. The 9^{th} grade textbooks did not differ at the level of either the criteria or the sub-criteria. The textbooks were found lacking in respect of sub-criteria *favourable factors* and *obstacles*, of the criterion *risks and impacts of S&T*, of the sub-criterion *local environmental impact*, of the sub-criterion *different sources of information* and, finally, of the sub-criterion *international comparisons* in *decision making processes*.

The 12^{th} grade textbooks differed at criteria as well as sub-criteria levels, revealing two different statement patterns. For criterion *S&T events and their social contextualization*, P12-1 showed a higher statement frequency than randomly to be expected, which was not the case of P12-2, especially in the sub-criterion *event time*. In contrast, P12-2 provided more statements in the criterion *risks and impacts of S&T.* In particular, P12-2 provided more statements related to *social impacts* and to *environmental impacts*. Similarly, P12-2 scored higher with respect to the criterion *controversial issues*. P12-2 especially out-performed P12-1 in the sub-criteria *different perspectives* and *conflicting values*. In the criterion *decision making process*, P12-2 stood out in the sub-criterion *citizen participation.* Regarding the DSNVST, P12-1 made no reference to the distorted idea *technology as applied science*, contrasting to P12-1 that offered three indicators of this incorrect idea.

We generally found about two and a half times as many statements within the 12^{th} grade books compared to the 9^{th} grade books. When relating these differences to the given number of pages (see above), both book pairs also differed. Regarding the ratios *statements/number of pages* between the four textbooks, higher ratios were displayed by the 9^{th} grade books.

9^{th} and 12^{th} grade textbooks differed both at the level of the criteria and of the sub-criteria, showing different statement patterns. P12 textbooks outperformed P9 textbooks concerning the criteria *S&T events and their social contextualization* and *S&T as means to solve societal problems*, the sub-criteria *events per se* and *favorable factors.* On the other hand, P9 textbooks contained comparatively more statements regarding the criterion *controversial issues,* but even so, fewer statements than those randomly to be expected. P9 and P12 contain only a few statements referring to the distorted idea *technology as applied science.*

6.3. Sub-study D

We identified 2390 statements within the chapters containing genetic and gene technology contents in our eight textbooks (four German and four Portuguese ones).

With respect to page numbers, there were no differences in all the book pairs. As to what concerns the ratio pages to statement frequencies, neither 9th grade book pairs nor Portuguese P12 books differed. In contrast, German 11th grade book pair did differ, with G11-1 supplying considerably more statements than G11-2 and the P12 books, therefore apparently attenuating the correlation between the relative prevalence of STSE issues, among other genetic issues, with nationality.

Concerning the compliance with criteria, we found statements for all 26 sub-criteria only in one textbook (P12-2). All seven other textbooks lacked one to three of the sub-criteria. G9-1, P9-1 and P9-2 lacked the sub-criterion *favourable factors;* and P9-1 and P9-2 lacked the sub-criterion *obstacles* (both sub-criteria for criterion *science and technology* event). P12-1 presented no reference to *technology as applied science*. Textbook G9-2 lacked the sub-criterion *costs* (of S&T processes or devices). Textbooks G9-1, G9-2, P12-1 and P9-2 lacked the sub-criterion *local environmental impact* while G11-1 lacked *global environmental impact*; the presentation of *different sources of information* was lacked by G11-2 and P9-1. Finally, the textbooks G9-1 and P9-2 lacked the sub-criterion *international comparisons* (concerning decisions in terms of legislation of S&T issues).

All the eight textbooks differed at the level of criteria and at the level of sub-criteria, especially in five of the six criteria, with less relevance for the criterion *controversial issues.* The Portuguese textbooks exceeded the German ones for the following criteria: *Science and technology events and their contextualization* (for the generality of sub-criteria), *Science and technology as a means to solve societal problems* (in particular P12-1 and P12-2) and *Risks and impacts of science and technology*. However, G9-1 in particular, but also G9-2, descriptively exceeded P9 in referring general *risks* of S&T. On their turn, the German textbooks exceeded the Portuguese ones for the following criteria: *Interplay between science and technology* (in particular G11-1 and G11-2) and *Decision making process.*

Detailed horizontal comparison of the German and the Portuguese 9th grade textbooks showed that they differed at the level of the criteria and of the sub-criteria especially regarding two criteria:

Science and technology events and their contextualization (in general, G9 books descriptively achieved higher frequencies in comparison to P9 books), *Decision making process*, with particular relevance to the sub-criterion *citizen participation.*

Regarding the other criteria, the differences found were brought out mainly due to the compliance of one textbook rather than of nationality. At the higher secondary school level, German 11th and the Portuguese 12th grade textbooks differed at both the criteria, and the sub-criteria level revealing different patterns. The Portuguese textbooks exceeded the German for the criterion *Science and technology as a means to solve societal problems*. Regarding the other criteria, we descriptively found some notable differences comparing sub-criteria.

7. Discussion

7.1. Methodological Aspects

With respect to our methodology, three aspects should be considered: Firstly, our criteria and sub-criteria helped to identify gaps in the information about STSE issues, adequate and inadequate ideas about S&T; guided data analyses and reduced subjectivity, and clarified dubious interpretations; Secondly, qualitative analysis provided an impression of the textbook author's DSNVST (Knain, 2001), while the criteria and sub-criteria frequencies provided an overview of the general text compliance with STSE issues, representing additional and complementary information for confirming or refuting the presence of that misconception (Pingel, 2010). Thirdly, though we analysed the criteria and sub-criteria frequencies, we did not define thresholds for determining the presence or the absence of a certain S&T view, which prevents a classification of textbooks in absolute terms.

7.2. Comparison of the textbooks

7.2.1 Sub-study B

Our analyses revealed somewhat different textbook profiles between the two 11th grade German textbooks. Indeed, while the statistical analysis pointed to considerable similarities regarding the compliance with most of our STSE criteria, it also showed differing approaches to some sub-criteria. Similarly, our qualitative analysis recognised differences in terms of style of message conveyance. Firstly, both textbooks are aligned with "the historical current" in STSE education (Pedretti & Nazir 2011, p. 607–608), neither of them contextualized events adequately. Secondly, scientific and technological achievements were approached from a non-problematic perspective in respect of processes (Gardner, 1990). Thirdly, in approaching risks, they conform to the "logical reasoning current" in STSE education (Pedretti & Nazir, 2011, p. 612), though some meaningful differences were found. Fourthly, both textbooks failed to adequately refer to environmental aspects of S&T. Fifthly, the textbooks differed particularly in their discussion of controversial issues: While textbook A focussed mainly on social impacts, textbook B explicitly formulated controversial issues, though not adequately. Regarding the decision-making processes, textbook A relieved scientists and technologists of responsibility for potential undesirable effects of technologies, while Textbook B tended to blame them.

We recognized, in German biology textbooks, an orientation towards providing learning materials concerning STSE issues in the context of genetics and gene-technology. However, some naive and inadequate ideas about S&T were detected, which might contribute to the promotion of DSNVS, thus compromising the achievement of SL. Our results suggest that some features of textbooks might be justified by the sociocultural background in which they were conceived. In respect of this misconception, we proposed the addiction of the T for technology, i.e. DSNVST.

7.2.2. Sub-study C

Regarding the vertical comparison of the four Portuguese textbooks, we identified two remarkable results. The 12th grade textbooks provided about two and a half times more statements concerning STSE issues than the 9th grade textbooks. That might derive from the decision to treat more superficially both substantive knowledge (genetics) and technological aspects (gene-technology) in the earlier grade, while deepening them in the later one. The ratio *statements/number of pages* suggest that P9 books privileged frequency rather than depth (see below). Qualitatively, examination of statements confirmed that 9th grade textbooks very often provide superficial references instead of detailed reasoning (e.g., regarding transgenic plants; P9-2, p. 183; P12-2, p. 296-298); that is, we found a superficial STSE approach in P9 books, in dissonance with Portuguese 9th grade guidelines. P9 books disregarded some aspects, like social factors and individual interests that might have influenced events, while P12 books focussed on them. Nonetheless, none of the textbooks, though following some of the guidelines, entirely follow the corresponding holistic pedagogical principles.

Calado, Neves, & Morais (2013) have analyzed the broad guidelines to the middle school revealing a high level of conceptual demands, which has decreased when transposed into the guidelines for teachers and textbooks writers, and is even more evident in the re-contextualization in textbooks.

The visible simplification might result from an attempt of publishers to anticipate teachers' criticisms and constraints, or it can also be seen as a strategy to target weaker students or classes, as a way to adapt to inclusion principles. Similarly, the different depth of approaching STSE issues made clear that final compulsory school grades and final secondary school grades set diverging goals and deal with different student profiles.

We found a co-existence of ideas that can be argued as DSNVST indicators and of ideas indicating non-DSNVST. Although introducing the social component, all of the textbooks provided a quite incomplete picture in terms of both inputs and outputs of S&T and, therefore, tended to the naive DNSVST, but deviating from the opposite view of DSNVST. In P9 textbooks some social aspects of S&T were hardly approached and significant ideas were lacking. In turn, P12 books were much centred on the S&T products and revealed both high expectations, and great enthusiasm towards them. P12-2 made an attempt to show the relationship between S&T and the social sphere and the environment. In contrast, P12-1 fairly contextualized the inputs of society into S&T and portrayed the interplay between them in a balanced way.

Within P9 textbooks, we found no reflection of positive attitudes towards S&T which correlates with public knowledge about science in a country at an industrial stage (Inglehart, 1990). Indeed, our results seem to reflect more distrust in science (and technology; see Prpić, 2011) than indifference (see Gaskell et al., 2006). Positive attitudes seem to be displayed in P12-1, while P12-2 revealed high enthusiasm and expectations towards the achievements of S&T, though having fairly observed the negative aspects in quantitative terms.

The enthusiastic and sensationalistic messages might reveal commitment to the economic argument for SL, justified by a society struggling to achieve scientific and technological development. Results in general seem to mirror public inexperience in genetics and in gene-technology and reflect the unfamiliarity with controversies. Therefore, assuming that textbooks reflect, to some extent, the predominant public views, our results suggest the prevalence of a naive perception of S&T by the Portuguese public.

7.2.3. Sub-study D

As we found considerably different textbook profiles at the level of nationality in terms of STSE extension and of compliance with the most of criteria and sub-criteria, we see our hypothesis as confirmed. Horizontally, 9th grade German and Portuguese textbooks differed more than their 11th and 12th grade pairs. The G9 books contained more discussion of extensive genetics, than the P9 books. This disparity seems to be a response to the requirements of two different educational systems. On the one hand, the aim of the *Gymnasium* branch of the German system, preparing a selected student population to university level (BME, 2016), that is pointing out the goals of preparing students for pursuing scientific and technical carriers, as an argument for SL (Bencze & Carter, 2011; Osborne & Dillon, 2008). Even though research in science education and educational policies contribute to the improvement and the updating of syllabi and guidelines, educational traditions and socio-cultural dynamics seem to counteract their effects.

On the other hand, the Portuguese system embraces a considerable diversity of students (Authors, in press) and tries to adopt inclusive principles (Vislie, 2003), at least in national policy documents (César e Santos, 2006), towards the ideal of *Schools for all* (Ainscow, 1999; César, 2003); that is, it is consonant with the democratic argument for SL (Bencze & Carter, 2011; Dillon, 2008). The textbook market, in turn, may have to adapt to those inclusive principles, providing teachers with versatile didactic materials as, in Portugal, textbooks are adopted by teachers' councils, and financed by families. This configuration might have led to the simplification of contents observed in P9 textbooks as an attempt to reconcile diverse school contexts and to address teachers' preferences.

Regarding the horizontal comparison of the G11 and P12 books, the pairwise quantitative analyses revealed the existence of two different profiles, more particularly in some criteria or sub-criteria. We observed two stronger textbooks, G11-1 and P12-2, and two weaker ones, G11-2 and P12-1. However, regarding the ratio statement frequencies to number of pages, G11-1 outperformed all other textbooks. In summary, these results yielded no correlation between the preponderance given to STSE issues, in the context of genetic issues, and nationality. However, the descriptive analysis revealed that, at the level of some criteria and sub-criteria, the Portuguese sample was more successful in mentioning the inputs of science, while the German one better presented the outputs of science and their implications in the social sphere, both at the pragmatic and at the spiritual level.

Both quantitative and qualitative analysis detected omissions and inadequate ideas in all the textbooks, especially regarding the DSNVST, even though some contrasting ideas coexisted in the same textbook, thus preventing its allocation into one of the extremes of the DSNVST.

The different textbook profiles suggest plausible linkages with sociocultural contexts. Portuguese syllabi revealed the purpose of educating students for understanding the socio-scientific issues, which transposition was more successfully achieved in 12th grade textbooks. However, the public unfamiliarity with both S&T and the public communication about STSE issues is here reflected. Oppositely, despite the superficiality of German syllabi guidelines, the German textbooks showed more concern for conveying to students the societal rights and the duties with respect to the regulations and control of the social use of genetics and gene-technologies, probably due to the tradition of scientific and technological enterprises, as well as of active public participation in decision-making (Weber, 2009; Kohring & Matthes, 2002, O'Mahony & Schäfer, 2005).

8. Conclusions

Our methods were ascertained to be appropriate for exposing textbooks' strengths and weaknesses in approaching STSE issues and to detect information gaps or inadequate ideas as indicators of the DSNVST.

We have demonstrated the suitability of our set of criteria and sub-criteria and of our methods for analysing the STSE content of biology textbooks and consider our quantitative analysis as suitable for emphasising the relative predominance of single ideas by highlighting the ones that are clearly stressed, the ones rarely mentioned, or those that are totally absent. Despite the methodological limitations inherent to the size of the sample, we argue for the suitability of the employed combination of methods for the detection of notable divergences within a heterogeneous country or for carrying out an international comparison between diverse socio-cultural contexts, as well as for the applicability of our framework to other contexts of biology (e. g., ecology) or to other subjects, such as physics(e. g., nuclear power). Our findings, when incorporated into science educators' training and in further training programs, may provide a framework for curricula makers, helping them to incorporate STSE issues into curricula; may provide a reference for textbook writers, pointing out a way to approach such issues; and may guide teachers in exploring STSE issues in their classes. Furthermore, our set of criteria might be useful for publishers to formulate their textbook's guidelines; for encouraging textbook writers to include STSE issues in textbooks and guiding textbook writing; for orienting textbook selection by teachers; and finally, for shaping the criteria used by textbook reviewers and evaluating committees.

9. References

Abd-El-Khalick, F., Waters, M., Le, A. (2008). Representations of Nature of Science in High School Chemistry Textbooks over the Past Four Decades. *Journal of Research in Science Teaching*, *45*(7), 835-855.

Ainscow, M. (1999). *Understanding the development of inclusive schools*. London: Falmer.

Aguirre, J. M., Haggerty, S. M., Linder, J. C. (1990). Student-Teachers' Conceptions of Science, Teaching and Learning: a Case Study in Pre-service Science Education. *International Journal of Science Education*, *12*(4), 381–390.

Aguirre, J. M., Haggerty, S. M., Linder, J., C. (1990). Student-teachers'conceptions of science, teaching and learning: A case study in pre-service science education. *International Journal of Science Education*, *12*(4), 381–390.

Aikenhead, G. S. (1996). Science Education: Border Crossing into the Subculture of Science. *Studies in Science Education*, *27*(1), 1–52.

Aikenhead, G. (2002). Renegotiating the Culture of School Science: Scientific Literacy for an Informed Public. A paper presented to Lisbon's School of Science conference commemorating its 30 years of teacher training; Centre for Educational Research, Universidade de Lisboa. Retrieved from http://www.kcvs.ca/martin/EdCI/literature/literacy/aikenhead.pdf

Aikenhead, G. S. (2006). *Science Education for Everyday Life: Evidence-based Practice*. New York, NY: Teachers College Press.

Aikenhead, G. S. (2007). Humanistic perspectives in the science curriculum. In S. K. Abell, N. G. Lederman (Eds.), *Handbook of Research on Science Education* (pp. 881-910). Mahwah, N J: Lawrence Erlbaum Associates, Publishers.

Ávila, P., Gravito, A. P., Vala, J. (2000), Cultura científica e crenças sobre ciência [Scientific culture and believes about science]. In M. E. Gonçalves (org.). *Cultura Científica e Participação Pública* [Scientific culture and public participation] (pp. 19-31), Oeiras: Celta Editora.

Bauer, M.W. Gaskell, G. (2002). Researching the public sphere of biotechnology. In M. Bauer, G. Gaskell, (Eds.), *Biotechnology -The Making of A Global Controversy* (pp. 1–17). Cambridge, UK: Cambridge University Press.

Bavarian Ministry of Education (2016). The Bavarian school system. Retrieved from https://www.km.bayern.de/education-in-bavaria.html.

Bavarian Ministry of Education (BME, 2004a). *Lehrplan Gymnasium Biologie*, *Jahrgangsstufe 9* [Syllabus *Gymnasium* Biology, Grade 9]. Wolznach: Kastner.

Bavarian Ministry of Education (2004b). *Lehrpläne Gymnasium Biologie*, *Jahrgangsstufe 11* [Syllabus *Gymnasium* biology, Grade 11]. Wolznach: Kastner.

Bell, R.L. & Lederman, N.G. (2003). "Understanding of the NOS and Decision Making on Science and Technology-Based Issues". *Science Education*, *87*(3), 352–77.

Bencze, L.,Carter, L. (2011). Globalizing students acting for the common good. *Journal of Research in Science Teaching*, *48*(6), 648–669.

Blachowicz, J. (2009). How Science Textbooks Treat Scientific Method: A Philosopher's Perspective. *British Journal for the Philosophy of Science*, *60,* 303–344.

Brossard, D., Shanahan, J. (2006). Do they know what they read? *Science Communication*, *28*(1), 4763.

Bonoli, G. (2006). New social risks and the politics of post-industrial social policies. In K. Armingeon & G. Bonoli (Eds.), *The Politics of Post-Industrial Welfare States: Adapting Post-War Social Policies: adapting post-war social policies to new social risks*, (pp.3-26). Oxon: Routlege.

Cabral, M. (2005). *Como Analisar Manuais Escolares* [How to Analyse Textbooks]. Lisboa: Texto Editores.

Calado, F.M., Bogner, F.X. (2013). A Reflection on Distorted Views of Science and Technology in Science Textbooks as Obstacles to the Improvement of Students' Scientific Literacy. *European Journal of Educational Research*, *2*, 51–68.

Calado, F. M., Scharfenberg, F., Bogner, F.X. (2015). To What Extent do Biology Textbooks Contribute to Scientific Literacy? Criteria for Analysing Science-Technology-Society-

Environment Issues. *Education Sciences*, *5*, 255–280.

Calado, F. M., Scharfenberg, F. J. & Bogner, F.X. (2016). The Influence of the Socio-cultural Context in the Approach of Science-Technology-Society-Environment Issues in Biology Textbooks: A Cross-Cultural Study of German and Portuguese Textbooks. *Revista Portugusa de Investigação Educacional. 16*, 253-287.

Calado, S., Neves, I. P., Morais, A. M. (2013). Conceptual demand of science curricula: a study at the middle school level. *Pedagogies: An International Journal*, *8*(3), 255–277.

Carter, L. (2007). Sociocultural influences on science education: Innovation for contemporary times. *Science Education*, *92*(1), 165–181.

César, M., Santos, N. (2006). From exclusion to inclusion: Collaborative work contributions to more inclusive learning settings. *European Journal of Psychology of Education*, *21*(3), 333–346.

César, M. (2003). A escola inclusiva enquanto espaço-tempo de diálogo de todos e para todos [Inclusive schooling as a dialogical space-and-time of all and for all]. In D. Rodrigues (Ed.), *Perspectivas sobre a inclusão: Da educação à sociedade* (pp. 119-151). Lisboa: Porto Editora.

Christidou, V. (2011). Interest, attitudes and images related to science: Combining students' voices with the voices of school science, teachers, and popular science. *International Journal of Environmental Science Education*, *6*(2), 141–159.

Chiang-Soong, B. & Yager, R.E. (1993). The inclusion of STS material in the most frequently used secondary science textbooks in the U.S. Journal of Research in Science Teaching, 30(4), 339349.

Chiappetta, E.; Fillman, D.; Sethna, G. (1991). Method to Quantify Major Themes of Scientific Literacy in Science Textbooks. *Journal of Research in Science Teaching*, *28*, 713–725.

Clément, P., Castéra, J. (2013). Multiple Representations of Human Genetics in Biology Textbooks. In D. Treagust, C. Tsui (Eds.), *Models and Modeling in Science Education*, vol. 7, (pp. 147-163). Netherlands: Springer

Cohen, J. (1968). Weighted kappa: Nominal scale agreement provision for scaled disagreement or partial credit. *Psychological Bulletin*, *70*, 213–220.

Costa, A. F., Ávila, P. D., Mateus, S. (2002). *Públicos da ciência em Portugal* [Public(s) of science in Portugal]. Lisboa: Gradiva.

DeBoer, G. (2000). Scientific Literacy: Another Look at Its Historical and Contemporary Meanings and Its Relationship to Science Education Reform. *Journal of Research in Science Teaching*, *37*(6), 582-601.

Fensham, P.J. (2002). "Time to Change Drivers for Scientific Literacy". *Canadian Journal of*

Science, Mathematics and Technology Education, *2*(1), 9–24.

Dillon, J. (2008). Approaching ‘soft disasters' in the classroom: teaching about controversial issues in science, technology, society and environment education. In, Jones, A. & M. de Vries (Eds), *International Handbook on Research and Development in Technology Education*. Rotterdam: Sense.

Fernández, I. (2000). *Análisis de las concepciones docentes sobre la actividad científica: una propuesta de transformación* [Analyses of teachers conceptions about scientific activity: A proposal for transformation]. PhD thesis. Departamento de Didáctica de las Ciencias Experimentales y Sociales. València: Universitat de València.

Fernández, I., Gil, D., Carrascosa, J., Cachapuz, A. & Praia, J. (2003). Visiones Deformadas de la Ciencia Transmitidas por la Enseñanza. *Enseñanza de las Ciencias* [Distorted views of science conveyed by teaching], *20*(3), 477–488.

Fernández, I., Gil, D.,Vilches, A.,Valdés, P., Cachapuz A., Praia, J., Salinas, J. (2003). El olvido de la tecnología como refuerzo de las visiones deformadas de la ciencia [Disregard of technology as an endorsement of the distorted views of science]. *Revista Electrónica de Enseñanza de las Ciencias*, *2*(3).

Ferreira, S., Morais, A. M. (2013). The Nature of Science in Science Curricula: Methods and concepts of analysis. *International Journal of Science Education*, *35*(16), 1–22.

Fontes, M., Novais, A. Q. (1998). The conditions for the development of a biotechnology industry in Portugal: The impact of country specific factors. *Technology Analysis & Strategic Management*, *10*(4), 497–509.

Galvão, C., Neves, A, Freire, A. M., Lopes, A. M., Santos, M. C., Vilela, M. C., Oliveira, M. T., Pereira, M. (2001). Orientações curriculares para o 3º Ciclo do Ensino Básico: Ciências Físicas e Naturais. Ministério da Educação – Departamento da Educação Básica. Retrieved from http://www.dge.mec.pt/sites/default/files/ficheiros/eb_cfn_orient_curriculares_3c_0.pdf

Gardner, P. L. (1990). The technology-science relationship: Some curriculum implications. *Research in Science Education*, *20*(1), 124–133.

Gaskell, P.J. (1992). Authentic Science and School Science. *International Journal of Science Education*, *14*, 265–72.

Gaskell, G., Stares, S., Allansdottir, A., Allum, N., Corchero, C., Jackson, J. (2006). *Europeans and biotechnology in 2005: patterns and trends: final report on Eurobarometer 64.3*. Retrieved from https://ec.europa.eu/research/biosociety/pdf/eb_64_3_final_report_second_edition_july_06.pdf

Gil-Pérez, D., Vilches, A., Fernández, I., Cachapuz, A., Praia, J., Valdéz, P. & Salinas, J. (2005). Technology as “Applied Science”: A Serious Misconception that Reinforces Distorted and

Impoverished Views of Science. *Science & Education*, *14*, 309-320.

Gonçalves, M. E., Castro, P. (2009). Local is beautiful? Governing science-society relations in Europe. *Portuguese Journal of Social Sciences*, *8*(2), 191–207.

Gonçalves, M. E., Delicado, A., Raposo, H. & Domingues, M. (2007). Consumidores, pacientes, activistas, cidadãos: representação e participação do público na gestão do risco, em Maria Eduarda Gonçalves (coord.), pp. 169-215. *Os Portugueses e os novos riscos* [The Portuguese and the new risks]. Lisboa: Imprensa de Ciências Sociais.

Green, W., Naidoo, D. (2008). Science Textbooks in the Context of Political Reform in South Africa: Implications for Access to Science. *Science Education International*, *19*(2), 235–250.

Hamm, M. (1992). Achieving Scientific Literacy Through a Curriculum Connected with Mathematics and Technology. *School science and Mathematics*, *92*(*1*), 6–9.

Hansen, J. (2006). Operationalising the public in participatory technology assessment: a framework for comparison applied to three cases. *Science and Public Policy*, *33*(8), 571–584.

Harding, P.; Hare, W. (2000) Portraying science accurately in classrooms: Emphasizing open-mindedness rather than relativism. *Journal of Research in Science Teaching*, *37*, 225–236.

Harding, S. (1998). Multiculturalism, post-colonialism, feminism: Do they require new research epistemologies? *The Australian Educational Researcher*, *25*(1), 37–51.

Hodson, D (1998). Science fiction: The continuing misrepresentation of science in the science school curriculum. *Journal of Curriculum Studies*, *28*(2), 115–135.

Hollingsworth, S. (1989). Prior Beliefs and Cognitive Change in Learning to Teach. *American Educational Research Journal*, *26*(2), 160–189.

Höttecke, D.,Silva, C. C. (2011) Why Implementing History and Philosophy in School Science Education is a Challenge: An Analysis of Obstacles. *Science & Education*, *20*(3-4), 293–316.

Inglehart, R. (1990). *Culture shift in advanced industrial society*. Princeton, NJ: Princeton University Press.

Jenkins, E. W. (1992). School science education: towards a reconstruction. *Journal of Curriculum Studies*, *24*(3), 229–246.

Knain, E. (2001). Ideologies in school science textbooks. *International Journal of Science Education*, *23*(3), 319–329.

Kolstø, S. D. (2001). Scientific literacy for citizenship: Tools for dealing with the science dimension of controversial socioscientific issues. *Science Education*, *85*(3), 291–310.

Kohring, M., Matthes, J. (2002). The face (t) s of biotech in the nineties: how the German press framed modern biotechnology. *Public understanding of Science*, *11*(2), 143-154.

Kurzer, P., Cooper, A. (2007). What's for dinner? European farming and food traditions confront American biotechnology. *Comparative Political Studies*, *40*(9), 1035-1058.

Laugksch, R. C. (2000). Scientific Literacy: A Conceptual Overview. *Science Education*, *84*(1), 71–94.

Lakin, S.,Wellington, J. (1994). Who will teach the “nature of science”? Teachers’ views of science and their implications for science education. *International Journal of Science Education*, *16*(2), 175–190.

Leite, L. (2002). History of Science in Science Education: Development and Validation of a Checklist for Analysing the Historical Content of Science Textbooks. *Science & Education*, *11*(4), 333–359.

Lewenstein, B. V. (2001). Who produces science information for the public? In J. H. Falk (Ed.), *Freechoice science education: How we learn science outside of school*, pp. 21-43. New York: Teachers College Press.

Markert, M. (2013). History of Science in School Biology Textbooks: Characteristics and Consequences. In P. Heering, S. Klassen, D. Metz (Eds.), *Enabling Scientific Understanding through Historical Instruments and Experiments in Formal and Non-Formal Learning Environments* (pp. 313–322). Flensburg: Flensburg University Press.

McComas, W.F.; Olson, J. (1998). The nature of science in international science education standards documents. In W. McComas (Ed.), *The Nature of Science in Science Education: Rationales and Strategies*, pp. 41–52. Dordrecht: Kluwer Academic Publishers.

Mendes, A. M. P., Rebelo, D. H. V., Pinheiro, E. J. G. (2004). *Programa biologia 12º ano*. [Biology Syllabus 12th grade].

Retrieved from http://www.dgidc.min-edu.pt/data/ensinosecundario/Programas/biologia_12.pdf

Millar, R. (2002). Towards a science curriculum for public understanding. In S. Amos & R. Boohan (Eds.), *Teaching science in secondary schools*, pp. 113-128. London: Routlege/Falmer and The Open University.

Millar, R. & Osborne, J. (1998). *Beyond 2000: Science Education for the Future. The Report of a Seminar Series Funded by the Nuffield Foundation*. London: King’s College London, School of Education.

Miller, J. D. (1998). The measurement of civic scientific literacy. *Public Understanding of Science*, *7*(3), 203–223.

Morris, H. (2014). Socioscientific Issues and Multidisciplinarity in School Science Textbooks. *International Journal of Science Education*, *36*(7), 1137–1158.

O’Mahony, P.; Schäfer, M.S. (2005). The book of life in the press: Comparing German and Irish media discourse on human genome research. *Social Studies of Science*, *35*, 99–130.

Osborne, J. (2000). Science for citizenship. In M. Monk & J. Osborne (Eds.), *Good practice in science teaching*, pp. 225-240). Buckingham: Open University Press.

Osborne, J. & Dillon, J. (2008). *Science Education in Europe: Critical reflections*. London: The Nuffield Foundation.

Osborne, J., Collins, S., Ratcliffe, M., Millar, R., & Duschl, R. (2003). What"ideas-about-science" should be taught in school science? A Delphi study of the expert community. *Journal of Research in Science Teaching*, *40*(7), 692–720.

Osborne, J., Duschl, R., Fairbrother, R. (2002). *Breaking the mould: Teaching science for public understanding*. London: The Nuffield Foundation.

Patton, M.Q. (2010). *Qualitative Research & Evaluation Methods.* Thousand Oaks: Sage.

Pearson, K. (1904). On the theory of contingency and its relation to association and normal correlation. In *On the General Theory of Skew Correlation and Non-Linear Regression*. Cambridge: Cambridge University Press.

Peters, H.P.; Lang, J.T.; Sawicka, M.; Hallman, W.K. (2007). Culture and technological innovation: Impact of institutional trust and appreciation of nature on attitudes towards food biotechnology in the USA and Germany. *International Journal of Public Opinion Research* , *19*, 191–220.

Pedretti, E., & Nazir, J. (2011). Currents in STSE education: Mapping a complex field, 40 years on. *Science Education*, *95*(4), 601–626.

Pepinsky, T. B. (2013). The Global Economic Crisis and the Politics of Non-Transitions. *Government and Opposition*, *47*(02), 135–161.

Prpić, K. (2011). Science, the public, and social elites: How the general public, scientists, top politicians and managers perceive science. *Public Understanding of Science*, *20*(6), 733–750.

Pingel, F. (2010). *UNESCO Guidebook on Textbook Research and Textbook Revision*. Unesco. Retrieved from

http://unesdoc.unesco.org/ulis/cgi-bin/ulis.pl?catno=117188&gp=1&mode=e&lin=0

Quessada, M. & Clément P. (2007). An Epistemological Approach to French Syllabi on Human Origins during the 19th and 20th Centuries. *Science & Education*, *16*, 991-1006.

Reis, P. R. (2008). *A Escola e as Controvérsias sociocientíficas: Perspectivas de Alunos e Professores* [The school and the scientific controversies: Perspectives of students and techers]. Lisboa: Escolar Editora.

Reis, P., Galvão, C. (2004). The impact of socio-scientific controversies in Portuguese natural science teachers' conceptions and practices. *Research in Science Education*, *34*(2), 153–171.

Roberts, D.A. (2007). Scientific literacy. In S. K. Abell, & N. G. Lederman (Eds.), *Handbook of Research on Science Education* (pp. 729–780). Mahwah, NJ: Lawrence Erlbaum Associates.

Rocard, M., Csermely, P., Jorde, D., Lenzen, D. Walberg-Henriksson, H. & Hemmo V. (2007). *Science Education Now: A Renewed Pedagogy for the Future of Europe*. Brussels: Directorate General for Research, Science, Economy and Society.

Rosenthal, D. B. (1984). Social issues in high school biology textbooks. Journal of Research in Science Teaching, *21*(8), 819–831.

Rudolph, J. L. (2003). Portraying Epistemology: School Science in Historical Context. *Science Education*, *87*, 64-79.

Sadler, T. D. & Zeidler, D.L. (2004) "The Morality of Socioscientific Issues: Construal and Resolution of Genetic Engineering Dilemmas". *Science Education*, *88*(1), 4–27.

Schwartz, R. S. & Lederman, N. G. (2008). What Scientists Say: Scientists' views of nature of science and relation to science context. *International Journal of Science Education*, *30*(6), 727-771.

Selmaoui, S., Agorram, B., Kzami, S., Razouki, A., Clément, P., & Caravita, S. (2012). Cultural and Socio-economical Dimensions of Human Reproduction and Sex Education in the Biology Textbooks of Eight Countries. *Sociology Study ISSN*, *2*(12), 963–968.

Shamos, M. H. (1995). *The myth of scientific literacy*. New Brunswick: Rutgers University Press.

Scharfenberg, F. J., & Bogner, F. X. (2011). A new two-step approach for hands-on teaching of gene technology: effects on students' activities during experimentation in an outreach gene technology lab. *Research in Science Education*, *41*(4), 505-523.

Stinner, A. (1995). Contextual settings, science stories, and large context problems: Toward a more humanistic science education. *Science Education*, *79*(5), 555–581.

Thomas, G. & Durant, J. (1987). Why should we promote the public understanding of science? Scientific Literacy Papers, *1*, 1-14.

Torgersen, H., Hampel, J., Bergmann-Winberg, M., Bridgman, E., Durant, J., Einsiedel, E., Fjaestad, B., Gaskell, G., Grabner1, P., Hieber, P., Jelsoe, E., Lassen, J., Marouda-Chatjoulis, A., Nielsen, T., Rusanen, T., Sakellaris, G., Seifert1, F., Smink, C., Twardowski, T., Wambui Hovmand, M. (2002). Promise, Problems and Proxies: 25 Years of European Biotechnology Debate and Regulation. In: M. Bauer and G. Gaskell (Eds.), *Biotechnology. The Making of a global controversy* (pp. 21-94). Cambridge: Cambridge University Press,

Turner, S. (2008). School Science and its controversies; or, whatever happened to scientific literacy? *Public Understanding of Science*, *17*, 55-72.

Turner, S., & Sullenger, K. (1999). Kuhn in the classroom, Lakatos in the lab: Science educators confront the nature-of-science debate. *Science, Technology & Human Values*, *24*(1), 5-30.

Asian Programme of Educational Innovation for Development. Unesco. Regional Office for Education in Asia and the Pacific (1983). *Science for all: report of a regional meeting, Bangkok*. Bangkok: Unesco Regional Office for Education in Asia and the Pacific.

Vaz, M. E., & Valente, M. O. (1995). Atmosfera CTS nos currículos e manuais [Atmosphere STS in sylabi and textbooks]. *Noesis*, *34*, 22-27.

Weber, K., Rao, H., & Thomas, L. G. (2009). From streets to suites: how the anti-biotech movement affected German pharmaceutical firms. *The American Journal of Sociology*, *74*, 106-127.

Wellington, J. (1991). Newspaper science, school science: friends or enemies?. *International Journal of Science Education*, *13*, 363-372.

Wellington, J., & Osborne, J. (2001). *Language and literacy in science education*. Buckingham: McGraw-Hill Education.

Vislie, L. (2003). From integration to inclusion: focusing global trends and changes in the western European societies. *European journal of special needs education*, *18*(1), 17-35.

Weinstein, M. (1998). Playing the Paramecium: Science Education from the Stance of the Cultural Studies of Science. *Educational Policy*, *12*(5), 484–506.

Yates, T. B., & Marek, E. A. (2013). Is Oklahoma really OK? A regional study of the prevalence of biological evolution-related misconceptions held by introductory biology teachers. *Evolution: Education and Outreach*, *6*(1), 1-20.

Zeidler, D.L., Sadler, T.D., Simmons, M.L. & Howes, E.V. (2005). Beyond STS: A Research-Based Framework for Socioscientific Issues Education. *Science Education*, *89*(3), 357–77.

Zimmerman, C., Bisanz, G. L., Bisanz, J., Klein, J. S. & Klein, P. (2001). Science at the supermarket: A comparison of what appears in the popular press, experts' advice to readers, and what students want to know. *Public Understanding of Science*, *10*(1), 37-58.

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Publications

I. A Reflection on Distorted Views of Science and Technology in Science Textbooks as Obstacles to the Improvement of Students' Scientific Literacy

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Scientific literacy has been increasingly considered a major goal of science education. While textbooks remain the most widespread tools for pursuing this goal within classrooms, they have been slow to adapt to the most recent epistemological paradigms, often still conveying distorted views of science and technology. Accordingly, we present herein a theoretical framework specifically intended to highlight the potential of textbooks to promote students' scientific literacy. It is additionally argued that, often, the misconceptions conveyed by textbooks represent obstacles to the acquisition of a fair image of science and, therefore, to the acquisition of scientific literacy. Finally, a textbook analysis is suggested.

Key Words: scientific literacy, knowing about science, science, inquiry, technology, society, environment, textbooks, conceptions

Introduction

Science and technology interfere constantly, and in tight coexistence, with our daily lives. In spite of that, the complex arguments raised in the course of scientific and technological controversies are often not well understood (Miller & Pardo, 2000; Organisation for Economic Co-operation and Development [OECD], 2007). Although the media increasingly make scientific information available to the public (Brossard & Shanahan, 2006; Lewenstein, 2001), this information seems to be unintelligible to the vast majority of consumers. Therefore, the challenge in the classroom is to provide individuals with the background required to understand the news. Koelshe (1965) already highlighted the pressing need to improve peoples' scientific background. Nevertheless, scientific-technological issues, frequently involve complex interactions between several social entities. Their analysis, understanding and judgement must rely on more than the underlying scientific knowledge (Reis, 2008). Citizens should be aware of what triggered certain research, how knowledge was achieved, what this achievement represents and how it may positively or negatively affect individuals, society and the environment. Science educators in particular have the double task of conveying, to all students, the scientific background required for conscious citizenship, while preparing students intending to pursue scientific careers. In consequence, Osborne and Dillon (2008) pointed out the importance of 'scientific literacy' (SL) in science education, irrespective of the students' professional future. Hereby, the actual meaning of the term "SL" needs discussion, especially which content should be conveyed, how students are helped to become scientifically literate citizens, whether current learning materials in particular science textbooks are adequate means to that end and, finally, how deficiencies in textbooks are to be surveyed. Therefore, the objectives of our study are the following: - (i) To reflect about the concept of SL, which is seen as a pre-condition to identify the range of general requirements a citizen should comply with in order to reach scientific literacy. In our view, science textbooks need to foster the development of SL. These ideas exceed the level of factual knowledge (knowledge of science), which is quite rigidly determined by syllabi, and therefore less dependent on textbook authors' options or epistemological orientations. Consequently, our focus was set on the fields known as Nature of Science (NoS), Nature of Scientific Inquiry (NoSI) and Science-TechnologySociety-Environment (STSE), to which guidelines allow wider elbowroom. - (ii) To highlight the potential of textbooks to promote the understanding of science and technology and their interplay with society and the environment. - (iii) To discuss how distorted views of science and technology (misconceptions), consciously or unconsciously conveyed by textbooks, may constitute obstacles to that understanding. - Last but not least (iv) to highlight how detecting those distorted views in textbooks can help to determine the extent to which a textbook may contribute to SL.

Science Curricula: Problems and Challenges

A major concern, for instance, expressed by Osborne and Dillon (2008) is that progressively fewer young people seem to be interested in scientific and technical subjects. Research has shown that even bright and creative science students, discouraged by a boring and irrelevant curriculum, drop out of science (Aikenhead, 2002). On the other hand, to students who are pursuing neither scientific nor technical careers, the conventional school curriculum has little relevance to their future lives (Aikenhead, 1980; Layton, Jenkins, Macgill, & Davey, 1993; Millar & Osborne, 1998). Although several voices (Rocard 2007; Osborne & Dillon, 2008) claim the importance of developing efforts to re-imagine science education in order to fit the modern world and meet the needs of all students. These authors argued that, during the last two decades, little attention has been given to its nature and structure, and curricula mainly focus on factual knowledge. Fensham (2002), for instance, claimed an urgent need to recruit new “drivers” to form a counterweight to those who are steering the curriculum process. Contesting the value of the preponderance of factual knowledge in curricula, he argued that, in conflicting decisions, individuals values are more important determinants of trust in the scientific information than factual knowledge of science. Moreover, he criticized attempts to enrich this curriculum with NoS or STS material, because it is simply been added to an already excessive body of scientific content. Considering the traditional techno-scientific approaches, some authors argue that they have failed in the classroom because they have not been prepared explicitly to embrace ethical considerations as a preliminary to any discussion of civic SL (Zeidler, Sadler, Simmons, & Howes, 2005; Sadler & Zeidler, 2004; Bell & Lederman, 2003). This problem is intimately connected with that of representations of science and technology being placed in curricula which, according to Rudolph (2003), are shaped by scientists' activities and the social and political context in which they are developed. Quessada and Clemént (2007) favoured the didactic transposition of scientific ideas as resulting from the interaction between knowledge, values and social practices and pointed to a delay associated with the transfer of scientific ideas from curricula to textbooks. It is legitimate to assume that not only is factual knowledge affected by these constraints, but also by the ideas having emerged from the epistemological debate surrounding the image of science and how it should be conveyed to students.

Scientific Literacy: State of the Art

The term "SL" became a recognized educational term connected with the contemporary educational goal of "science for all" (UNESCO, 1983), and nowadays it represents the main goal of science education (DeBoer, 2000; Hodson, 1998). However, a consensual definition has not yet been reached (Shamos 1995). Together with the concern for public engagement in science and technology that emerged in the 1980s, the movement for Public Understanding of Science (PUoS) arose to instil confidence in and support the scientific enterprise. Another movement, "science for all", envisaged a shift of the curricular science education towards the needs of the majority of students, those not pursuing scientific or technological careers. It thrived under the catchy American slogan "SL" (Turner, 2008). Several definitions of SL have been proposed since then, varying according to their historical and political contexts (Turner, 2008), and based on interest groups (Laugksch, 2000) or on economical, utilitarian, cultural, democratic, or even moral arguments (Millar, 2002; Osborne, 2000; Thomas and Durant, 1987). Among them, two major labels prevail: "nature of science" (NoS) and "science, technology, and society" (STS) which, together, converge to the concept of "civic SL" (Turner, 2008). From that perspective, these two domains comprise the knowledge that citizens should be aware of as requirements for understanding and judging scientific and technological advancements. However, note that STS and civic SL are not just two labels for the same concept. Consonant with the Nature-of-Science movement (NoS), for Durant (1993, p. 129) SL stands for "what the general public ought to know about science". Jenkins (1994) extends this concept by arguing that SL requires "an appreciation of the nature, aims, and general limitations of science" (p. 5345), which can also be summarized as knowing about science. However, in his view this knowledge must be coupled with some understanding of the conceptual knowledge achieved by the scientific enterprise. Schwartz and Lederman (2008) also linked these two domains, although emphasizing each of them differently. According to them, scientifically literate individuals should possess not only a conceptual knowledge of science, but also epistemological views of science that are consistent with the currently acceptable ones. For these authors, epistemological views of science involve two separate yet overlapping concepts: one's view of scientific knowledge as a way of explaining the nature of science (NoS); and one's view of the processes through which that knowledge is acquired, constructed and justified - nature of scientific inquiry (NoSI). Some authors defend that students' understanding of the scientific enterprise (involving both the NoS and the NoSI) is increased by allowing them to engage in authentic science (Gaskell, 1992; Turner & Sullenger, 1999; Scharfenberg & Bogner, 2010). The "authentic science movement" entered into powerful symbiosis with the constructivist learning theory, as it expected students to extract an individual meaning from the results they obtained, both through analysis of obtained data and through classroom discussion and negotiation (Turner, 2008). Along these lines, the so-called Rocard report (Rocard et al., 2007), while calling for an urgent reform of science education, recommended inquiry-based methods for raising students' interest in science and for developing certain intellectual skills. It is, however, relevant to determine to what extent inquiry-based teaching contributes to the students' SL. According to NSES (NRC, 1996) and Benchmarks for Science Literacy (AAAS, 1993), it is the understanding of NoSI, rather than the skills of inquiry, that contribute to scientific literacy. For different reasons, the arguments above support the thesis that understanding the nature of scientific enterprise from the internal perspective and its methods contributes to SL. Nevertheless, recent studies point out that students' attitudes towards socio-scientific issues are determined more by ethical assumptions than their understanding of the "methods of inquiry" or by the "nature of science" (Turner 2008). Halfway between these two positions the referenced Rocard report, despite emphasizing inquiry-based methods, highlights the understanding of the interactions between science, technology and society as a pre-requisite for acquiring "science literacy". Major multinational studies are currently being carried out to support the requirements above formulated (e. g. EU-projects such as PATHWAY, ESTEM, FIBONNACI, etc.). A shift in science education appears to be occurring as goals are being set beyond the internal perspective of science, crossing the boundaries of the subject-focused scientific community. The relationship between science and technology, as well as their positive and negative repercussions in society and the environment, has been gaining increased prominence. Over the past three decades a movement called "Science-Technology-Society" (STS) (Turner, 2008) challenged the status quo of science education and asked for a redefinition of SL. Accordingly, the STS slogan changed during the last five decades due to growing concerns about environmental degradation, assuming the designation of STSE ("E" for environment) movement (Aikenhead, 2002). These evolutions exceeded the debate among scholars and penetrated the general school syllabi. The STS curricula were intended to promote SL in citizens, trigger the interest of students in science and technology, foster an interest in the complex interactions between science, technology and society, and to develop students' critical and logical reasoning skills in order to promote abilities in creative problem resolution and conscious decision making (Aikenhead, 1994; Bybee, 1985; Solomon, 1993).

This movement drifted, therefore, away from the investigatory activity that generated knowledge. It focused instead on the impact of technology, in consonance with the more recently emergent concept: civic SL (Turner, 2008). Despite the different roots and different learning visions of STSE and NoS, some STS defenders (Ratcliffe, 2001; Solomon & Aikenhead, 1994; Ziman, 1994) believe that the impact of science on society and the environment, together with the Nature of Science in the broad sense, must be approached inseparably, as co-operators in a common final product. Indeed, the understanding of the means through which scientific knowledge is achieved, both from the conceptual and the methodological perspectives, seems to be a prerequisite for citizens to understand the real meaning of "scientific evidence" or scientific "truths" required to follow techno-scientific issues. The perception that scientific knowledge is merely tentative, despite the fact that it is the best we have (McComas and Olson, 1998), disassembles the naive views of science either to a super confidence in science and technology or an extreme scepticism. It is only with awareness of their benefits and negative implications in all these domains that it is possible to critically analyse a certain controversial issue and to judge more objectively the connected economic interests, and corresponding political decisions. The above referenced concept of civic SL was proposed by Miller (1998) as a threedimensional construct: (1) a vocabulary of basic scientific knowledge sufficient to read competing views in a newspaper or magazine, (2) an understanding of the process or nature of scientific inquiry, and (3) some level of understanding of the impact of science and technology on individuals and on society. In more recent cross-national studies of civic SL, the author observed that the dimension (3) is supposed to vary substantially in content among different countries according to their corresponding socio-cultural contexts. This suggests that the expected optimal level of SL in a certain community should consider its historical pathway and its background in science and technology (McComas, Clough and Almazroa, 2000). Nevertheless, despite the acceptable variability, a definition of the concept and the clarification of its requirements remains a matter of great importance. The domain of knowledge prevails in the definitions of SL and the majority restrict themselves to it. This position in the range of definitions is shared by other authors (Lee, 1997; National Science Teachers Association [NSTA], 1971; Shamos, 1995); Scottish Consultative Council on the Curriculum [SCCC], 1996); Hodson, 1998; NSTA, 1971; OECD, 2007; SCCC, 1996; Shamos, 1995); Aikenhead, 2002; Miller, 1998; NSTA, 1971). Nevertheless, other dimensions embracing more than knowledge are included by several authors in the definition of the concept, such as scientific skills (OECD, 2007), attitudes towards the role of science in society (Hodson, 1992; Mathews, 1998; OECD, 2007; SCCC, 1996; Turner, 2008) and the ability to take a stand (Hodson, 1998; NSTA, 1971). This synthesis illustrates the broadness of the term "SL", encompassing many historically significant educational themes that have shifted over time (DeBoer, 2000), as well as "the wide spectrum of opinions that exists today among educators" (Turner 2008, p. 56).

Boundaries of Our Present Study

It is not our purpose to discuss the essence of the concept of SL. Nevertheless, we also attempt to position ourselves in this spectrum of opinions according to the following: In our perspective, a scientifically literate citizen should be capable of, at least, a superficial understanding of the “happenings” in all scientific and technological domains. Even people who pursue a career in science or technology cannot follow the primary literature for all scientific disciplines (Bauer, 1994). Therefore, a scientist with expertise in a certain field is no more skilled than any other citizen when exposed to a completely different field of knowledge. Therefore, we don’t consider scientific skills to be essential to the understanding of science and technology. While these may influence positively the understanding of science, they should only be required to reach another level of SL: the researcher’s SL. Our conception of SL does not comprise the attitudes towards science and technology nor the ability to take a stand. Indeed, a good level of SL may have influence these areas, but they also depend on other factors, such as values, personal experiences, individual interests and personality, among others. Therefore, we place our conception of SL in the domain of knowledge, particularly in knowledge of science and technology, for the following reasons: Firstly, we recognize the possession of scientific knowledge as the cornerstone for comprehending science and technology. Knowing the lexicon of a certain scientific or technologic domain, and being aware of the concepts underlying a particular issue, are prerequisites for understanding evidence provided by science and for following scientific and technological developments. Secondly, we also consider the awareness of how relative scientific “truths” really are to be an indispensable requirement of SL. To reach this level of critical thinking citizens should, whether by engaging in real science or by analysing the work of others, be acquainted with the way scientific evidence is generated (NoSI). Unless they are able to understand the different processes that contributed to the reported results as well as the researchers’ reasoning, common citizens feel lost when equally qualified researchers assume different positions (Bauer, 1994). Furthermore, citizens must gain awareness of a more embracing concept of science, far beyond its methods of inquiry: scientific knowledge must be seen for what it is, a social construct (McComas and Olson, 1998; Osborne et al., 2003). Scientists, rather than working in isolation, establish vertical relationships with their predecessors and horizontal relationships with their peers and with other disciplines. Therefore, the understanding of the ways in which knowledge evolves within the scientific community (NoS) may also contribute to a more realistic image of science. Finally, in our view, understanding science nowadays requires knowledge of: (1) the social factors which have triggered, slowed down, or even impeded a particular scientific research; (2) the way scientific and technological progress influences society and the environment, and of its ethical implications (STSE issues). In summary, there is a coincidence between the conception of SL that binds the present reflection and that of Miller. It can be defined as the knowledge of, and about, science and technology, that together with personal experiences and cultural values contributes to the development of attitudes and behaviours required for a participative citizenship, as represented in Figure 1. In view of the reasons laid down above, the scope of this article is the discussion of the potential and the fragilities of science textbooks to convey knowledge about science and technology, with the focus placed on the domains of NoS, NoSI and STSE.

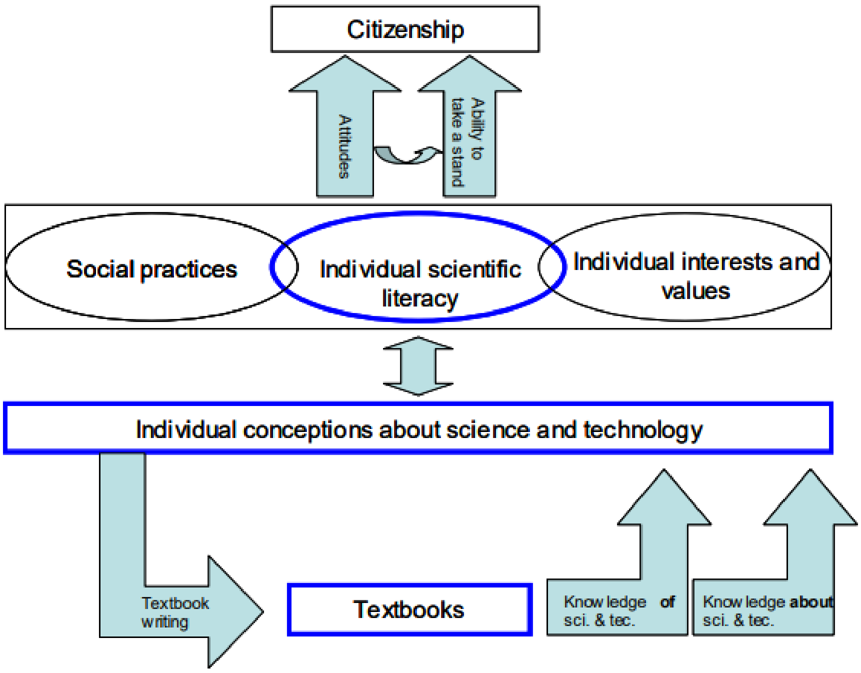

Figure 1 - Schematic representation of the concepts involved in the present work

Sources of Scientific Knowledge about Science and Technology

Having placed the conception of SL in the domain of knowledge, a reflection on the sources of the knowledge essential to becoming a scientifically literate citizen is required. Millar and Osborne (1998) pointed out that the main purpose of the teaching of science is to prepare students for a critical interpretation of the news conveyed by the media, and to promote the construction of personal opinions about daily socio-scientific questions. The authors suggest that the media are the prevailing sources of new information about scientific research for the common citizen. Nevertheless, despite its potential importance to SL, Zimmerman, Bisanz, Bisanz, Klein and Klein (2001) state that little is known by common citizens about the content of media reports. Is science education therefore failing to achieve its main objective? There is a time lag between the advancements disclosed by scientific and academic journals and their announcement in the general media. Furthermore, news is shaped by journalists' interpretation Individual scientific literacy Textbooks Individual conceptions about science and technology Citizenship Attitudes take a stand Ability to Textbook writing Social practices Individual interests and values Know ledge of sci. & tec. Know ledge about sci. & tec. Individual scientific literacy Textbooks Individual conceptions about science and technology Citizenship Attitudes take a stand Ability to Textbook writing Social practices Individual interests and values Know ledge of sci. & tec. Know ledge about sci. & tec. Know ledge of sci. & tec. Know ledge about sci. & tec. of scientific reports, without describing the processes behind the achievements (Wellington, 1991). An equivalent delay (Quessada and Clemént, 2007) and erosion occurs between the descriptions of research disclosed by the original sources of scientific knowledge and their appearance in textbooks, as conventional and well established science contents Zimmerman, Bisanz, Bisanz, Klein and Klein, 2001. Bauer (1992) calls particular attention to the difference between frontier science, the one that is reported by the media, and science textbooks, that is filtered and modified. Traditional science portrayal is, therefore, frequently only a selective representation of the scientific practices (Rudolph, 2003). Despite this limitation, learning materials represent privileged opportunities not only to present the established fundamental knowledge in science, but also to expose those aspects of science and technology that are not discussed in the media. Are textbooks fulfilling their task? To what extent do science textbooks present material that may contribute to the students' understanding of science and technology?

The potential of textbooks as vehicles of SL

Textbooks, in general, are relevant as learning materials, but they also seem to dictate the curriculum for many teachers (Osborne, Duschl and Fairbrother 2003). Textbooks provide them with guidance and support, also promoting the participation of parents (Bartholomew, Osborne, and Ratcliffe, 2004) and enable students to learn independently (Aufdermauer & Hesse, 2006). Science textbooks are referred to by several authors (Chiappetta, Fillman & Sethna, 1991; Hodson, 1996; Leite, 2002) as powerful resources for teachers and students alike. As discussed above, in parallel with the mere presentation of achievements of science and technology, science textbooks also offer teachers and students the opportunity to work out the way in which they have been achieved. That can be accomplished by contextualizing events (Leach, Millar, Ryder and Séré, 2000; Rudolph, 2003) externally and internally to the scientific community by describing processes and demonstrating the repercussions of scientific and technological events in society and in the environment. This can be done through brief references to events emphasizing their meaningful aspects, or by exploring historical reports of representative events (Hodson 1996), generally referenced as case studies. The latter may include stories and anecdotes about scientists which illustrate scientific and technological progress (Leite, 2002). Despite the unquestionably informative and motivational potential of case studies, some considerations about their inclusion in textbooks are required: primarily, teachers must be aware of the principal shortcomings of case studies. Secondly, even though every single case, as reported by historical documents, does illustrate particular aspects of science and technology, any individual case should not be expected to contain all the relevant aspects of science. For instance, while some case studies evoke the social factors that triggered particular research, others display how knowledge was acquired, while still others are more appropriate for explaining how scientific ideas succeed each other or what their repercussions are in society or in the environment. Additionally, ideas about science and technology can also be conveyed to students if the use of simple references to historical or contemporary scientific and technological achievements are accompanied by meaningful details. Therefore, through a balanced combination of extensive reports and brief references to illustrative events, textbooks can help students realize how scientific knowledge was generated, evolved and established itself. Actually, studies undertaken with undergraduate students provided evidence that the use of hermeneutical circle strategies, besides enhancing students' understanding of textbook content, also operate changes in students' views of science (Kalman, 2011). Despite the above, it is important to note that analysing reports of others' experiments or following suggestions or instructions for experimental activities, is not the same as performing science. Nevertheless, awareness of the nature of scientific inquiry (NoSI) may also be achieved, not only as learning science by inquiry, i. e., by engaging in real science, but also learning science as inquiry (Tamir 1985). Learning science as inquiry includes learning about the way in which the scientific endeavour progresses by analysing the inquiry process performed by others, either using historical perspectives (Bybee, 2000), or discussing contemporary research. Historical events of science have been largely recommended and used as a means of understanding the contemporary social issues of science (Shortland and Warwick, 1989). However, the history of science is still being written and in our view goes far beyond the classical case studies. It also embraces contemporary "cases", which illustrate new challenges to science and technology and their desirable, undesirable and even controversial repercussions in the present world. Science textbooks should, therefore, comprise detailed reports of relatively recent events, thus providing students with the opportunity to perceive what remains constant in scientific activity and what has changed over time. The description of contemporary case studies is most clearly advantageous in content such as genetics, gene technology or nuclear energy. Addressing socio-scientific issues in this context may confront teachers and students with questions that frequently have moral and ethical implications. This confrontation has been considered by several authors (Hamm, 1991; Gaskell, 1992; Vaz e Valente, 1995; Kolsto, 2001; Aikenhead 2002; Reis, 2008) as a valuable strategy for preparing citizens to face problems that could be perceived and judged from different perspectives, frequently involving values. Consequently, textbooks should provide adequate and reliable material supportive of discussions of both classical and contemporary socio-scientific issues in the classroom. This material should facilitate the conveyance of correct ideas about science and technology, thus representing a step towards lessons promoting SL.

What Knowledge or Ideas about Science and Technology Should Be Taught?

It is quite consensual that the domains: NoS, NoSI and STSE need specific consideration when accessing SL. Nevertheless, it still remains questionable which ideas about science, scientists' work, and the interactions between science, technology, society and the environment students should be made aware of. While some authors, such as Stanley and Brickhouse (2001); Hipkins, Barker and Bolstad (2005), express concern about the negligible consensus amongst philosophers, historians of science, scientists, and science educators about which ideas about science (IAS) should be placed on curricula, others (Smith, Lederman, Bell, McComas, & Clough, 1997; Smith & Scharmann, 1999) point out the existing consensus on fundamental IAS that are relevant and accessible to school science education. Osborne, Duschl and Fairbrother (2003) challenged the latter statement by arguing that the studies based on curriculum documents, such as Benchmarks for SL (AAAS, 1993) and others from New Zealand, Canada, the United Kingdom and Australia (McComas & Olson, 1998), rather than displaying a consensus, represent a necessary compromise for the drafting of reports by the committees. According to these authors, those studies simply fail to represent the lowest common denominator around which it would be possible to reach agreement, thus also failing to represent a coherent account of the NoS. As a counterproposal, those authors have conducted a Delphy study to empirically determine the extent of any consensus among scientists, science teachers, philosophers, sociologists of science and science educators on IAS that should be included in the school science curricula. In the present article, a parallelism between the consensual ideas and those identified by Mc Comas and Olson (1998) was described by concluding that a considerable agreement between both sets does exist. Meaning, despite the use of differing methods in different studies, many of the ideas referred to are also consensual among scholars. However, despite the considerable correspondence between most agreed and consensual ideas, some of them reveal divergent epistemological orientations. The observed divergence may be a reflex of differing underlying conceptions of science, from both conceptual and methodological perspectives of individual scholars. This is the case in, for example, the ideas expressed by the statements "science is tentative" (McComas & Olson, 1998) and "science and certainty" (Osborne et al., 2003). Regarding such divergences, these two sets, though containing relevant nuclear ideas, would hardly provide adequate guidelines for writing or analysing science textbooks. Moreover, as described below, abundant bibliography points out other ideas about science and technology which, though not consensual, seem to be indispensable for many science education researchers in constructing a correct image of these interconnected entities. With respect to the specific domain of NoSI, recent studies built upon international science education standard documents and the existing literature in science education, and undertaken by Schwartz and Lederman (2008), produced an instrument suitable for surveying the scientists' views of scientific inquiry (VoSI). The indicators used in this study could therefore provide an appropriate basis for defining detailed and precise criteria for checking the presence or absence of relevant ideas about scientific practice in textbooks.

The Knowledge about Science in Science Textbooks

The content included in science textbooks for illustrating the context and processes through which scientific knowledge and technological advancements were achieved, should be wisely selected in order to display an epistemologically established image of both, and of their interaction with other spheres. "The kind of historical material used and the way it is used is what determines the image given to students (even if an incorrect one) of science, scientists and scientific practice" (Leite, 1986, p. 334). The same considerations apply to the contemporary events, in particular to socio-scientific issues, which should consider their controversial nature as well as their ethical, moral and religious implications. Several studies already exist that focus on the knowledge about science in textbooks. For instance, Orpwood (1984) analysed biology textbooks from the perspective of STSE and the image of science conveyed by textbooks (he has gone beyond that, also focusing on the domains stated intentions and scientific skills). Two of Orpwood's themes, namely scientific skills and the image of science, were also used by Tamir (1985) while analysing how biology textbooks approach the scientific inquiry. Chiappetta, Fillman and Sethna (1991) selected four aspects or themes of SL which had been pointed out by the NSTA (1982) as components of SL: science as a body of knowledge; science as a way of investigating; science as a way of thinking; and the interaction between science, technology and society. This method has also been followed by Wilkinson (1999) while analysing Physics textbooks from the same perspective. Chiang-Soong and Yager (1993) analysed the pure space devoted to STS issues in textbooks and concluded that they receive poor coverage, worsening with increasing grade levels. Rosenthal (1984) analysed social and controversial issues in textbooks and concluded that attention to social issues decreased between 1963 and 1983. Leite (2002) focused on the quality of the approach to history of science in physics textbooks, while Abd-El-Khalick, Waters, Le (2008) analysed the representations of NoS in high-school chemistry textbooks. Teachers' views, and therefore very likely textbook writers' views (since they are predominantly teachers) of the NoS are not consistent with currently accepted definitions (Lederman, 1992; Leach, Millar, Ryder and Séré, 2000; Lederman, Wade, and Bell, 1998; Gil-Pérez et al., 2005). Rosenthal (1984) analysed the treatment of social issues in biology textbooks and found that attention to social issues decreased between 1963 and 1983. Nevertheless, Chiappetta, Fillman and Sethna (1991) argue that if one were to analyse some of the more recent textbooks, a higher proportion of their content would probably be devoted to STS since this theme has been attracting progressively more attention in science education. If there is a gap between ideas emerging from the scientific and the educational communities and curricula, then an equally meaningful gap exists between each official curriculum and the content conveyed to students. This discrepancy depends upon several elements of the “hidden curriculum” (Cachapuz, Praia, Jorge, 2004; Pingel, 1999), such as the decisions of publishers conditioned by market dynamics, the conceptions of textbook authors, and the interpretations of teachers which are influenced by their own conceptions about science. Textbooks usually present science as a body of knowledge acquired in a linear way (Finley, 1994), avoiding or neglecting movements back and forth (Leite, 2002) that characterize the dynamics of scientific research and, therefore, the evolution of scientific ideas. Chiappetta, Fillman and Sethna (1991) state that the empiricist vision of science displayed by students and teachers is due to the fact that textbooks, explicitly or implicitly, place an emphasis on facts, while processes are omitted.

Distorted Views of Science in Science Textbooks

Having defined the domains of knowledge as essential components of SL (chapter 3), it is imperative to collect from the epistemological and science education debates the ideas about science and technology that can contribute to a formal science education oriented to SL. Based on these ideas, criteria should be specified according to which both science lessons and textbook content may be evaluated and compared. As explained in the previous chapter, studies in this domain were undertaken by several researchers but, in our opinion, a method capable of providing a holistic overview of the same reality is still absent. Along with concerns for the promotion of scientific understanding in the broad sense, many scholars draw attention to both the lack of information about science and technology placed in textbooks, and the incorrect ideas displayed by them. Incorrect ideas can represent filters or even barriers to the achievement of SL in students. They can induce and cement distorted views that interfere in the construction of a fair image of science as a body of knowledge, as well as in the comprehension of scientists’ work and of the role of science and technology in our lives. At first glance, compliance with the requirements of SL can be surveyed by looking for absent or incorrect ideas about science and technology. However, in our opinion this method misses an important point: there is evidence that incorrect ideas and the absence of correct ones, do not appear in isolation or at random. Instead, their occurrence is interconnected with other ideas, according to certain patterns revealing distorted views of science and technology. For example, by nourishing the idea that all scientists are exceptional people, one is hardly able to recognize that science has a collaborative character. Instead, one is drawn to the idea that scientists work in isolation in their ivory towers. These two incorrect ideas occur very likely together as components of a distorted view of the scientific enterprise. Fernández, Gil, Carrascoa, Cachapuz and Praia, (2003) identified seven distortions of the image of science mostly referred to in the literature. These views coincided with those found by Fernández (2000) in his analysis of current science teaching practice by means of, among other procedures, analysis of textbooks, laboratory guides and assessment exercises, and by direct observation of classroom activities, as well as questionnaires and interviews. Given continuity to that work, Gil-Pérez et al. (2005) argued that the simplistic conception of the relationship between science and technology, according to which technology is seen as a mere product of science or as applied science, and the role of technology in the construction of scientific knowledge is underestimated or even disregarded. That misunderstanding appears to underlie the distorted views of science and technology, often considered as one of the main obstacles to renovation in science education. According to Fernández, Gil, Carrascosa, Cachapuz and Praia, (2003) and Gil-Pérez, Gil-Pérez et al. (2005), the seven most commonly identified distorted views are the following:

1. Empiric-intuitivist and non-theoretical conception of science

This is considered as the most referred to conception in the literature. It emphasizes the role of "neutral" observation and experimentation as if the knowledge had been achieved by chance, without "contamination" by previous ideas. The hypothesis as the focus of investigation, as well as the role of theories as a coherent body of knowledge that guides the whole process and upon which the design of new research relies, are both disregarded.

2. Rigid conception of scientific activity

A conception that conveys a rigid (algorithmic, rigorous, fail-safe) image of scientific work. The figure of "scientific method" is often explicitly referred to or implicitly presented as a set of rigid steps to be mechanically followed. Quantitative processing and rigorous control of experiments are emphasized, while "invention", "creativity" and "doubt" are disregarded. On the other hand, the rejection of this rigid and dogmatic view of science can conversely lead to an extreme relativism. This view qualifies both the methods used in science (Feyerabend, 1975), and the concepts of science, thus denying any certainty in science. This follows the principle that the "only basis for scientific knowledge is the consensus of the research community", and thereby neglects the value of empirical evidence.

3. A non-problematic and non-historic conception of science

This conception is quite commonly referenced and is denounced by the presentation of already elaborated knowledge and a disregard for the process of its gradual construction. There is a misrepresentation of the underlying problems that motivated progress, the limitations of current scientific knowledge, how ideas evolved and which difficulties confronted scientists, or the potential of science for giving yet unknown answers. In other words, the rationality of the scientific process as an answer to a question is omitted.

4. An exclusively analytic conception of science

This conception was rarely considered by research, but was identified by these authors in over 80% of teachers and textbooks. It is characterized by a disregard for the complexity of problems and therefore, for the multidisciplinary character of the scientific construction.

5. Merely cumulative conception of scientific development

This is the second less referenced conception in the literature. It is characterized by a disregard for crises and revolutions as stimuli to scientific development, as well as mere references to events, therefore suggesting a linear cumulative growth of scientific knowledge. Leite (2000) points out that textbooks frequently present tables summarizing the chronological sequence of science and technology events, mainly at the end of chapters, misrepresenting the real evolution of achievements.

6. An individualist and elitist conception of science

This is one of the most commonly occurring conceptions in the literature, according to which scientific knowledge is formed out of isolated genii completely neglecting collective work and cooperation between teams as a pre-requisite to progress. Contrary to this conception, another distorted view has been noticed, according to which scientific activity is seen as something very simple and close to common sense.

7. A decontextualized and socially neutral conception of scientific.

The connections between science, technology and society are approached superficially. It is a conception of positivist root, very much cantered on the products of science, which are represented as an absolute factor of progress, while technology is considered as a mere application of scientific knowledge, its role in the construction of scientific knowledge being neglected. Contrasting with this naive view, there is also a tendency to attribute to science and technology the responsibility for environmental degradation. The seven distorted views presented above represent common occurrence patterns of incorrect ideas about science. Stemming from this evidence, and in order to extract higher meaning from the compliance of textbooks with correct ideas about science and technology in the three mentioned domains of knowledge, a new task arose: the identification of the distorted ideas about science that have been transferred into individual textbooks. This task may offer the advantages of providing an overview of the textbook profile and of determining how close the textbook comes to fulfilling its potential contribution to students' SL.

8. Identifying distorted images of science in science textbooks

As argued above, certain ideas about science propounded by teachers, textbook writers, or inherited through patented pictures stored in databanks and placed in textbooks, represent indicators of conceptions that according to the current epistemological paradigm are considered misconceptions about science and technology or distorted views of science and technology. Based on the descriptions presented by Gil-Pérez et al. (2005), a correspondence can be observed between the seven distorted views of science and technology and the three domains that together represent the knowledge about science to be acquired by citizens, namely, NoS, NoSI and STSE issues, as presented in Table I. This correspondence suggests that each of the described distorted views is rooted in a misunderstanding of one or more of the three domains of knowledge. More importantly, it is also to be expected that the inclusion of these distorted views in teaching practice and textbooks, conveys misunderstandings to students in the same domains.

Table I – Correspondence between the seven distorted views of science and technology considered in the present article, and the domains of knowledge affected by them Domains of knowledge about science Distorted views of science and technology.

	Domains of knowledge about science		
Distorted views of science and technology	NoS	NoSI	STSE
1. Empiric-intuitivist and non-theoretical conception of science	X	X	
2. Rigid conception of scientific activity		X	
3. A non-problematic and non-historic conception of science	X		X
4. An exclusively analytic conception of science	X	X	
5. Merely cumulative conception of scientific development	X		
6. An individualist and elitist conception of science	X		
7. A decontextualized and socially neutral conception of scientific activity			X

Final Considerations

It is herein assumed that the contribution of textbooks to SL is directly proportional to the concordance of the conveyed ideas with the ideas about science and technology that, together, form a realistic image of the scientific and technological enterprises. Conversely, textbooks displaying distorted images or misconceptions are assumed to steer away from the goals of SL. For these reasons, we draw attention to the importance of carrying out textbook analysis in order to raise consciousness of the fact that naive and distorted ideas about science and technology are still conveyed by textbooks. According to our expectations, such analysis would render multi-faceted results, with samples exhibiting highly acceptable ideas coexisting and contrasting with very (according to the current epistemological paradigm) outdated ones. In view of the considerations above, we believe that seven groups of criteria for textbook analysis should be defined from the lens of the seven distorted views proposed by Gil-Pérez et al. (2005) in order to detect: i) the absence of key ideas about science and technology, which, per se, represent indicators of a certain misconception of science; ii) the presence of wrong ideas about science and technology that reinforce the presence of this misconception; iii) and similarly, but from a more positive perspective, to detect indicators that contribute to dismounting / refuting the presence of a certain misconception. Results should also be analysed by verifying the compliance of textbooks with groups of criteria that point out if, and to what extent, distorted images of science and technology are displayed by the analysed textbooks. This procedure has the advantage of not only showing the position of textbooks relatively to SL according to the three domains, NoS, NoSI and STSE issues, but also of emphasizing aspects that require improvement. It should be stated that is not our purpose to focus on the surveillance of authors' conceptions, but rather on the conceptions that are conveyed by textbooks. Notwithstanding the above, we believe that it may be useful for the production of future textbooks to emphasize two aspects: (i) The intentional selection of contents (case studies or statements about briefly referenced events) should be carried out according to their potential to illustrate the real evolution of scientific knowledge and technological development. Moreover, the most effective way of presenting them should also be chosen. (ii) Finally, in interplay with the deliberate selection of contents, a "hidden curriculum" resulting from the authors' conceptions also influences the final product. In view of the above, an analysis of textbooks restricted to the subject of Genetics and focussing on the domains of NoS, NoSI and STSE is currently being carried out. The criteria applied therein result from the combination of the consensus around the concept of SL with the seven predominantly referred misconceptions about science and technology.

References

AAAS, American Association for the Advancement of Science (1989). Science for all Americans: Project 2061. Washington.

AAAS, American Association for the Advancement of Science (1993). Benchmarks for science literacy. New York: Oxford University Press.

Abd-El-Khalick, F. Waters, M. Le, A. (2008). Representations of Nature of Science in Hight School Chemistry Textbooks over the Past Four Decades. Journal of Research in Science Teaching, 45(7), 835-855.

Aikenhead, G.S. (1980). Science in social issues: Implications for teaching. Science Council of Canada. Ottawa.

Aikenhead, G. (1994). What is STS science teaching? In J. Solomon and G. Aikenhead (Eds.), STS education: International perspectives on reform, pp. 47-59. New York: Teachers College Press.

Aikenhead, G. (2000). Renegotiating the culture of school science. In Millar, R., Leach, J., and Osborne, J. (eds) Improving Science Education: The Contribution of Research, pp. 245-264. Buckingham and Philadelphia: Open University Press.

Aufdermauer, A. & Hesse, M. (2006). Eine Analyse von Biologie-Schulbüchern – unter besonderer Berücksichtigung des Experimentierens mit Pflanzen. IBD Münster: Bericht des Institutes für Didaktik der Biologie, 15, 1-32.

Bartholomew, H., Osborne, J., & Ratcliffe, M. (2004). Teaching students' "ideas-about-science": Five dimensions of effective practice. Science Education, 88, 655-682.

Bates, B. (2005). Public culture and public understanding of genetics: a focus group study. Public Understanding of Science, 14(1), 47-65. Bell, R.L. & Lederman, N.G. (2003). "Understanding of the NOS and Decision Making on Science and Technology-Based Issues". Science Education, 87(3), 352–77.

Brossard, D., Shanahan, J. (2006). Do they know what they read? Science Communication, 28(1), 47- 63.

Bybee, R. (1985). The Sysyphean question in science education: What should the scientifically and technologically literate person know, value and do – as a citizen? In R.W. Bybee (Ed.), Science-technology-society. 1985 NSTA Yearbook, pp. 79-93. Washington: National Science Teachers Association.

Bybee, R. (2000). Achieving technological literacy: A national imperative. The Technology Teacher, 60, 23-28. Cachapuz, A., Praia, J., Jorge, M. (2004). From Science Education to Science Teaching: an epsitemological rethinking. Ciência & Educação, 10(3), 363-381.

Chiappetta, E., Fillman & Sethna, G. (1991). A method to quantify major themes of scientific literacy in science textbooks. Journal of Research in Science Teaching, 28, 713-725.

Chiang-Soong, B., & Yager, R.E. (1993). The inclusion of STS material in the most frequently used secondary science textbooks in the U.S. Journal of Research in Science Teaching, 30(4), 339- 349.

DeBoer, G. (2000). Scientifc Literacy: Another Look at Its Historical and Contemporary Meanings and Its Relationship to Science Education Reform. Journal of Research in Science Teaching, 37(6), 582-601.

Dimopoulos, K. & Kouladis V. (2003). Science and Technology Education for Citizenship: The Potential Role of the Press. Science Education, 87(2), 241-256.

Donnelly, J. (2005). Reforming Science in the School Curriculum: A Critical Analysis. Oxford Review of Education, 31(2), 293–309.

Durant, J. R. (1993). What is scientific literacy? In J. R. Durant & J. Gregory (Eds.), Science and culture in Europe, pp. 129–137. Science Museum. London.

Fensham, P. (1988). Development and Dilemmas in Science Education. Bristol: Taylor & Francis.

Fensham, P.J. (2002). “Time to Change Drivers for Scientific Literacy,” Canadian Journal of Science, Mathematics and Technology Education, 2(1), 9–24.

Fernández, I. (2000). Análisis de las concepciones docentes sobre la actividad científica: una propuesta de transformación. PHd tesis. Departamento de Didáctica de las Ciencias Experimentales y Sociales. València: Universitat de València.

Fernández, I., Gil, D., Carrascosa, J., Cachapuz, A. & Praia, J. (2003). “Visiones Deformadas de la Ciencia Transmitidas por la Enseñanza”. Enseñanza de las Ciencias, 20(3), 477–488.

Feyerabend, P. (1975). Against Method: Outline of an Anarchistic Theory of knowledge. London: NLB.

Finley, F. (1994). Por qué los estudiantes tienen dificultades para aprender de los textos de ciencias. In C. Santa & D. Alvermann. (comp.). Una Didáctica de las Ciencias. Argentina: AIQUE Didáctica.

Gaskell, P.J. (1992). Authentic Science and School Science. International Journal of Science Education, 14, 265–72.
Gil-Pérez, D., Vilches, A., Fernández, I., Cachapuz, A., Praia, J., Valdéz, P. & Salinas, J. (2005). Technology as “Applied Science”: A Serious Misconception that Reinforces Distorted and Impoverished Views of Science. Science & Education, 14, 309-320.
Hodson, D. (1992). “Redefining and Reorienting Practical Work in School Science”. School Science Review, 73(264), 65-78.
Hodson, D. (1996). ’New Thinking on the Role of Practical Work in Science Teaching’. In D. Stow & G. McCall (Eds), Geoscience Education and Training in schoolsand Universities, for Industry and Public Awareness, pp. 215–232. AGID, A. A. Balkema.
Jenkins, E. W. (1994). Scientific literacy. In T. Husen & T. N. Postlethwaite (Eds.), The international encyclopaedia of education, 9(2) 5345–5350. Oxford: Pergamon Press.
Kalman, C. (2011). Enhancing Students' Conceptual Understanding by Engaging Science Text with Reflective Writing as a Hermeneutical Circle. Science & Education. 20(2), 59-172.
Knain, E. (2001). Ideologies in School Science textbooks. International Journal of Science Education, 23(2), 319-329.
Koelsche, C. L. (1965). Scientific literacy as related to the media of mass communication. School Science and Mathematics, 65(8), 719-725.
Laugksch, R. C. (2000). Scientific Literacy: A Conceptual Overview. Science Education, 84(1), 71–94.
Layton, D., Jenkins, E., Macgill, S. & Davey, A. (1993). Inarticulate science? Perspectives on the public understanding of science and some implications for science education. Driffield: Studies in Education.
Leach, J., Millar, R., Ryder, J. & Séré, M-G. (2000) Epistemological understanding in science learning: the consistency of representations across contexts. Learning and Instruction, 10(6), 497-527.
Lederman, N. G., Wade, P. D., & Bell, R. L. (1998). Assessing understanding of the nature of science: Ahistorical perspective. In W. McComas (Ed.), The nature of science and science education: Rationales and strategies, pp. 331–350. Dordrecht: Kluwer Academic.
Lederman, N. G. (1992). Students’ and teachers’ conceptions of the nature of science: A review of the research. Journal of Research in Science Teaching, 29, 331-359.
Lederman, N. G., & Lederman, J. S. (2005). The nature of science and scientific inquiry. In G.Venville & V. Dawson (Eds.), The Art of Teaching Science, pp. 2-17. Crows Nest: Allen & Unwin.
Lee, O. (1997). Scientific Literacy for All: What Is It, and How Can We Achieve It? Journal of Research in Science Teaching, 34(3), 219-222.

Leite, L. (2002). History of Science in Science Education: Development and Validation of a Checklist for Analysing the Historical Content of Science textbooks.

Lewenstein, B. V. (2001). Who produces science information for the public? In J. H. Falk (Ed.), Freechoice science education: How we learn science outside of school, pp. 21-43. New York: Teachers College Press.

Mathews, M. (1998). “The Nature of Science and Science Teaching”, in B. Fraser & K. Tobin (Eds), International Handbok of Science Education, pp. 981-999. Dordrecht: Kluver Academic Publishers.

McComas, W., Clough, P. & Almazroa, H. (2000). The role and character of the nature of science in science education. In McComas W. (2002) The nature of science in science education: Rationales and strategies (pp. 3-39). Dordrecht: Kluwer Academic Publishers.

McComas, W. & Olson, J. (1998). The nature of science in international science education standards documents. In W. F. McComas (Ed.) The Nature of Science in Science Education: Rationales and Strategies, pp. 41-52. The Netherlands: Kluwer Academic Publishers.

Millar, R. & Osborne, J. (1998). Beyond 2000: Science Education for the Future. The Report of a Seminar Series Funded by the Nuffield Foundation. London: King’s College London, School of Education.

Millar, R. (2002). Towards a science curriculum for public understanding. In S. Amos & R. Boohan (Eds.). Teaching science in secondary schools, pp. 113-128. London: Routlege/Falmer and The Open University.

Miller, J. (1998). The measurement of civic scientific literacy. Public Understanding of Science, 7, 203.

Miller, J. & Pardo, R. (2000). Civic scientific literacy and attitude to science and technology: A comparative analysis of the European Union; THE United States and Canada. In Dierkes, M. & Grote, C. (Eds.), Between understanding and trust: The public, science and technology. Oxon: Routledge.

National Research Council (1996). National Science Education Standards. Washington: National Academic Press.

National Research Council (2000). Inquiry and the National Science Education Standards. Washington: National Academic Press. National Science Teachers Association (1971). NSTA position statement on school science education for the 70's. The Science Teacher, 38, 46 - 51.

OECD (2007). PISA 2006. Science competencies for tomorrow’s world – analysis. Retrieved from http://www.oecd.org/dataoecd/30/17/39703267.pdf

Orpwood, G. W. (1984). Science education in Canadian Schools, 1. Quebec: Canadian Government Publishing Centre.

Osborne, J. (2000). Science for citizenship. In M. Monk & J. Osborne (Eds.), Good practice in science teaching, pp. 225-240). Buckingham: Open University Press.

Osborne, J., Collins, S., Ratcliffe, M., Millar, R. & Duschl, R. (2003). What “ideas-about-science” Should Be Taught in School Science? A Delphi Study of the Expert Community. Journal of research in science teaching, 40(7) 692-720.

Osborne, J. & Dillon, J. (2008). Science Education in Europe: Critical reflections. London: The Nuffield Foundation.

Osborne, J., Duschl, R., Fairbrother, R. (2002). Breaking the mould: Teaching science for public understanding. London: The Nuffield Foundation.

Pingel, F. (1999). UNESCO guidebook on textbook research and textbook revision. Hannover: Verlag Hahnsche Buchhandlung.

Quessada, M. & Clément P. (2007). An Epistemological Approach to French Syllabi on Human Origins during the 19th and 20th Centuries. Science and Education, 16, 991-1006.

Ratcliffe, M. (2001). “Science, Technology and Society in School Science Education”. School Science Review, 82, 83–92.

Reis, P. R. (2008). A Escola e as Controvérsias sociocientíficas: Perspectivas de Alunos e Professores. Lisboa: Escolar Editora.

Rocard, M., Csermely, P., Jorde, D., Dieter Lenzen, Walberg-Henriksson, H. and Hemmo V. (2007). Science Education Now: A Renewed Pedagogy for the Future of Europe. Brussels: Directorate General for Research, Science, Economy and Society.

Rosenthal, D. B. (1984). Social issues in high school biology textbooks. Journal of Research in Science Teaching, 21(8), 819–831.

Rudolph, J. L. (2003). Portraying Epistemology: School Science in Historical Context. Science Education, 87, 64-79.

Ryan, A. & Aikenhead, G. (1992). Students’ preconceptions about the epistemology of science. Sience Education, 76(6), 559-580.

Sadler, T. D. & Zeidler, D.L. (2004) “The Morality of Socioscientific Issues: Construal and Resolution of Genetic Engineering Dilemmas”. Science Education, 88(1), 4–27.

Scharfenberg, F-J & Bogner, FX (2010). Instructional efficiency of changing cognitive load in an outof-school laboratory. International Journal of Science Education, 32(6), 829-844.

Schwartz, R. S. & Lederman, N. G. (2008). What Scientists Say: Scientists’ views of nature of science and relation to science context. International Journal of Science Education, 30(6), 727-771.

SCCC, Scottish Consultative Council on the Curriculum (1996). Science education in Scottish schools: Looking to the future. Broughty Ferry.

Shamos, M. H. (1995). The myth of scientific literacy. New Brunswick: Rutgers University Press.

Smith, M. U., Lederman, N. G., Bell, R. L., McComas, W. F. & Clough, M. P. (1997). How Great is the Disagreement about the Nature of Science: A Response to Alters. Journal of Research in Science

Teaching, 34(10), 1101-1103.

Smith, M. U., & Scharmann, L. C. (1999). Defining versus describing the nature of science: A pragmatic analysis for classroom teachers and science educators. Science Education, 83, 493-509.

Solbes, J. & Vilches, A. (1997). ‘STS Interactions and the Teaching of Physics and Chemistry. Science Education, 81(4), 377–386.

Solomon, J. (1993). Teaching science, technology and society. Buckingham: Open University Press.

Solomon, J. & Aikenhead, G. (1994) STS Education: International Perspectives on Reform. New York: Teachers College Press.

Stanley. W. B. & Brickhouse, N. W. (2001). Teaching sciences: The multicultural question revised. Science Education, 85, 35-49.

Stocklmayer, S. & Treagust, D. (1994). A Historical Analysis of Electric Currents in Textbooks: A Century of Influence on Physics Education. Science and Education, 3, 131-154.

Thomas, G. & Durant, J. (1987). Why should we promote the public understanding of science? Scientific Literacy Papers, 1, 1-14.

Tamir, P. (1985). Content analysis focusing on inquiry. Journal of Curriculum Studies, 17 (1), 87-94.

Turner, S. (2008). School Science and its controversies; or, whatever happened to scientific literacy? Public Understanding of Science, 17, 55-72. UNESCO (1983). Bangkok: Science for all.

UNESCO (2005). Paris: Unesco science report. Wellington, J. (1991). Newspaper science, school science: friends or enemies?. International Journal of Science Education, 13, 363-372.

Wilkinson, J. (1999). A Quantitative Analysis of Physics Textbooks for Scientific Literacy Themes. Research in Science Education, 29(3), 385-399.

Zeidler, D.L., Sadler, T.D., Simmons, M.L. & Howes, E.V. (2005). Beyond STS: A Research-Based Framework for Socioscientific Issues Education. Science Education, 89(3), 357–77.

Ziman, J. (1994) The Rationale of STS Education is in the Approach. In J. Solomon & G. Aikenhead (Eds) STS Education: International Perspectives on Reform, 21-31. New York: Teachers College Press.

Zimmerman, C., Bisanz, G. L., Bisanz, J., Klein, J. S. & Klein, P. (2001). Science at the supermarket: A comparison of what appears in the popular press, experts' advice to readers, and what students want to know. Public Understanding of Science, 10(1), 37-58.

II. To What Extent do Biology Textbooks Contribute to Scientific Literacy? Criteria for Analysing Science-Technology-Society-Environment Issues

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Abstract: Our article proposes a set of six criteria for analysing science-technology-society-environment (STSE) issues in regular textbooks as to how they are expected to contribute to students' scientific literacy. We chose genetics and gene technology as fields prolific in STSE issues. We derived our criteria (including 26 sub-criteria) from a literature review of the debate in science education on how to increase scientific literacy. We inspected the textbooks regarding the relationships between science, technology, society, and environment, and considered the presence of the decontextualized and socially neutral view of science as distorted view. We, qualitatively and quantitatively, applied our set of criteria to two German Biology textbooks and identified, in total, 718 STSE statements. Based on the frequencies of different criteria and sub-criteria in the textbooks, we drew conclusions concerning STSE issues and the underlying conceptions of science and technology, which might hinder the furtherance of scientific literacy. The applicability of our approach in other science education contexts is discussed.

Keywords: textbook analysis; scientific literacy; science; technology; society; environment; STSE issues; misconceptions

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1. Introduction

Scientific literacy (SL) has met with increased interest during the last decades, rooted mainly in two different arguments within science education: One argument arose from concerns about the decline of scientific and technological careers in Europe (e.g., Portugal, France, Germany, and The Netherlands:
see [1]). The European Commission [2] held school science education responsible for failing to attract students' interest in scientific issues and put forth the challenge to innovate educational settings and adapt curriculum and practices, in order to make scientific and technological careers more popular [3]. On the other hand, educational organizations as well as science education research have pointed to the need for a more participative citizenship, as science and technology make a significant impact in our daily lives (e.g., from nourishment to health care; e.g., [4,5]. Educators need to promote an understanding of the interactions between science and technology interactions and their influence in socio-cultural and environmental contexts. Besides possessing knowledge of science and understanding its concepts, scientifically literate citizens need to, at least superficially, understand scientific and technological activities and how they relate to society and environment [6], conventionally labelled as Science, Technology, Society, and Environment issues (STSE; e.g., [7–9]. Science textbooks have been suggested as a means to convey the notion of "the social context of science" [10] (p. 249). However, they may also "contrast radically with the curricula and other steering documents" of a given country [11] (p. 408). We analyse the contribution of textbooks to the understanding of the scientific enterprise; that is, how science interacts with technology, with society and the environment. We first present an overview of SL and STSE issues. We then proceed to examine the ideas about STSE issues that scholars have suggested should be taught. Finally, we summarize research on STSE issues in textbooks and present the objectives of our study.

2. Scientific Literacy and Science-Technology-Society-Environment Issues

The term SL (meaning: the personal fit to read science) encompasses many educational themes that have shifted over time [12], such as Public Understanding of Science (with the intent to increase confidence in science and support for the scientific enterprise) and Science for All (with its focus on the needs of those not choosing scientific or technological careers [13]). There are currently two major labels that prevail: the epistemological view of Nature of Science (NOS) and the relationships within STSE, converging with the concept of Civic SL [13], where scientifically literate citizens are thought to understand scientific and technological advancements and their interplay with society and the environment. Besides the knowledge domain, other aspects are thought to contribute, such as scientific skills and attitudes towards the role of science within societies [14,15]. However, nowadays, the cornerstone of SL is regarded as the understanding of the scientific enterprise in a broad sense [1,13]. Therefore, beside knowledge about science, we also consider understanding the interplay between Science, Technology, Society and Environment as a fundamental SL component [6].

In line with Pedretti & Nazir [8], we acknowledge that STSE issues began as science, technology, and society issues (e.g., [16]); that is, they are rooted in the interplay of these three issues, and "then later evolved to include the environment" [8] (p. 602). Some authors (e.g., [17,18]) have argued that STSE education has to approach the impact of science on both society and environment, together with NOS in broad sense, in order to obtain SL. The perception that scientific knowledge is merely tentative, despite the fact that it is the best we have [19], lays down two naive views of science: an extreme confidence in science and technology or an extreme skepticism. Only the awareness of their benefits and of their negative implications enables critical analysis of controversial issues, as well as more objective judgements of the related economic interests and political decisions [6].

Introducing STSE issues in classrooms has often been recommended as a method of confronting students with controversial socio-scientific issues, including moral and ethical implications (e.g., [20,21]). Such strategies are regarded as valuable for preparing students for multi-angled controversies (e.g., [22,23]), including links with morality [24]. Dilemmas related to biotechnology products, environmental problems, and human genetics are potential sources of STSE content. For instance, STSE issues arising from controversial subjects, such as genetic diagnostics and human genetic engineering, raise students' understanding of NOS and promote their SL [25]. We therefore focus on genetics as part of biology education.

Since it affects important domains of human lives, such as reproduction, health and nourishment, as well as the environmental balance, genetics is a field of notable social importance, and therefore, constitutes essential curriculum. Decision making in genetic issues frequently involves social dilemmas and requires complex reasoning. Apart from illustrating the merits of scientific evidence, such issues potentially allow students to make judgements involving emotive considerations and personal values [24]. In particular, controversial aspects of genetic engineering lead to moral dilemmas (e.g., gene therapy and cloning), thus engaging students in discussions. Controversies around genetic issues were particularly significant in the "great European biotechnology debate", involving gene technology and its commercial applications in food production, pharmacy and medicine [26] (p. 3). Triggered by the shipping of Round-up Ready Soya to Europe and by the cloning of the sheep Dolly, they led to a massive media coverage and to concerns about the possibility of human cloning. The multinational Human Genome Research also activated the debate, although the reception and the global discourse varied according to national dynamics [27]. Earlier studies have shown that Germany is quite peculiar regarding civic participation in this debate about societal aspects of genetic issues, attitudes towards biotechnologies, and media communication concerning science and technology (e.g., [28]). Perhaps, based on experiences in Hitler's Third Reich [17], collective memory of eugenic programs and the consequent mistrust in science and technology led to a particularly stringent legislation concerning genetic manipulation, which, in turn, imposes restrictions on research, technological production and applications [29,30]. In summary, discussing genetic issues in this context might help students to understand how science, technology, science and environment interact and how complex is the process of decision making, thus contributing to students' SL.

3. Which Ideas about STSE Issues Should Be Taught?

Implementing STSE issues represents for many authors a shift from the positivist view of science to "a post-positivist vision for science education" that considers science within its "social, technological, cultural, ethical, political, [and] environmental" contexts [8] (p. 602). However, despite the agreement on considering STSE issues when addressing SL, the kind of ideas about interactions between STSE are not well defined [6]: "There is no single, widely accepted view of STSE education" as Pedretti & Nazir summarized in their review of four decades of STSE education [8] (p. 602). They stated that differing discourses on STSE education lead to several distinct pedagogical approaches, programs, and methods. Osborne and colleagues reported a consensus, among scientists, science teachers, philosophers, sociologists of science, and science educators (see Table 1, right column) on which ideas about science (IAS) "students should encounter by the end of compulsory schooling" [31] (p. 712). Their ideas largely concurred with the ideas found by McComas & Olson [19] (Table 1, left column) in the analysis of international curriculum documents (from England, Wales, USA, Australia, Canada, and New Zealand. However, in our view, some of these ideas indicate distorted views about science and technology, for instance, the idea that *Science has played an important role in technology* is too simplistic, as it disregards the role of technology in the construction of scientific knowledge [32] (for details, see below). Despite the existence of considerable consensus, reported in the Delphi study [31], conflicting science views may still persist among educators, the scientific community, and epistemologists. In particular, constructivist science educators' views may diverge from the scientists' views [33,34]. Additionally, some scientists used a language associated with the traditionalist view of science, for instance, the description of a rigid step-by-step scientific method based on controlled processes and absolute truths [35]. Both sets of ideas (Table 1) represent a meaningful and referential basis. However, an additional literature review for building up an instrument serving our purpose was required.

Table 1. Parallelism concerning ideas about science (IAS) between international curriculum documents [19] and ideas of experts [31] (adapted from [31]).

Ideas about Science	
Most referred in curriculum documents (McComas & Olson, 1998)	Found in experts' *Delphi* Study (Osborne, Collins, Ratcliffe, Millar, & Duschl, 2003)
Scientific knowledge is tentative despite the fact that it is the best we have	Tentative nature of scientific knowledge
Science relies on empirical evidence	Science needs analysis and interpretation of data
Scientists require replicability and truthful reporting	Science needs experimental methods and critical testing
Science is an attempt to explain phenomena	Scientists develop hypotheses and predictions
Scientists are creative	Science involves creativity and continual questioning
Science is part of social tradition	Science needs cooperation and collaboration in the development of scientific knowledge
Science has played an important role in technology	Science and technology are different entities
Scientific ideas have been affected by their social and historical milieu	Scientific knowledge has historically been developed
	Science needs diversity of scientific thinking
Changes in science occur gradually	
Science has global implications	

4. STSE Issues in Textbooks

Many authors have pointed to textbooks as powerful resources for science education (e.g., [36,37]). Textbooks may support independent learning and promote parental participation [38]. From the teacher's point of view, textbooks transpose the official curriculum into the enacted curriculum [39]. In addition to the mere presentation of the achievements of science and technology, textbooks show how these achievements were realized, for instance, by contextualizing scientific and technological events [40,41]. Textbooks may emphasize meaningful aspects or explore historical reports of representative events. They may reference case studies or include stories and anecdotes about scientists, illustrating scientific and technological progress as a human enterprise [37]. The account, found in German textbooks [42], of the contribution of Robert Hooke to the development of microscopy is an example. Textbooks may also emphasize the positive and negative implications of science and technology in society and in environment; for example, an account of the Acquired Immune Deficiency Syndrome pandemic in European and African textbooks [43], and "the interaction between the genome and its environment" within French textbooks [44] (p. 58).

"To teach about science and consider its social implications", teachers are "reliant on the textbook" and, consequently, "good quality textbook[s]" are "considered essential" [45] (p. 9 and 13). In certain STSE aspects like historical contextualisation, "teachers rely heavily on textbooks" [37] (p. 334). However, curricular materials referencing STSE issues are often missing [46]. Due to their complexity and their controversial and value-laden nature, STSE issues are frequently avoided or treated superficially in science teaching [11,47]. Therefore, we summarized research on how biology textbooks address STSE issues and how they convey views of science and technology to students.

First, several studies have focussed on how *knowledge about science* is conveyed by textbooks. Chiappetta and colleagues [36] and Lumpe and Beck [48] analysed secondary school chemistry and biology textbooks in terms of the balance between four aspects: knowledge of science, investigative NOS, science as a way of thinking, and the interaction between science, technology, and society. The authors concluded that the textbooks focused on scientific content and its vocabulary, thus representing an unbalanced account for SL. Leite [37] examined the historical content included in physics textbooks: They did not provide students an adequate image of science. Regarding scientific inquiry in biology textbooks, most new science textbooks include technology issues as part of their science content [49].

Second, with respect to the interactions of science and technology with society, physics textbooks mostly emphasized the usefulness of science and/or technology, but often neglected to discuss societal issues and potentially negative aspects of science and technology [50]. More generally, the interaction of science and technology with society received poor coverage, a tendency that worsened as students progressed through the school system [51]. German science textbooks seem to completely neglect STSE issues [52]. However, the German National Standards of Competencies in Science [53] require students to be encouraged to reflect on ethical aspects in science education, especially in environmental, health, and gene technology education. Beside others issues (e.g., ecological content), genetics offers a promising way of promoting STSE issues. For instance, 9th graders should be aware of the effects of gene technology in the social and ecological spheres, of the *pro and contra* arguments, and of the fact that such issues imply ethical and moral considerations [54]. These demands seem to have been effective: Chemistry textbooks (secondary education) pointed both to the aspects of chemistry contextualization and to the socio-critical chemistry education [55]. The introduction of STSE issues into the curricula seems to be an international trend, although most textbooks still fail to include perspectives from social science [55].

Third, the “hidden curriculum” [56] (p. 372) might hinder the discussion of STSE issues. Hidden curricula are determined by several elements, such as the decisions of publishers caused by market dynamics, the conceptions of textbook authors, and the interpretations of teachers who have their own conceptions about science [57]. These considerations led to our first two specific research questions:

- Do biology textbooks explicitly and/or implicitly provide teachers and students with suitable information about the interplay between science and technology, their relationship to society, and their implications for the environment?
- Do textbooks stemming from the same socio-cultural context and based on the same guidelines differ essentially in the STSE issues discussed?

Along with the promotion of STSE issues, the above-mentioned distorted ideas of science deserve attention, as they may be conveyed to students through teaching practice in general and textbooks in particular. They may contribute to the construction of students’ distorted views of science and technology, thus representing filters or even barriers to the realization of the SL requirements [6]. Fernández and colleagues [58] identified some distorted ideas widely referred to in the literature (e.g., the cumulative conception of scientific development). We specifically examine the distorted idea of *decontextualized and socially neutral view of science* (DSNVS). This simplistic conception of the complex relationship between science and technology regards technology as a mere product of science and disregards its role in the construction of scientific knowledge [32,58]. We have argued for an integrated treatment of DSNVS and STSE issues [6] because this distorted view may represent an obstacle to a balanced approach of the relationships between science, technology, society and environment. From the DSNVS view, science is exalted as being the absolute factor of progress in society. Alternatively, science and technology (perceived as science’s application) presented as being alone responsible for the environmental degradation, and, therefore, are to be rejected. This simplistic exaltation or rejection of science portraits it as an activity carried out by isolated geniuses and separate from ordinary life. People possessing such a distorted view simply ignore the social context and the implications of science and technology in society and in the environment [32,59]. While science is seen as a mean of creating products, the social context in which scientific and technological events take place is disregarded. As mentioned above, DSNVS may encourage the opposite misconception; this less frequent conception considers science and technology alone as responsible for environmental degradation, and therefore ignores the responsibility of other agents [32,58] such as lawyers, politicians, entrepreneurs, and even citizens. In parallel, DSNVS neglects efforts of science and technology in solving problems that affect humanity, and ignores also scientists’ concerns with potential risks deriving from their own activity [21,58]. DSNVS is then in conflict with the humanistic perspectives of science education and the Roberts Visions of SL [60]. In the educational context, the Roberts Vision I seeks opportunities for students to integrate scientific ideas and scientific reasoning with moral reasoning and cultural considerations that underlie the decision-making in socio-scientific issues. Roberts Vision II views science from an external perspective on science, that is, views the context in which scientific ideas and processes are involved, as well as the role of science in society [60,61]. Our third specific research question is therefore:

- DSNVS, explicitly and/or implicitly, is conveyed by textbooks?

We hypothesize that biology textbooks (mostly written by teachers [42,62]) may convey a more or less DSNVS-distorted view of science and so may convey some misconceptions regarding the STSE issues related to genetics and gene technology.

5. Objectives of the Study

Following our previous work [6], our general objective was to propose criteria for textbook analysis, in order to to enable the identification of weaknesses and strengths of science-technology-society-environment issues and to detect misconceptions of science and technology that might enable the identification of hinder a fair approach to these issues.

Our specific objectives were twofold:

(i) to develop a set of criteria for textbook analyses in order to examine how two German textbooks address science-technology-society-environment issues in the context of genetics and to detect indicators for confirming or disproving the presence of the decontextualized and socially neutral view of science;

(ii) to apply, qualitatively and quantitatively, these criteria to genetics and gene technology contents within two German biology textbooks and to identify differences regarding these issues.

6. Methodology

Our study fits in with the Product Oriented Research, with emphasis on the textbook as a product [63]. We first describe our textbook sample, then explain the development of our criteria, and finally apply the analysing process to the textbooks.

6.1. The Textbook Sample

In Bavaria, all textbooks require state-certification. We randomly selected two 11th grade biology textbooks from two different publishers: textbook A [64] and textbook B [65]. We focussed on the chapters of genetics and gene technology as appropriate for approaching STSE issues involving divergence of opinions and values. Additionally, we are convinced that these issues provide an exploration not only of ethical and moral aspects, but also of evolutional and procedural aspects that underlie the achievement of scientific knowledge.

Both textbooks are similar in layout (e.g., allocation of pictures), but they present different strategies towards both the organization of contents and the type and the sources of non-compulsory information. Textbook A includes 71 pages in one chapter on *Genetics*. Two motivational pages provide an introduction, presenting the title and sub-titles for five sub-domains: *Classic*, *Cyto-*, *Human*, *Molecular Genetics*, and *Gene Technology*. Small text boxes describe the sub-domains and differentiate their goals and fields of action. Sub-domain-specific pictures and representative scientists are given in these texts. Five sub-domain-chapters follow, concluded by evaluation tests, mostly comprising conceptual knowledge, but two questions involve ethical considerations (foetal genetic diagnosis, and the advantages and disadvantages of gene therapy). The human genetics and gene technology chapter presents further ethical considerations, including the *Contribution to a Discussion* *of Ethical Questions* and the *Impulses* dedicated to controversial issues. Students are confronted with societal problems and challenged to research on their own how society handles socio-scientific questions. Textbook B has a chapter entitled *Genetics and Gene Technology* (83 pages) and organizes the contents into four sub-chapters: *Molecular Fundamentals of Heredity*, *Cyto- and Classic Genetics*, *Human Genetics,* and *Gene Technology*. The chapter lacks an introduction and starts with defining the title terms. Every sub-chapter finishes with a summary and an evaluation test, including ethical considerations (e.g., abortion, traditional and modern methods of cystic fibrosis treatment, and implications of germ cells therapy). However, this textbook does not provide suggestions for students' research. Regarding non-compulsory information, textbook A approaches controversial issues related to both genetic diagnostics and genetic interventions. For instance, the euthanasia and pre-implantation diagnostics are discussed from an ethical perspective based on excerpts from legislative and constitutional documents as well as press notifications. In textbook B, non-compulsory information also involves controversial issues: Science and technology events are framed by concepts and principles that one should be aware of (e.g., the concept of risk or the human dignity principle). Thereby, textbook B follows a deductive approach by explicitly mentioning *a priori* principles and regularities that underlie the relationship of science and technology with the societal sphere and the environment.

6.2. Criteria Development

In developing our criteria, we alternated between deductive and inductive methods [66], according to their appropriateness. The sets of ideas about science [19,31] displayed in Table 1, though not representing a suitable framework for our textbook analysis, provided ideas that oriented our criteria development: science is part of the social tradition; science has played an important role in technology [19]; science needs cooperation and collaboration in the development of scientific knowledge; and science and technology are different entities [31] (see Table 1). In order to define our criteria, we carried out a bibliographic revision, which consisted of analyzing documents, mostly derived from epistemological debate and from research in science education. We then extracted from this bibliography the ideas that we assumed to be likely observable in textbooks. We only excluded ideas that are unlikely to be included in textbooks. For instance, despite the evidence of a positive relationship between reading newspapers and science magazines and the readers' substantive scientific knowledge [67], we could only partially incorporate the idea that students should be prepared for a critical interpretation of the news conveyed by the media [68]. Indeed, one cannot expect textbooks to provide up-to-date news, though they may present some examples of media-based STSE exploration in order to raise understanding of both the controversial character of socio-scientific issues and the corresponding multiple perspectives. In the following sections, we first describe the procedure for developing criteria, by taking the first criterion as an example (see Table 2). We then derive and present the remaining five criteria, each representing one sub-domain of the STSE relationships (Table 2). Finally, we divide each criterion into sub-criteria (26, altogether; summarized in Table 2), which were, where needed (some are self-explanatory), justified by arguments either found in the literature or formulated by ourselves.

Table 2. Definitions, textbook examples and textbook frequencies of all sub-criteria (sub-criteria headed by the criterion, keywords in textbook statements in *italics*).

Sub-Criterion	Definition	Textbook Example	Textbook	Frequencies
	Science and technology events and their social contextualization		A [a]	B [b]
	Mentioning and/or suggesting			
Event per se	a scientific or a technological event	*chromosome theory of inheritance* of Boveri and Sutton (A, p. 98)	78	40
Event time	the time the event took place	*during the National Socialist regime* (A, p. 111)	70	20
Event place	the place the event occurred	Johann G. Mendel was a science teacher *in Brünn* (B, p. 98)	6	2
Underlying problem	the social problem that motivated research regarding the event	The *aim* is to *develop new possibilities for diagnoses and therapies for genetic diseases or cancer.* (A, p. 83)	11	7
Favourable factors	factors favourable for the event	The reason for that [advancement] were other *improvements in microscopes and staining techniques* (B, p. 102)	1	3
Obstacles	factors representing obstacles	had to fight, *as a woman*, against strong *prejudices of their colleagues* (A, p. 62)	1	1
	Interplay between science and technology			
Distinction	Science and technology are distinguished.	*Genetics* is *defined* as and *gene technology* is *defined* as (B, p. 58)	6	6
Technology towards science	A technology device or process is useful for achieving scientific knowledge.	These *enzymes* are *used* to *determine which genes are active* in a tissue (B, p. 131)	19	26
Science towards technology	Scientific knowledge is useful or even indispensable for technology advancements.	The *discovery* of enzymes was the *decisive condition for* the development of modern genetic *methods* (B, p. 128)	9	6
Science and applied science	Technology is seen as applied science	the *development of therapeutic possibilities*. In addition, *this branch of genetics* is (B, p. 112)	1	1
	Science and Technology as means to solve societal problems			
	Mentioning and/or suggesting of			
Potential applicability	potential applicability of science and technology in the future	In cancer patients, we *attempted* to *make* cancer genes *ineffective*." (A, p. 121)	19	7
Applicability	real benefits of science and technology processes or devices	Bacteria *can* now *produce* the *desired insulin* (A, p. 113)	42	63
Costs	costs of science and technology processes or devices	The *1 million-Dollar*, two-month *project* (A, pg. 83)	6	3
Limitations	limitations of science and/or technology	Nevertheless, it *isn't possible* to gain every desired medicament from bacteria cells (B, p. 135)	13	9
	Risks and impacts of Science and Technology			
	Mentioning and/or suggesting of			

Risks	risks of science and technology	The development of Bt-toxin resistant corn borers represents a *further risk* (B, p. 138)	22	19
Social impact	an potential and/or real science and technology impact on society	The introduction of pre-implantation diagnostics *might lead to a dam crack in the direction* of Brave New World (A, p. 111)	13	6
Local environmental impact	a local potential and/or real science and technology environmental impact	*Protection* of the *environment* remains primary *objective* of the [German] *gene technology law* (A, p. 125)	1	1

Table 2. *Cont.*

Sub-Criterion	Definition	Textbook Example	Textbook	Frequencies
Global environmental impact	a global potential and/or real science and technology environmental impact	Once accepted, Bt-maize would *in the future worldwide* and *almost exclusively* grow and the dimension of *damages* would be *enormous* (B, p. 138)	0	7
	Controversial issues			
	Mentioning and/or suggesting of controversial issues			
Different perspectives	given with different perspectives	Nevertheless, the *pros and cons* of cultivating [genetically modified plants] are still hotly debated in society (B, p. 138)	17	8
Conflict values	by referring to values interfering with decisions	The *human dignity* is inviolable (A, p. 111)	25	14
Involved interests	given with potentially involved interests (e.g., social, individual, political and/or economic ones).	Discuss *reasons* why *private companies invest millions of Dollars* to sequence human genes (A, p. 83)	10	4
Different sources of information	presented with different information sources conveyed by media	This year's 50th anniversary of the discovery of the structure of DNA has kindled many debates (*Guardian, 2003*) (A, p. 124)	11	0
	Decision making process			
	Mentioning and/or suggesting of			
Legislation	legislation processes and/or results	According to an *EU directive of 1998*, DNA sequences can be patented (A, p. 83)	26	7
International comparison	decisions by comparing international realities concerning legislation	but it is *not forbidden in other countries*, such as U.S.A. (B, p. 137)	4	1
Agents	the agents involved in decision making	In Germany, every treatment requires the *approval* of the *Ethics Committee* and of the *German Medical Association* (A, p. 121)	18	3
Citizen participation	the citizens as participants in decisions (e.g., as consumers, as voters, as informed human beings)	To the question "Would you eat genetically modified food?" *answer* 70% of *respondents* with "no" (A, p. 125)	23	2

6.2.1. Science and Technology Events and Their Social Contextualisation

Within science teaching, science and technology advances are frequently presented as occurring by chance, detached from their historical and socio-cultural context [32,59]. However, participative citizenship requires awareness of how scientific work is conditioned by the contexts (e.g., social, historical, moral and spiritual; see [69]). Scientists and educators agree that social and historical contexts have affected scientific ideas [19,31] (see Table 1); especially, concerning the way in which science is executed, interpreted and accepted by society. Assessing "the historical current" as one of the recently identified "six currents in STSE education" [8] (p. 610 and p. 601) lead us to assume that this idea is presented in textbooks. Based on a review of literature, we inductively dissected this idea into sub-ideas. For instance, Abd-El-Khalik and Lederman [70] (p. 1087) recommended "explicitly addressing certain aspects" of history of science. In a textbook, such aspects might be the spatial and temporal locations of scientific events as "concrete examples [as to] how the scientific enterprise operates" [71] (p. 1). That is, we identified a level of event contextualization (the event level). Additionally, Hackett [72] (p. 288) recommended a process level for "discovery and invention in science textbooks" in order to avoid students being "mislead into thinking of science as an activity conducted apart from society by lone heroes for unknown reasons". Hence, the circumstances (e.g., positive influencing factors) surrounding the event should also be mentioned in a textbook. At the process level, socially neutral perspectives may lead to misconceptions, especially when scientific research is expected to provide solutions to societal problems based on technological solutions [32]. Attention also needs to be given to the social fabric, to world views, power structures, and philosophical, religious, political, and economical factors [72]. In order to realistically assess embedding science and technology into society, Gardner [73] suggested the incorporation of historical case studies as blue prints for understanding how social factors may foster or hinder technological development. This reasoning underlies the definition of our first criteria and corresponding sub-criteria.

The first author initially applied these first-round sub-criteria definitions to randomly selected parts of textbook A. The definitions of the sub-criteria were iteratively applied and refined in order to reduce subjectivity and to increase accuracy. In the case of the first criterion and its sub-criteria, the event level was differentiated into *mentioning and/or suggesting of* the *event per se*, of the *event time*, and of the *event place* (see Table 2), while the process level was differentiated into *the underlying problem*, *favourable factors* and/or *obstacles*. Finally, a reviewer, a biology in-service teacher and non-participant in this survey, completed the validation test (interpersonal comparison). First, he received training in the context and the goals of the survey and to create familiarity with the criteria and sub-criteria. Second, he was invited to match the given definitions of criteria and sub-criteria with selected textbook statements as examples. In case of lack of clarity or ambiguousness, the first author and the reviewer cooperatively incorporated his feedback into refining the definitions. For instance, in a first sub-criteria version, we had included the assessment of risks as part of this sub-criteria definition. However, we ended up deleting the assessment aspect (see Table 2) because it was not clearly identifiable in textbook statements.

Due to the German language of the textbooks, we did all the analyses in German. After finishing the work, we translated the anchor examples (see Table 2) from German into English; for instance, "die Chromosomentheorie der Vererbung von Boveri und Sutton" into "chromosome theory of inheritance of Boveri and Sutton [65] (p. 98); "Zeit des Nationalsozialismus" into "during the National socialist regime" [65] (p. 111), or "hatte damals als Frau stark gegen Vorurteile ihrer Kollegen zu kämpfen" into "had to fight, as a woman, against strong prejudices of their colleagues" [65] (p. 62). We validated all the translations by a native speaker.

6.2.2. Interplay between Science and Technology

Science and technology are regarded as distinct entities, often explicitly distinguished by their different purposes [31,74]. Pragmatic definitions of each entity offer two possible relationships: technology helps science or science helps technology [75,76]. For instance, technology often precedes science, while scientific knowledge may play an important role in technological processes [73]. On the other hand, technology has often been seen as a by-product of applied science [77]. This idea has been viewed as the simplest misconception of interplay between science and technology, and as to reinforce distorted views of science [32]. We looked for statements referring to gene technology processes portrayed as being applied genetics. In contrast, we consider statements illustrating the usefulness of scientific advancements in transforming resources into goods and services as positive indicators of the role of science. Similarly, we marked statements mentioning a certain technological device or process as necessary for the fulfilment of a certain scientific advancement as indicators of the catalyst role of technology in science.

6.2.3. Science and Technology as a Means to Solve Social Problems

Two different perspectives may apply: One, where technology is naively portrayed as a mere product of science may tend to praise science. While science education tends to integrate technology elements, it may focus on applications of technology by promoting products and disregarding technological processes. A balanced compromise may shift away from the paradigm of technology as being applied science [32], towards a view of technology as an autonomous entity that seeks to overcome problems by invention [73]. Another perspective is that, by highlighting problems that motivated research, may help students to appreciate science and technology as a human enterprise committed to satisfy societal needs and solve societal problems. However, students should understand both the strengths and the limitations intrinsic to science and technology [1]. Additionally, mentioning financial costs associated with technologies may convey the message that such processes are somehow socially constrained [69].

6.2.4. Risks and Impacts of Science and Technology and Controversial Issues

Many political and moral dilemmas originate in science and technology, requiring the need to balance reasons for potential and/or real risks and economic benefits [1]. Students should appreciate the social impact of scientific and technological changes in their daily lives and also analyse risk minimisation and undesired side effects [22]. Controversial issues are frequently handled by mass media from a common sense perspective. Although the media constitute an important forum for discussing these issues, their messages often rely on limited or even one-sided information and ignore potential co-existing options [47]. Citizens need to possess scepticism, open-mindedness, critical thinking, inquiry, ambiguity or even skills in the interpretation of data-driven knowledge [78]. Science education is an excellent basis to train such skills that synthesize scientific knowledge and social needs by instilling different ranges of options [21]. Exposing students to scientific controversies may not only raise their interest in techno-scientific issues, but also contribute to scientific and technological literacy, along with higher order thinking skills [79]. Such strategies may force re-evaluation of prior understandings and restructure conceptual understanding of subject matter through personal experiences and social discourse [80]. In particular, since controversial issues around genetic manipulation tend to be framed by socio-philosophic positions instead of scientific positions, their discussion requires the consideration of values, interests, needs, and beliefs as essential factors [81]. Given teacher's reliance on textbooks, the presentation of controversial issues in textbooks should reflect diverse perspectives, especially by highlighting the interests potentially involved. Scientific knowledge may serve opposite and sometimes conflicting interests [21]. While formal science education is centred in conventional non-controversial science, and while the media may tend to emphasize a controversial, superficial, and sensationalist science, textbooks may incorporate both to show controversial issues.

6.2.5. Decision-Making Process Concerning STSE Issues

A STSE curriculum should foster the ability to make decisions about science-related social and environmental issues [12]. According to our view, five aspects may counteract a student's misunderstanding of the relationship between science and technology in this context: specification of concrete legislation, awareness that decisions differ according to their social context, personification of decision agents, and awareness of the fact that common citizens may influence decisions. This misunderstanding may lead to the misconception that environmental degradation only is caused by science [60]. Therefore, textbooks should also enable students to learn about making choices and participating in political decisions.

6.3. Textbook Analyses

Textbook discourse contains interpretations beyond the content coverage. Such interpretations require qualitatively deductive content analysis [82] to extract meaning and assumptions [57]. Following Knain [83], we analysed textbooks' statements in the contexts genetics and gene technology. By identifying the co-variation between text and context, we inferred the ideas about science and technology that matched our criteria and we recorded them. That is, by applying our criteria and sub-criteria to our textbook sample, we gathered data that helped to infer the views about science and technology. With regard to the reliability of our statement categorization, we randomly selected 23% of textbook statements for a second intra-rater categorization (163 of 718 statements) and 36% of textbook statements for an inter-rater categorization (258 of 718 statements). We computed Cohen's Kappa coefficient [84] and obtained reliability scores for the intra-rater reliability of Kappa as 0.93 and for the inter-rater reliability of Kappa as 0.76. The first is regarded as "almost perfect", the second as "substantial" [85] (p. 165).

As recommended [57], we continued with quantitative analysis and combined our content analysis with a quantitative frequency analysis. In line with other researchers [37,50], we used our anchor examples (Table 2) for determining the extent of compliance of the textbook statements with the sub-criteria. The content analysis allows differentiation between explicit and implicit statements. We took also eloquence into account: A very expressive, although implicit, statement might convey messages more effectively than an explicit statement; for instance: (i) "However, besides this advantage, Bt-corn has also risks" [66] (p. 136); (ii) "Markers with antibiotic resistance are a necessary technical aid in the laboratory, however, in public debate they are also a cause for concern" [65] (p. 113). The first statement explicitly conveys the idea that a specific genetically modified cultivation also involves risks; using a different discourse strategy, the second statement merely supposes a potential risk implicitly, but, unlike the previous one, is emotionally charged. However, this differentiation was only taken into account as a qualitative qualifier and not as a quantitative one. In summary, we scored all statements equally. We examined potential contingencies between criterion frequencies and the analysed textbooks by computing adjusted Pearson's contingency coefficients *C* [86]. Due to multiple testing, we reduced our Alpha level to 0.01.

7. Results

We applied our sub-criteria framework to textbooks A and B and identified 718 STSE statements within the genetics and gene technology chapters (for examples, see Table 2). Textbook A supplied significantly more statements than textbook B (ratio A: 452/71 pages = 6.4; ratio B: 266/83 pages = 3.2; $\chi^2(1, N = 872) = 14.99$, $p<0.001$). In both textbooks, we found statements for at least 25 sub-criteria. Textbook A lacked the sub-criterion global environmental impact and textbook B the sub-criterion different sources of information (Table 2). Generally, criteria and sub-criteria frequencies significantly differed between the two books (adjusted Pearson's contingency coefficients: $C = 0.308$ and $C = 0.399$; in both cases: $p<0.001$; $N = 718$), pointing to different textbook profiles (Table 2).

Textbook A focussed on the criteria *science and technology events and their contextualization* (167 statements *vs.* 151 randomly expected ones; B: 73 *vs.* 89) as well as *decision-making processes* (71 statements *vs.* 53 randomly expected ones; B: 13 *vs.* 31). In contrast, textbook B focussed on the criteria *interplay between science and technology* (39 statements *vs.* 27 randomly expected ones; A: 35 *vs.* 47) *and science and technology as means to solve societal problems* (82 statements *vs.* 60 randomly expected ones; A: 80 *vs.* 102). At the level of sub-criteria, we only found differences for the criterion *science and technology as a means to solve societal problems* ($C = 0.326$; $p = 0.001$; $n = 162$). Textbook B exceeded textbook A regarding the sub-criterion (current) *applicability* of science and technology (Table 2) and provided more statements than randomly to be expected (63 *vs.* 53; A: 42 *vs.* 52). However, textbook A provided more statements on the sub-criterion *potential applicability* (19 *vs.* 13; B: 7 *vs.* 13). That is, both textbooks showed and explained social applications of science and technology and stressed their potential for solving problems in the future, but treated these
sub-criteria differently. Generally, *costs* and *limitations*, both in scientific research and technological solutions, were cited less frequently in both textbooks.

With respect to the remaining criteria, the textbooks displayed a similar degree of agreement with sub-criteria (insignificant *C* values: $0.688 > p > 0.021$): Both textbooks made an effort to frame substantive contents within the realm of real life. They provided numerous references to historical and contemporary events that one might see as an attempt to convey the correct idea that science and technology achievements are a progressive human construction. However, the science and technology events were not completely contextualized: Beyond the references to *time* (when) and *place* (where), only a few and mostly implicit references occurred with regard to underlying social problems that triggered research. The contextual factors that, either positively or negatively, influenced research were rarely mentioned (Table 2). Regarding the interplay between science and technology, both entities were explicitly distinguished in both textbooks, though coexisting with one indicator per book with the incorrect idea that technology is considered applied science. However, the interplay was demonstrated and the mutually positive influence in their achievements was clearly marked (Table 2). Both textbooks primarily focussed on risks rather than negative impacts. Explicitly, textbook B pointed to a scientists' ethical code: "Scientists have the responsibility to assess risks as accurately as possible" [66] (p. 138).

With respect to the social and environmental impacts, the textbooks differ substantially (Table 2): While textbook A gave emphasis to the social dimension, textbook B emphasized the environmental dimension, so that no textbook provided a complete account. The textbooks differed in the character of the statements about controversial issues. Textbook A provided numerous examples, thus illustrating how and why solutions for societal problems may in certain cases be controversial, or even challenged students to investigate the reasons for controversy. It consistently demonstrated the existence of different perspectives by evaluating the genetic issues, the interference of values in these judgements, and the influence of particular, private, or social interests in the decisions by providing excerpts of media articles and other documents (e.g., official legislation document concerning abortion; § 218a StGB, 1992; a newspaper excerpt about the pre-implantation diagnostics; Washington Post, 1.10.2001; all [65] (p. 111)). Textbook B opted for stating explicitly the reasons for controversy (e.g., ethical values involved). It categorized the principles that underlie decisions in socio-scientific issues, such as the *principle of usefulness*, in opposition to the *principle of human dignity*. For instance, statements like "Genetic counselling may be associated with ethical problems" [66] (p. 123) or "On these ethical questions, there are no right answers" [66] (p. 124) stress the controversial nature. The textbooks also handled differently the aspects of *decision-making processes*. Textbook B formally presented principles that underlie decisions, such as the *precautionary principle* that might help students to understand the framework in which socio-scientific issues interact with society. Having based its strategy on portraying real situations (see above), textbook A provided a more contextualized overview of the regulation process and of the agents involved, therefore facilitating students' perception that science and technology are regulated by society through financing, legislation, and control, and that decision making depends upon socio-cultural contexts.

In summary, both textbooks supplied teachers and students with a considerable basis for generally raising understanding of the complex STSE relationships, although lacking relevant information. On the other hand, despite being compliant with the same state guidelines, they seem to follow considerably different orientations.

8. Discussion

We first present methodological aspects. We then discuss the specific criteria and sub-criteria frequency profiles we found in our textbook sample. Third, we take DSNVS into account and discuss the indicators of both extremes of this distorted view that we identified in textbooks. Finally, we discuss the implications of our findings for students' SL.

8.1. Methodological Aspects

With respect to our methodology, four aspects should be considered: First, concisely defined and reliable sub-criteria, covering the issues mentioned in the theoretical framework, helped to identify lack of information, correct and incorrect statements, and more complex ideas. They guided data analyses and reduced subjectivity, as they facilitated the distinction between similar, though different, statements and clarified dubious interpretations; Second, qualitative analysis of every meaningful statement provided an impression of the textbook author's STSE views [83], while the sub-criteria frequencies provided an overview of the general text compliance with STSE issues, representing additional and complementary information [57]. Third, though we analysed the sub-criteria frequencies, we did not define thresholds for determining the presence or the absence of a certain science and technology view, which prevents a classification of textbooks in absolute terms. Fourth, our selection of two related textbook chapters is a limitation of our study. Other chapters and contents may lead to different conclusions.

8.2. Comparison of the Textbooks

Despite the same provenance (in terms of nationality and state) and, therefore, compliance with the same guidelines and the same guidelines, our analyses revealed somewhat different textbook profiles. Indeed, while the statistical analysis (adjusted Pearson's contingency coefficients) pointed to considerable similarities regarding the compliance with most of our STSE criteria, it also showed differing approaches to some sub-criteria. Similarly, our qualitative analysis recognized differences in terms of style of message conveyance, as exemplified below. The main differences and/or similarities identified between textbooks A and B are outlined below.

First, considering the relationships between science, technology, society, and environment, both textbooks referred mostly to science and technology events *per se* and the event times as a mode of social contextualization. These aspects might already provide a basis for contextualization both for teachers and students well versed in history of science [37], or at least in history, but otherwise might be of little help. Similarly, Markert [42] concluded, based on his analyses of treatments of history of science in German biology textbooks. They "simply state historical events and actors in a serial way, never or only seldom mentioning disciplinary, social, political, or cultural contexts [42] (p. 317); that is, "contextual aspects of science are dramatically disregarded" [42] (p. 317). To increase understanding. We argue for a more embracing contextualization, especially for providing information about the underlying problem and the circumstantial factors that influenced both research and establishment of new knowledge. However, our textbooks scored quite low on the sub-criteria corresponding to circumstantial factors (*favourable factors* and *obstacles*) (Table 2). In summary, despite the fact that both textbooks (but mainly textbook A) are aligned with "the historical current" in STSE education [8] (p. 607–608), neither of them provided complete information for contextualization of science and technology events.

Second, a focus on scientific and technological achievements, without describing the processes that led to these achievements, may lead to the view that scientific and/or technological problems have been overcome with no difficulties [73]. Therefore, we applied the sub-criteria *obstacles* as social problems, *costs* as economic problems, and *limitations* as technical problems, that scientists and technologists have to surmount. Nevertheless, both textbooks scored quite low in all three sub-criteria (Table 2).

Third, both textbooks approached the *risks* and *impacts* of science and technology. In approaching risks, they conform to the "logical reasoning current" in STSE education [8] (p. 612). However, some meaningful differences were found. Textbook A focussed on the social impacts of gene technology, perhaps explainable by the role of genetics in the recent German history, which represents a heavy burden on German memory [27], and is mirrored through some statements (e.g., "Till 1942, more than 70.000 of the 'sick' people [were] killed by SS doctors"; [65] (p. 111)). That is, the collective memory of the Nazi eugenic programs interferes with the communication about human genetics [27]. Textbook B exemplified a coherent and informative reasoning regarding risks, but based on one topic only: transgenic microorganisms in laboratories. Some statements (e.g., "[they] are considered to be biologically safe. When outside of the laboratory, they are neither viable nor able to transfer their DNA to other organisms" [66] (p. 138)) convey an optimistic, but also simplistic message: if security rules are tightly controlled, nothing can go wrong.

Fourth, both textbooks failed to adequately refer to environmental relationships of science, technology, and society. With only one reference, textbook A nearly neglected the environmental-related sub-criteria, (Table 2). That is, in our view, a weakness of textbook A and is worthy of improvement. Textbook B, although mentioning environmental impacts, did so infrequently (Table 2). In this respect, our findings are in line with results of the analyses of Finish [87] and French textbooks [88] as, "in many cases they don't take environmental effects into consideration" [90] (p. 148). Here, we suggest references to "environmental problems that originate from science and technology" [8] (p. 618). For instance, case studies about "experimental releases of genetically modified (GM) insects" [89] (p. 1) may meet this demand.

Fifth, the textbooks differed particularly in their discussion of controversial issues. Textbook A scored high in all sub-criteria, focussing mainly on social impacts. Textbook B explicitly formulated controversial issues and we recognize the didactical utility of this way of conveying messages. However, controversial issues might be better illustrated if excerpts of documents illustrating diverse perspectives, interests, and values, are provided (as in textbook A). Regarding decision-making processes, textbook A relieved scientists and technologists, as a whole, from the responsibility for negative effects of science and technology. It consistently proposed activities that emphasize the importance, for citizens, of being informed about social application of genetics and gene technology. Additionally, this textbook presented activities that foster the ability to raise arguments and to define perspectives. In contrast, textbook B called attention to the need for basing decisions upon empirical evidence, but denounced the trend for blaming scientists and technologists for the potential undesirable effects of technologies, in this case, of genetically modified plants.

In summary, we revealed textbooks' strengths and weaknesses in STSE content, as well as their differences in approaching STSE issues. We consider that textbook A presented a more balanced contribution for teaching and learning the complex relationships involved. Regrettably, relationships to the environmental level were poorly accounted for and nearly lacking. However, textbook A was on track for a more realistic paradigm concerning the understanding of science, technology, and society. On the other hand, textbook B provided valuable core concepts and includes all four STSE dimensions but lacked information that is fundamental to understanding how they relate and interact with each other.

8.3. Textbooks and DSNVS

Neither textbook provided the complete information for contextualization of science and technology events, which constitutes a first indicator of DSNVS [32]. In respect of interplay between science and technology, analyses exposed a second indicator of DSNVS. Once per book, we found the incorrect idea of technology as merely applied science (Table 2), which has been argued as the root of

DSNVS [32]. However, both textbooks implicitly contradicted this view by distinguishing scientific and technological activities. Additionally, they diverged from DSNVS by mentioning mutual support of science and technology as distinct entities. Textbook B emphasized obvious support provided by technological equipment to scientific progresses (e.g., by microscopes). Mainly in the biotechnology chapters, both textbooks contributed to a fair view of the interplay between science and technology with considerable examples of advancements in genetics that depended on gene technology tools, as well as on advancements in gene technology based on genetics knowledge.

The textbooks differed in presenting *science and technology as a means to solve societal problems*. Textbook B overemphasized the social applicability of science and technology products as an advantage which has also been seen as an indicator of DSNVS [32], in our case the third. Overemphasizing these products is often connected with the tendency to blame science and technology for the degradation of the environment [32], reflected in the emphasis placed on risks and impacts. We did not find this tendency within textbook B. As far as the sub-criterion *risks* is concerned, textbook B conveyed the simplistic message (see above) that the responsibility is that of scientists and technologists. Here, we see a fourth indicator of DSNVS. As written above, textbook A insufficiently characterized societal contexts that led to science and technology advancements (see criterion *events and contextualization*), which might point to the presence of DSNVS. However, with respect to the considerable relevance given to social impacts of science and technology (see criterion *risks* and *impacts*), as well as to its performance concerning the criterion *controversial issues*, textbook A diverged from the socially neutral profile, and, therefore, from the DSNVS.

Summarizing, we found interconnected DSNVS indicators partially mirrored in our textbooks, but also some contradictions. Textbook B is more consonant with the DSNVS than textbook A. Finally, we suggest naming this misconception as DSNVST by adding T for technology.

8.4. Textbooks and Students' SL

In regard to the development of students' SL, both textbooks revealed their orientation by providing learning material concerning STSE issues in genetics and gene technology. Nevertheless, they still lack important information and convey naive and incorrect ideas about science and technology. Neither textbook completely highlighted the view of science and technology that scholars have been proposing as requirements of SL. Some of the ideas, though conveyed by the textbooks, are scarcely developed (amongst others, for instance, *costs* of technologies and *impact* of technologies *in environment*; Table 1). In both textbooks, we found statements that indicate to the co-existence of ideas that can be seen as DSNVST indicators and ideas that point out non-DSNVST views. Potential explanations might be: (i) STSE material might have been added from different sources to a syllabus in an attempt to enrich this curriculum [76]; (ii) some confusion concerning the recent incorporation of the concept SL and its components (e.g., NOS) in educational systems; or (iii) specific national dynamics in the elaboration of STSE discourses as well as in their reception [27]. For instance, the Nazi history, but also the co-dominance of the Catholic and the Protestant religion in Germany may prevent the dominance of one world view over the other, thus increasing communication about risks and, particularly, about the social impact of genetic issues [27]. German media coverage of Human Genome Research has been characterized by involving a considerable variety of voices, demonstrating scepticism about science and scientific achievement [27]. A similar pattern was also observed in the coverage of other genetic issues such as health and environmental concerns [90]. We assume that such a variety of voices coexisting in the media coverage is also mirrored in the public opinion, and, therefore, is expected to be transferred to textbooks. Indeed, it was reflected in our sample in the context of *controversial issues*. Both textbooks provided references to different perspectives, and textbook A often presented external sources of information, such as excerpts of newspaper articles, of web pages, among others. This phenomenon could explain the coexistence of indicators of opposite views of science and technology in the analysed sample.

In our view, it is important that textbooks present science and technology events with significance for the socio-cultural context of the target population. However, we advise textbook writers to select events in view of their potential for representing the interactions between science and technology and between them and society and the environment. Textbook writers should therefore go beyond simply referencing science and technology events. Textbooks should elucidate the way through which a certain final product has been realized, preferably both from the internal (scientific community) and from the external (society) perspectives of the scientific and technological enterprises [40,41]. A classic example of such an event is the Human Genome Project (as demonstrated to certain extend by O'Mahony and Schäfer [27]), as it possesses all the necessary elements: which entities were involved; which disciplines contributed; how it was funded; what difficulties were faced; what potential it had; which technical or knowledge limitations constrained the research; what kind of risks were involved; which legislation framed it; how the society reacted; which interests played a role in decisions; who took decisions; and, finally, how the results were interpreted by the media. In summary, simple references to events and some disconnected details should be replaced by complete, structured and diverse case studies of scientific and technological events, thus supporting the conveyance of a more realistic SL. Additionally, links to environmental concerns should be considered; for instance, problems of seed patenting. Either in the national or in the global context, this issue may lead to a multidisciplinary debate, where advantages, disadvantages, social, and environmental risks of technologies can be exposed and explained to the students. We deem such a framework indispensable in order to render possible the conveyance of a fair portrayal of scientific and technological activity and to foster the development of students' SL.

9. Conclusions

Our study confirms that the confrontation of epistemological reasoning with evidence in science teaching may provide a practical basis for analysing educational discourse involving STSE issues. We have demonstrated the suitability of our set of criteria and sub-criteria and of our methods: The criteria provided guidance for both a qualitative and a quantitative textbook analysis in the domain of STSE issues. In further research or for practical purposes, our set might be used as a check list for verifying which ideas are conveyed to students and which are missing. Applying our criteria and sub-criteria may expose the proficiency of textbooks in approaching STSE issues and, therefore, in being helpful for promoting students' SL. Our quantitative analysis is adequate for emphasizing the relative predominance of single ideas by highlighting the ones that are clearly stressed, the ones slightly mentioned, or those that are absent. The observed balance or imbalance between the expressed ideas about science and technology may enable researchers to identify both the internal coherence of textbooks concerning the (positively or negatively) correlated ideas, and the views of science and technology that textbooks convey. Additionally, our methodology provides understanding about the intentional or the arbitrary character of decisions that underlie (the making of) textbooks, thus highlighting the arguments for SL [1] behind the textbook's conception. All in all, it allows the differentiation of different textbook profiles. Despite the methodological limitations inherent in the size of the sample, we argue for the suitability of the employed combination of methods for the detection of notable divergences within a heterogeneous country or for carrying out an international comparison between diverse socio-cultural contexts. Regarding the history of science in biology textbooks, Markert [42] (p. 318) found "strikingly similar results in different countries (e.g., Great Britain, Canada, Greece, Spain, United States), for different target audiences (students in secondary school, college, university), in different disciplines (biology, chemistry, physics) and for several decades". Whether a similar match will exist in STSE issues remains an open question which we are examining in ongoing work. We also argue for the applicability of our framework in other contexts of biology (e.g., ecology) or in other subjects, such as chemistry (e.g., nuclear power). Equivalent analyses in those domains would contribute to enhance transferability and validity of our criteria and methods. We recognize the similarity of our results to that of previous analysis of textbooks in terms of knowledge about science carried out by other researchers both in other countries and in Germany (see above). While maintaining some caution with generalizations, we argue that the current contribution of biology textbooks to SL is outlined in our work.

It is to be noted that any engagement in an epistemological debate, or classifying textbooks, was beyond the scope of the present work. Instead, we sought to identify aspects requiring improvement (e.g., including environmental STSE aspects) and the presentation of good practices (e.g., social impact of science and technology). In this sense, we stress that our analysis has exposed the political basis for constructing a framework to include STSE in the biology curriculum. It has also provided evidence of the transposition of epistemological ideas driven by the four decade-long debate on the inclusion of STSE issues in science education [8]. However, important ideas are still absent and others are overemphasized, thus displaying, at least partially, the DSVSNT. We argue therefore that presenting this distorted view in textbooks is an obstacle for students' construction of a fair image of science and technology, therefore limiting students' SL.

In summary, the introduction of STSE issues represents a challenge to curriculum developers and to teachers, even though it seems to be an international trend [55]. The progressive intention of adding STSE material into the curriculum, either by curriculum makers into syllabi, by textbook writers into textbooks or by teachers in their science lessons must be accompanied by the awareness that one's views of science and technology might influence the views conveyed to students. On the other hand, in-service teachers (mainly the less experienced ones) strongly rely on textbooks (e.g., [37,45,88]. They express reluctance or difficulty in approaching controversial issues [23,91]. Hence, our findings, when incorporated into science educators' training and in further training programs, may provide a framework for curricula makers, helping the incorporation of STSE issues into curricula; may provide a reference for textbook writers, pointing out a way to approach such issues; and may guide teachers in exploring STSE issues in their classes. Furthermore, our set of criteria might be useful for publishers to formulate their textbook guidelines; for encouraging textbook writers to include STSE issues in textbooks and guiding textbook writing; for orienting textbook selection by teachers; and finally, for shaping the criteria used by textbook reviewers and evaluating committees.

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Author Contributions

Florbela Calado completed the textbook analyses, Franz-Josef Scharfenberg finalized the statistical analyses. Florbela Calado wrote the first version of the manuscript which by all three authors concertedly was refined to the final printed version.

Conflicts of Interest

The authors declare no conflict of interest.

References

1. Osborne, J.; Dillon, J. *Science Education in Europe: Critical Reflections*; The Nuffield Foundation: London, UK, 2008.
2. European Commission. Europe Needs More Scientists: EU Blueprint for Action. 2004. Available online: http://ec.europa.eu/research/press/2004/pr0204en.cfm (accessed on 5 September 2015).
3. Rocard, M.; Csermely, P.; Jorde, D.; Lenzen, D. Walberg-Henriksson, H.; Hemmo, V. *Science Education Now: A Renewed Pedagogy for the Future of Europe*; Directorate General for Research, Science, Economy and Society: Brussels, Belgium, 2007.
4. Miller, J.; Pardo, R. Civic scientific literacy and attitude to science and technology: A comparative analysis of the European Union; The United States and Canada. In *Between Understanding and Trust: The Public, Science and Technology*; Dierkes, M., Grote, C., Eds.; Routledge: Oxon, UK, 2000; pp. 54–88.
5. Zimmerman, C.; Bisanz, G.L.; Bisanz, J.; Klein, J.S.; Klein, P. Science at the supermarket: A comparison of what appears in the popular press, experts' advice to readers, and what students want to know. *PUS* **2001**, *10*, 37–58.
6. Calado, F.; Bogner, F. A Reflection on Distorted Views of Science and Technology in Science Textbooks as Obstacles to the Improvement of Students' Scientific Literacy. *EUJER* **2013**, *2*, 51–68.
7. Kim, M.; Roth, W. Rethinking the ethics of scientific knowledge: A case study of teaching the environment in science classrooms. *APER* **2008**, *9*, 516–528.
8. Pedretti, E.; Nazir, J. Currents in STSE education: Mapping on a complex field, 40 years on. *Sci. Educ.* **2011**, *95*, 601–626.

9. Yore, L.D. Foundations of scientific, mathematical, and technological literacies—Common themes and theoretical frameworks. In *Pacific Crystal Center for Science, Mathematics and Technology Literacy: Lessons Learned*; Yore, L.D., Flier-Keller, E.V., Blades, D.W., Timothy, W.P., Zandvliet, D.B., Eds.; Sense Publishers: Rotterdam, The Netherlands, 2011; pp. 23–44.
10. Green, W.; Naidoo, D. Science textbooks in the context of political reform in South Africa: Implications for access in Science. *SEI* **2008**, *19*, 235–250.
11. Gericke, N.M.; Hagberg, M.; Carvalho dos Santos, V.; Joaquim, L.M.; El-Hani, C.N. Conceptual variation or incoherence? Textbook discourse on genes in six countries. *Sci. Educ.* **2014**, *23*, 381–416.
12. DeBoer, G. Scientifc Literacy: Another Look at Its Historical and Contemporary Meanings and Its Relationship to Science Education Reform. *JRST* **2000**, *37*, 582–601.
13. Turner, S. School Science and its controversies; or, whatever happened to scientific literacy? *PUS* **2008**, *17*, 55–72.
14. Hodson, D. Redefining and Reorienting Practical Work in School Science. *SSR* **1992**, *73*, 65–78.
15. Mathews, M. The nature of science and science teaching. In *International Handbook of Science Education*; Fraser, B., Tobin, K., Eds.; Kluver Academic Publishers: Dordrecht, The Netherlands, 1998; pp. 981–999.
16. Gallagher, J.J. A broader sense for science teaching. *Sci. Educ.* **1971**, *55*, 329–338.
17. Solomon, J.; Aikenhead, G. *STS Education: International Perspectives on Reform*; Teachers College Press: New York, NY, USA, 1994.
18. Ziman, J. The rationale of STS education is in the approach. In *STS Education: International Perspectives on Reform*; Solomon, J., Aikenhead, G., Eds.; Teachers College Press: New York, NY, USA, 1994; pp. 21–31.
19. McComas, W.F.; Olson, J. The nature of science in international science education standards documents. In *The Nature of Science in Science Education: Rationales and Strategies*; McComas, W., Ed.; Kluwer Academic Publishers: Dordrecht, The Netherlands, 1998; pp. 41–52.
20. Gaskell, P.J. Authentic Science and School Science. *IJSE* **1992**, *14*, 265–272.
21. Kolstø, S.D. Scientific literacy for citizenship: Tools for dealing with the science dimension of controversial socio-scientific issues. *Sci. Educ.* **2001**, *85*, 291–310.
22. Aikenhead, G. Renegotiating the culture of school science. In *Improving Science Education: The Contribution of Research*; Millar, R., Leach, J., Osborne, J., Eds.; Open University Press: Buckingham, UK; Philadelphia, PA, USA, 2000; pp. 245–264.
23. Reis, P. A escola e as controvérsias sociocientíficas—Perspectivas de alunos e professors. In *The School and the Socio-Scientific Controversies—Perspectives of Students and Teachers*; Escolar Editora: Lisboa, Portugal, 2008.
24. Sadler, T.; Zeidler, D. The morality of socioscientific issues: Construal and resolution of genetic engineering dilemmas. *Sci. Educ.* **2003**, *88*, 4–27.
25. Lederman, N.G.; Antink, A.; Bartos, S. Nature of Science, Scientific Inquiry, and Socio-Scientific Issues Arising from Genetics: A Pathway to Developing a Scientifically Literate Citizenry. *Sci. Educ.* **2012**, *23*, 285–302.

26. Bauer, M.W.; Gaskell, G. Researching the public sphere of biotechnology. In *Biotechnology—The Making of A Global Controversy*; Bauer, M., Gaskell, G., Eds.; Cambridge University Press: Cambrigde, UK, 2002; pp. 1–17.
27. O'Mahony, P.; Schäfer, M.S. The book of life in the press: Comparing German and Irish media discourse on human genome research. *SSS* **2005**, *35*, 99–130.
28. Peters, H.P.; Lang, J.T.; Sawicka, M.; Hallman, W.K. Culture and technological innovation: Impact of institutional trust and appreciation of nature on attitudes towards food biotechnology in the USA and Germany. *IJPOR* **2007**, *19*, 191–220.
29. Kevles, D.J. Eugenics and the Human Genome Project: Is the Past Prologue? In *Justice and the Human Genome Project*; Murphy, T.F., Lappé, M., Eds.; Unversity of California Press: Berkeley, CA, USA, 1994.
30. Palmer, E. Restrictions on Genetically Modified Organisms: Germany, Library of the Congress. Available online: http://www.loc.gov/law/help/restrictions-on-gmos/germany.php (accessed on 25 August 2015).
31. Osborne, J.; Collins, S.; Ratcliffe, M.; Millar, R.; Duschl, R. What "ideas-about-science" should be taught in school science? A Delphi study of the expert community. *JRST* **2003**, *40*, 692–720.
32. Gil-Pérez, D.; Vilches, A.; Fernández, I.; Cachapuz, A.; Praia, J.; Valdéz, P.; Salinas, J. Technology as "Applied Science": A Serious Misconception that Reinforces Distorted and Impoverished Views of Science. *Sci. Educ.* **2005**, *14*, 309–320.
33. Blachowicz, J. How Science Textbooks Treat Scientific Method: A Philosopher's Perspective. *British Journal for the Philosophy of Science* **2009**, *60*, 303–344.
34. Harding, P.; Hare, W. Portraying science accurately in classrooms: Emphasizing open-mindedness rather than relativism. *JRST* **2000**, *37*, 225–236.
35. Yore, L.D.; Hand, B.M.; Florence, M.K. Scientists' views of science, models of writing, and science writing practices. *JRST* **2004**, *41*, 338–369.
36. Chiappetta, E.; Fillman, D.; Sethna, G. Method to Quantify Major Themes of Scientific Literacy in Science Textbooks. *JRST* **1991**, *28*, 713–725.
37. Leite, L. History of Science in Science Education: Development and Validation of a Checklist for Analyzing the Historical Content of Science Textbooks. *Sci. Educ.* **2002**, *11*, 333–359.
38. Bartholomew, H.; Osborne, J.; Ratcliffe, M. Teaching students' "ideas-about-science": Five dimensions of effective practice. *Sci. Educ.* **2004**, *88*, 655–682.
39. Valverde, G.A.; Bianchi, L.J.; Wolfe, R.G.; Schmidt, W.H.; Houang, R.T. *According the Book—Using TIMSS to Investigate the Translation of Policy into Practice through the World of Textbooks*; Kluver: Dordecht, The Netherlands, 2002.
40. Leach, J.; Millar, R.; Ryder, J.; Séré, M.G. Epistemological understanding in science learning: The consistency of representations across contexts. *Learn. Instruct.* **2000**, *10*, 497–527.
41. Rudolph, J.L. Portraying epistemology: School science in historical context. *Sci. Educ.* **2003**, *87*, 64–79.
42. Markert, M. History of Science in School Biology Textbooks: Characteristics and Consequences. In *Enabling Scientific Understanding through Historical Instruments and Experiments in Formal and Non-Formal Learning Environments*; Heering, P., Klassen, S., Metz, D., Eds.; Flensburg University Press: Flensburg, Germany, 2013; pp. 313–322.

43. Bernard, S.; Carvalho, G.; Berger, D.; Thiaw, S.M.; Sabah, S.; Salaheddine, K.; Skujiene, G.; Abdelli, S.; Calado, F.; Bogner, F.X.; *et al*. Sexually transmitted infections and the use of condoms in biology textbooks. A comparative analysis across sixteen countries. *Sci. Educ. Int.* **2008**, *19*, 185–208.
44. Castera, J.; Bruguière, C; Clément, P. Genetic diseases and genetic determinism models in French secondary school biology textbooks. *J. Biol. Educ.* **2008**, *42*, 53–59.
45. Osborne, J.; Duschl, R.; Fairbrother, B. *Breaking the Mould? Teaching Science for Public Understanding: Lessons from the Classroom*; The Nuffield Foundation: London, UK, 2002.
46. Sadler, T.D.; Amirshokoohi, A.; Kazempour, M.; Allspaw, K.M. Socioscience and Ethics in Science Classrooms: Teacher Perspectives and Strategies. *JRST* **2006**, *43*, 353–376.
47. Vazquéz-Alonso, Á.; Massanero-Mas, M.; Acevedo-Díaz, J. An Analysis of complex multiple-choice Science-Technology-Society items: Methodological development and preliminary Results. *Sci. Educ.* **2006**, *90*, 681–706.
48. Lumpe, A.T.; Beck, J. A profile of hight school biology textbooks using scientific literacy recommendations. *Am. Biol. Teach.* **1996**, *58*, 147–153.
49. Yager, R.; Akay, H. Comparing science learning among 4th-, 5th-, and 6th-Grade Students: STS *versus* textbook-based instruction. *JESE* **2009**, *21*, 15–24.
50. Wilkinson, J. A Quantitative analysis of physics textbooks for scientific literacy themes. *RISE* **1999**, *29*, 385–399.
51. Chiang-Soong, B.; Yager, R.E. The inclusion of STS material in the most frequently used secondary science textbooks in the U.S. *JRST* **1993**, *30*, 339–349.
52. Riess, F. Problems with German science education. *Sci. Educ.* **2000**, *9*, 327–331.
53. Standing Conference of the Ministers of Education and Cultural Affairs of the Länder in the Federal Republic of Germany, Eds. *Education Standards in Biology for Middle School Graduation*; Wolters Kluwer Deutschland: Munich, Germany, 2005. Available online: http://www.kmk.org/fileadmin/veroeffentlichungen_beschluesse/2004/2004_12_16-Bildungsstandards-Biologie.pdf (accessed on 24 September 2015).
54. Staatsinstitut für Schulqualität und Bildungsforschung München. Lehrplan für Biology: Jahrgangsstufe 11 [State Institut for School Quality and Education Research Munich. Syllabi for Biology: 11th grade]. Available online: http://www.isb-gym8-lehrplan.de/contentserv/3.1.neu/g8.de/index.php?StoryID=26196 (accessed on 10 October 2015).
55. Morris, H. Socioscientific issues and multidisciplinarity in school science textbooks. *IJSE* **2014**, *36*, 1137–1158.
56. Cachapuz, A.; Praia, J.; Jorge, M. From Science Education to Science Teaching: An epistemological rethinking. *Sci. Educ.* **2004**, *10*, 363–381.
57. Pingel, F. *UNESCO Guidebook on Textbook Research and Textbook Revision*, 2nd revised and updated edition; UNESCO: Paris, France, 2010. Available online: http://unesdoc.unesco.org/images/0011/001171/117188e.pdf (accessed on 6 September 2015).
58. Fernández, I.; Gil, D.; Vilches, A.;Valdés, P.; Cachapuz A.; Praia, J.; Salinas, J. Disregard of technology as an endorsement of the distorted views of science. *Electron. J. Sci. Teach.* **2003**, *2*, 1–22.

59. Stinner, A. Contextual settings, science stories, and Large Context Problems: Towards a more humanistic science education. *Sci. Educ.* **1995**, *79*, 555–581.
60. Roberts, D.A. Scientific literacy. In *Handbook of Research on Science Education*; Abell, S.K., Lederman, N.G., Eds.; Lawrence Erlbaum Associates: Mahwah, NJ, USA, 2007; pp. 729–780.
61. Sadler, T.; Zeidler, D. Scientific Literacy, PISA, and Socioscientific Discourse: Assessment for Progressive Aims of Science Education. *JRST* **2009**, *46*, 909–921.
62. Baradat, L. *Understanding American Democracy*; HarperCollins: Toronto, CA, Canada, 1991.
63. Cabral, M. *How to Analyse Textbooks*; Texto Editores: Lisboa, Portugal, 2005.
64. Heidenfelder, G.; Moßer, H.; Oberkampf, S.; Rummey, H.; Sommermann, U.; Ströhle, G. *Biology for High Schools*; Klett Verlag: Stuttgart, Germany, 2009.
65. Bayrhuber, H.; Drös, R.; Kull, U. *Linder—Biologie 11*; Schroedel: Braunschweig, Germany, 2009.
66. Patton, M.Q. *Qualitative Research & Evaluation Methods*; Sage: Thousand Oaks, CA, USA, 2010.
67. Nisbet, M.C.; Scheufele, D.A.; Shanahan, J.; Moy, P.; Brossard, Dominique; Lewenstein, B. Knowledge, reservations, or promise? A media effects model for public perceptions of science and technology. *CR* **2002**, *29*, 584–608.
68. Millar, R.; Osborne, J. Beyond 2000: *Science Education for the Future. The Report of a Seminar Series Funded by the Nuffield Foundation*; King's College London, School of Education: London, UK, 1998.
69. American Association for the Advancement of Science. *Benchmarks for Science Literacy*; Oxford University Press: New York, NY, USA, 1993.

Abd-El-Khalick, F.; Waters, M.; Lee, A. Representations of Nature of Science in High School Chemistry Textbooks over the Past Four Decades. *JRST* **2008**, *45*, 835–855.

70. Abd-El-Khalick, F.; Lederman, N.G. The Influence of History of Science Courses on Students' Views of Nature of Science. *JRST* **2000**, *37*, 1057–1095.
71. American Association for the Advancement of Science. Benchmarks for Science Literacy Online. Historical Perspectives. Available online: http://www.project2061.org/publications/bsl/online/index.php?chapter=10 (accessed on 20 July 2015).
72. Hackett, E.J. Trends and opportunities in science and technology studies: A view from the National Science Foundation. In *Science Technology, and Society: A Sourcebook on Research and Practice*; Kumar, D.D., Chubin, D.E., Eds.; Kluwer Academic/Plenum: New York, NY, USA, 2000; pp. 277–291.
73. Gardner, P. The technology-science Relationship: Some curriculum implications. *RISE* **1990**, *20*, 124–133.
74. McComas, W.F.; Clough, M.; Almazroa, H. The role and character of the nature of science in science education. In *The Nature of Science in Science Education: Rationales and Strategies*; McComas, W., Ed.; Kluwer Academic Publishers: Dordrecht, The Netherlands, 2000; pp. 3–39.
75. Hacker, M.; Barden, A. *Technology in Our World*; Delmar Publishers: Albany, NY, USA, 1987.
76. Fensham, P.J. Time to Change Drivers for Scientific Literacy. *Can. J. Sci. Math. Tech. Educ.* **2002**, *2*, 9–24.

77. Maiztegui, A. The role of technology in science education: A forgotten dimension. *RIE* **2002**, *28*, 129–158.
78. Zeidler, D.; Sadler, T.; Simmons, M.; Howes, E. Beyond STS: A research-based framework for socio-scientific issues education. *Sci. Educ.* **2005**, *89*, 357–377.
79. Yehudit, J.D.; Tal, R.T.; Tsaushu, M. Teaching biotechnology through case studies—Can we improve higher order thinking skills of non-science majors? *Sci. Educ.* **2003**, *87*, 767–793.
80. Zeidler, D.; Nichols, H. Socioscientific issues: Theories and practice. *JESE* **2009**, *21*, 49–58.
81. Szanto, T. Value communities in science: The recombinant DNA case. In *Controversial Science: From Content to Contention*; Brante, T.; Fuller, S., Lynch, W., Eds; State University of New York Press: New York, NY, USA, 1993; pp. 241–263.
82. Elo, S.; Kyngäs, H. The qualitative content analysis process. *JAN* **2008**, *62*, 107–115.
83. Knain, E. Ideologies in School Science Textbooks. *IJSE* **2001**, *23*, 319–329.
84. Cohen, J. Weighted kappa: Nominal scale agreement provision for scaled disagreement or partial credit. *Psychol. Bull.* **1968**, *70*, 213–220.
85. Landis, J.R.; Koch, G.G. The Measurement of Observer Agreement for Categorical Data. *Biometrics* **1977**, *33*, 159–174.
86. Pearson, K. On the theory of contingency and its relation to association and normal correlation. In *On the General Theory of Skew Correlation and Non-Linear Regression*; Cambridge University Press: Cambridge, UK, 1904.
87. Aivelo. T.; Uitto, A. Genetic determinism in the Finnish upper secondary school biology textbooks. *NorDiNa* **2015**, *11*, 139–152.
88. Clement, P.; Castera, J. Multiple representations of human genetics in biology textbooks. In *Multiple Representations in Biology Education*; Treagust, D.F., Tsui, C.Y., Eds.; Springer: Dordrecht, The Netherlands, 2013, pp. 147–164.
89. Reeves, R.G.; Denton, J.A.; Santucci, F.; Bryk, J.; Reed, F.A. Scientific Standards and the Regulation of Genetically Modified Insects. *PLoS Negl. Trop. Dis.* **2012**, *6*, 1–15.
90. Kohring, M.; Matthes, J. The face(t)s of biotech in the nineties: How the German press framed modern biotechnology. *PUS* **2002**, *11*, 143–154.
91. Dawson, V.; Venville, G. Teaching strategies for developing students’ argumentation skills about socioscientific issues in high school genetics. *RISE* **2010**, *40*, 133–148.

III. To What Extent does Genetic Content in Textbooks Contribute to Scientific Literacy? Analysis of STSE Issues in Textbooks

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Abstract: Our article analyses science-technology-society-environment (STSE) issues in the genetics-related chapters of Portuguese natural sciences and biology textbooks and considers how they contribute to students' scientific literacy. We inspected manner of imparting of the decontextualized and socially neutral view of science and technology (S&T) as an obstacle for achieving scientific literacy. Our sample comprised four textbooks for the 9th and the 12th grades. We identified and content-analytically analyzed 1019 STSE statements with regard to their compliance with previously proposed criteria. We quantitatively analyzed the statements' frequencies. We noted an attempt to approach STSE issues, but we found important deficiencies in all the textbooks, as well as indicators of a distorted view of science. We discuss possible influences of the socio-cultural context in the selection of STSE contents, in the terms being applied, as well as in the S&T conceptions displayed by the textbooks.

Keywords: textbook analysis; scientific literacy; science; technology; society; environment; STSE issues; misconceptions; socio-cultural context; public views of science.

Resumo: O nosso artigo analisa o tema das relações entre a ciência, a tecnologia, a sociedade e o ambiente (conhecidos na língua inglesa como STSE issues), nos capítulos relacionados com a genética, em manuais de ciências naturais e de biologia, e considera em que medida eles contribuem para a literacia científica dos alunos. Adicionalmente, foi averiguada a transmissão da visão descontextualizada e socialmente neutra da ciência e da tecnologia, enquanto obstáculo à literacia científica. A amostra compreende quatro manuais portugueses de biologia e de ciências naturais para o 9º e para o 12º ano respetivamente. Identificámos e analisámos 1019 expressões com conteúdo STSE, conformes com critérios previamente propostos, e procedemos à análise de frequências. Verificou-se uma tentativa de abordagem de conteúdos STSE, tendo sido também detectadas

deficiências importantes em todos os manuais, assim como indicadores daquela visão distorcida da ciência e da technologia. Discutem-se ainda possíveis influências do contexto socio-cultural na seleção dos conteúdos STSE, nos termos utilizados, bem como na conceção sobre ciência e tecnologia refletidas nos manuais.

1. Introduction

1.1. Visions of science and perspectives of science education

A variety of arguments has been proposed for educating students towards scientific literacy (SL), including economic, utilitarian, cultural, democratic and moral (Millar, 2002; Osborne, 2000; Wellington, 2001) ones. These seem to derive from underlying visions of science. Roberts (2007) argued for the existence of two visions of science that generate different conceptions of SL, and therefore determine different curricular options. Vision I focuses on the internal perspective of science itself and sets as the goals of science education students' acquisition of knowledge and skills, leading them to think and act like a professional scientist would, with goals underpinned by traditional views of science education. Vision II is consonant with humanistic perspectives of science education (Aikenhead, 2006), viewing science both from the context in which scientific ideas and processes evolved, and from their role in society. In the educational context, this view seeks opportunities for students to integrate scientific ideas and scientific reasoning with moral reasoning and cultural considerations that underlie decision-making about socio-scientific issues (Roberts, 2007; Sadler and Zeidler, 2009; Lee et al., 2013). The present survey is guided by Robert's Vision II of science, and therefore, by the democratic argument. We here consider the interplay between Science, Technology, Society and Environment as a fundamental SL component (Authors, 2015), conventionally labelled as STSE issues (e.g., Kim and Roth, 2008, Pedretti and Nazir, 2011). According to this perspective, and in order to foster students' SL, educators need to promote understanding of the interactions between S&T and their influence in society and environment (Authors 2015).

Science textbooks have been suggested as a means to convey the notion of the "social context of science" (Green and Naidoo, 2008, p. 249). However, they may convey distorted views of S&T (Authors, 2015) deriving from public and individual misconceptions. They are expected to follow the official syllabi and guidelines, but may also "contrast radically with the curricula and other steering documents" of a given country (Gericke, Hagberg, dos Santos, Joaquim, and El-Hani, 2014 p. 408). We decided to analyze the contribution of Portuguese biology textbooks to students' SL in the manner in which they approach STSE issues. In the positive sense, we seek ideas that help understanding STSE interactions. However, we also look for potential ideas or deficiencies indicating distorted views of S&T propagated by textbooks.

1. 2. SL and STSE issues in genetics

Introducing STSE contents in classrooms has often been recommended as a method of confronting students with controversial socio-scientific issues, including those with moral and ethical implications (e.g., Gaskell, 1992; Kolstø, 2001). Particularly in such controversial aspects as human genetics and genetic engineering, decision-making may lead to moral dilemmas (e.g., gene therapy and cloning). Such issues therefore require complex reasoning and may allow students to engage in discussions and to make judgments, involving emotive considerations and personal values (Sadler and Zeidler, 2004). Genetics and gene-technology are essential contents in biology curricula and affect important domains of human lives, such as reproduction, health and nourishment, as well as the environmental balance. However, they also include controversies concerning genetic processes and products (Bauer and Gaskell, 2002). For these reasons, we consider genetics to be an adequate field for surveying the approach to STSE issues of textbooks.

1. 3. Textbooks: Support for teaching STSE or vehicles of mis(conceptions)?

Textbooks are considered to be powerful resources for science education, especially for approaching STSE issues (Authors, 2015). However, even though the incorporation of STSE issues into the curricula seems to be an international trend, most textbooks still fail to include perspectives from social science (Morris, 2014; Authors, 2015).

Along with the promotion of STSE issues, distorted views of S&T deserve attention, as they may be conveyed to students through teaching practice in general and textbooks in particular. We specifically examine the distorted idea of a decontextualized and socially neutral view of science and technology (DSNVST; Fernández et al., 2003; Authors, 2015): Science is either exalted as being the absolute source of progress in society or, alternatively, S&T (perceived as applied science) are presented as being solely responsible for environmental degradation, and therefore to be rejected. That is, DSNVST ignores the responsibility of other agents of decision (Fernández et al., 2003; Stinner, 1995) such as lawyers, politicians, entrepreneurs, and even citizens. DSNVST also disregards the efforts of S&T in solving problems that affect humanity and scientists' concerns with potential risks deriving from their own activity (Kolstø, 2001; Fernández et al., 2003). Approaching STSE issues in classrooms provides an opportunity for students to identify their own misconceptions and to replace them by correct ideas about the nature of science (NoS). On the other hand, simply including STSE content *per se* does not guarantee the conveyance of a fair image of the interactions involved. In previous work (Authors, 2015), we recognized in German biology textbooks an orientation towards providing learning material concerning STSE issues in the context of genetics and gene-technology. However, we also found deficiencies and detected some naive and incorrect ideas about S&T, which might contribute to the promotion of DSNVST. Our results suggested that some features of textbooks might be justified by the socio-cultural background in which they were conceived. Those conclusions led to the following research question:

Does our set of criteria for analyzing STSE issues in textbooks reveal similar usefulness when applied to a different socio-cultural context?

1.4. Socio-cultural context and the science curriculum

Perceptions of the “impact of S&T on individuals and society” may vary substantially between different nations (Miller, 1998, p. 205). Local political decisions may be in conflict with educationally driven research findings concerning the inclusion of STSE issues into curricula (and learning materials). Which knowledge is of most value to a science curriculum is very likely mostly oriented by economic criteria (Aikenhead, 2007), but might also be influenced to a certain extent by distorted S&T views of decision makers. As Höttecke and Silva (2011) have argued, epistemological views are significant as they also seem to condition beliefs about science teaching. A community’s perception of S&T might influence its expectations of science education. Both together may lead to particular STSE syllabi and, consequently, to particular science textbook profiles.

The final contents in the curriculum, and, ultimately, in textbooks, depend strongly on the arguments for promoting SL underlying the selection process (Authors, 2015). Implementing STSE issues in school science curricula may be consonant with humanistic initiatives, as an alternative to traditional approaches, aiming to enable citizens to critically and rationally assess S&T (Aikenhead, 2007). However, science education is often intertwined with economic globalization; and is mainly concerned with generating scientists and technologists competent in developing mechanisms of production of goods and services (Bencze and Carter, 2011). Bencze and Carter (2011) found frequent statements in political documents urging school systems to prepare students to “compete in the global economy” (p. 651), thus contradicting the concerns of promoting a science education towards SL. This led to our second research question:

Are textbooks in an inclusive educational system, where diversity is privileged, independently of learners particular needs (Ainscow & César, 2006), conceived for targeting education for citizenship or are they more focused on preparing future scientists and technologists?

1.5. Transferring S&T views in science education

1.5.1 Public S&T views

Several studies have viewed science as a socio-cultural construct (Jenkins, 1992; Aikenhead, 1996; Hodson, 1998). As scientific knowledge has arisen from local contexts and in response to local needs, there might be as many sciences as there are contexts and cultures (Harding, 1998). On a smaller scale, science is seen as a system, reflecting the social position of individual groups and their role in society (Prpic, 2011), and resulting in a *cultural common sense notion of science* (Weinstein, 1998). Public S&T views seem therefore to derive from a combination of “cultural traditions, practical experiences, school learnings and mediatic messages” (Costa, Ávila and Mateus, 2002, p. 43).

Knowledge about science and understanding of the relationship between science and the other STSE spheres determine individual views, which, together with personal experiences and cultural values, might contribute to the development of a participative citizenship (Authors, 2013). Gaskell (1992) has argued that both knowledge about and views of the object should be seen as influencing one's attitudinal judgements; and this perspective has guided debate in science education. Despite the necessary caution in avoiding simplistic cause-effect relations, knowing public attitudes in a particular context might help to interpret the S&T views displayed by textbooks.

Curriculum designers determine syllabus orientations by selecting and emphasizing some issues, while neglecting or excluding others. The language selected is affected by the prevailing ideology (Knain, 2001), since “the freedom to choose language resources... may differ immensely between cultures and individuals” (Liberg, Geijerstam and Folkeryd, 2007, p. 42). Either explicitly or implicitly, the narrative construction of S&T events is influenced by the corresponding socio-cultural context (Lakin and Wellington, 1994). One can therefore assume that science education, either by inclusion or by omission, reinforces a naive image of the scientific knowledge construction, which has been consolidated and become a socially accepted stereotype in a certain context. All these considerations led to our third research question:

Are prevailing public views of science reflected in textbooks?

1.5.2. Individual S&T views

Curriculum design teams might include scientists, science teachers, philosophers, sociologists of science, and science educators (Osborne, Collins, Ratcliffe, Millar, and Duschl, 2003). The multidisciplinary character of these working groups may contribute to a balanced account in terms of S&T ideas, conveyed by the contents selected, the strategies proposed and by the discourse employed. Even so, some curricular documents display misconceptions about S&T (Authors, 2015). Textbook writers are mostly teachers (Markert, 2013), who,as members of the general public with similar levels of education, are likely to hold similarly distorted views (Yates and Marek, 2013). Although textbook writing is supposed to follow the official pedagogical recommendations, both in terms of content selection and of didactical strategies, a re-contextualization that “creates space for changing” is intrinsic to the pedagogical discourse (Ferreira and Morais, 2013; p. 5). Thus, one may expect textbook writers to transfer their own views to textbooks. Pre-service teachers may already hold a wide variety of views about NoS despite their Bachelor’s degree in a science subject or in engineering (Aguirre, Haggerty, and Linder, 1990); and their views may diverge from recommended ones (Abd-El-Khalick and Lederman, 2000; Gil Pérez et al. 2005). Consequently, pre-service teachers may retain their own socially and culturally defined beliefs (Hollingsworth, 1989) as textbook writers later on.

Assuming that teachers' epistemological S&T views condition their beliefs about science teaching (Höttecke and Silva, 2011), one can assume from a constructivist view of teaching and learning that teachers as textbook writers will transfer their conceptions of teaching and of learning to the pedagogical orientation of textbooks (e.g., Aguirre et al., 1990; Carter, 2007). School textbooks are therefore, together with teachers, transmitters of social models, working as key agents that might contribute to the improvement of students' interests in, attitudes towards, and images of science (Christidou, 2011).

1.6. Textbooks as vehicles of misconceptions

Comparison of biology textbooks from eight countries has shown significant interactions between scientific knowledge and values. Cultural, socio-economic and ethical dimensions were rarely found (Selmaoui, Agorrama, Kzamia, Razoukia, Clément and Caravita, 2012). Analyses of biology textbooks from 16 countries have found implicit ideological messages, conveyed by representations of social conditions and beyond the messages of scientific content (Castéra, Sarapuu, and Clément, 2013). These messages may have ethical, cultural and social implications (Clément and Castéra, 2013). Therefore, the integration of updated substantive S&T knowledge and of modern epistemological views about the STSE relationships are important requirements of SL.

Summarizing, school science textbooks might exert influence on students' views of science which "makes analysis of their content particularly important in order to determine their aspects or features negatively affecting youngsters' conceptions, interests and attitudes related to science, and formulate relevant suggestions for their design" (Christidou, 2011, p.151).

1.7. Objectives of the study

First, we examine the extent of STSE content in Portuguese biology textbooks for middle and secondary schools. Second, we examine the presence of incorrect S&T ideas, especially DSNVST as a barrier to the achievement of students' SL. Third, we examine syllabi and guidelines and include several social studies in order to isolate the view of S&T under study. Finally, we infer possible relationships between misconceptions displayed by textbooks and the constraints imposed by socio-cultural milieu, in terms of communication between S&T settings and the general public S&T, such as historical background, socio-economic development and values.

2.Methodology

2.1. The Portuguese socio-cultural context in terms of STSE issues

Differentiation among the European countries with respect to their attitudes towards S&T depends predominantly on stronger or weaker scientific and technological systems (Gonçalves and Castro, 2009). Portugal is a late-industrializing country (Fontes and Novais, 1998; Pepinsky, 2013), where scientific competencies at the level of public research, particularly in the field of biotechnology, have not been successfully transferred to industry (Fontes and Novais, 1998). Portuguese public opinion displays optimism towards biotechnology and a high acceptance of genetically modified organisms (GMO; (Kurzer and Cooper, 2007) with more supporters than opponents (Gaskell et al., 2006).

Several studies have pointed out that the greater scientific knowledge, the more positive the attitude to science (Sturgis and Allum, 2001), but there is also evidence that this linkage is weaker than supposed, in certain cases even negative with respect to specific technologies (Allum, Sturgis, Tabourazi, and Brunton-Smith, 2008). An ambivalent attitude is also observed where a relatively high scientific knowledge level coexists with positive attitudes, but also with readiness to criticism (Ávila, Gravito and Vala, 2000), frequently a precursor of public debate about socio-scientific issues. Costa, Ávila and Mateus (2002) pointed out that positive attitudes towards S&T are strongly related to school attendance, in particular to the highest school grades. Portugal did not enact compulsory education effectively, and had a long period of only four-year compulsory education (Candeias, 1993),being among the countries where more than 50% of the population aged 25 to 64 had not completed upper secondary education (OECD, 2008). On the other hand, the Portuguese people have been subjected to long-term authoritarian politics, that disregarded public interests and discouraged capabilities in decision-making (Gonçalves et al., 2007), and is still experiencing an immature democracy (Menezes, 2003).These political constraints prevented the development of a strong and organized civil society (Roberts, 1995) where social movements and citizens' organizations could defend opinions and interests. The change of regime in 1974, despite brief experiences in popular mobilization during the revolutionary period, did not provide the platforms for public debate, and debate was confined to parliament (Santos and Nunes, 2004). Portugal has a short tradition of public communication of science (Gonçalves and Castro, 2009). Some controversies triggered by a more sensationalist than informative media have shaken Portuguese society; especially human cloning, which awakened emotional reactions, such as fear, anger and hysteria, and caused social tensions, thus moving public conceptions of science towards an unbalanced attitude on socio-scientific issues (Reis and Galvão, 2004).

2.2. The Portuguese educational context

Portuguese schools embrace a considerable diversity of students, for instance, children from immigrant families, from minority cultures, and students with special education needs. Following the inclusive education principles of the national policy (César and Santos, 2006), the educational system adopted the ideal of "Schools for all" (César, 2003, p. 3; Turner, 2008, p. 2), integrating all children in one school type and following one curriculum (Vislie, 2003). In 2012, twelve years compulsory education was enacted. Before, 9th grade was the last grade for many children, even disregarding the high Portuguese rates of early school leavers (Portdata, 2014).

The textbook market continuously adapts its products to student diversity, supplying teachers with versatile didactic material, but also with textbooks offering partly simplified options, in order to fit heterogeneous classes. Despite the legislative directives to form diverse classes, Portuguese schools have autonomy for homogenizing classes, for promoting educational success, and for combating student dropout (ME, 2007).

In 2001, Portugal reformed the lower secondary curricula, and upper secondary curricula in 2004. The reform integrated STSE issues into both natural sciences (9th grade) and biology (12th grade) syllabi. Implemented within the theme *To live better on the Earth*, 9th grade guidelines repeatedly refer to "*contributing to the development of students' scientific literacy"* (Galvão et al., 2001, p4). They suggest a multidisciplinary approach, relating contents to students' daily lives; and they extensively recommend STSE relationships through exploration of both events in the history of science, and analysis of contemporary controversial issues as presented by the media. The 12th grade guidelines (Mendes, Rebelo, and Pinheiro, 2004) address students' citizenship as well as the acquisition of basic biological knowledge and scientific skills. They also emphasize the role of substantive knowledge in individual decision-making, the importance of understanding science as a human endeavor, dependent on the context in which it develops, and the mutual influence of biology/biotechnology and society, including ethical dimensions. The guidelines suggest "exploring explicit and reciprocal relationships between Science, Technology and Society" (Mendes Rebelo and Pinheiro, 2004, p. 9), including the component *environment* with references to environmental risks. Concepts of gene technology in particular are presented in a problem solving context, starting from the identification of social problems, through the contents, to possible solutions. Nonetheless, [the remainder of the sentence seems incomplete. It certainly makes little sense:]limitations of S&T are scarcely referred while approaching genetics issues.

2.3. Characterization of the Textbooks Sample

We selected four Portuguese textbooks (student versions), two each for the 9th and 12th grades, as the textbooks most adopted in the school year 2013/2014 (data provided by DGE[1]) for our subjects and school grades. They represent two publishers. Pair One: 9th grade natural sciences textbook P9-1 (Antunes, Bispo and Guindeira, 2014) and 12th grade biology textbook(P12-1 (Matias and Martins, 2009); Pair Two: 9th grade natural sciences textbook P9-2 (Motta and Viana, 2014) and 12th grade biology textbook P12-2 (Silva et al, 2006).

Both 9th grade textbooks allocate genetics issues to two chapters. P9-1: *Fundamentals of Heredity* (17 pp.) include the contributions of genetic engineering towards the solution of contemporary problems; *Science and Technology in the Resolution of Individual and Social Health Problems* integrates previous genetics contents with non-genetic contents. P9-2: *Fundamentals of Heredity* (20 pp.) and *Science and Technology in the Resolution of Individual and Social Health Problems- Assessment and Management of Risks* (4 pp.). Our 12th grade textbooks differ in the number of chapters. P12-1: *Genetic Patrimony* (67 pp.), *Changes in Genetic Material* (38 pp.) including *Fundamentals of Genetic Engineering,* and *Food Production and Sustainability* (28 pp.)

including genetics in sub-chapter *Exploration of the Potential of Biosphere*. In the latter, specific sections refer to STSE relationships. P12-2: *Genetic Patrimony* (84 pp.) comprises the sub-chapters *Genetic Heritage* and *Changes in Genetic Material*, the latter including *Fundamentals of Genetic Engineering;* and *Food Production and Sustainability* (104 pp.)including the sub-chapters *Food Obtained by Genetic Manipulation*, *Genetic Engineering and Plants Improvement*, *Genetic Engineering and Animal Breeding* and *Genetic Control*.

2.4. Qualitative Analysis

We based our study on Product Oriented Research (Cabral, 2005). Textbooks present interpretations beyond their content. Extracting their meaning and assumptions requires qualitatively deductive content analysis (Elo and Kyngäs, 2008; Pingel, 2010). We applied such an analysis using our previously proposed methods (Authors, 2015): we analyzed STES statements by identifying the co-variation between text and context (Knain, 2001). We recorded all the statements matching our set of criteria and sub-criteria (Authors, 2015). As recommended (Pingel, 2010), we combined the content analysis with a quantitative frequency analysis in order to identify deficits in the treatment of STSE issues,and to detect indicators of DSNVST (for details and representative examples, see Table 1). We randomly selected 12% of the textbook statements (127 of 1019 statements) for a second intra-rater and inter-rater categorization. We computed Cohen's Kappa coefficient (Cohen, 1968) and obtained Kappa values of 0.94 (intra-rater reliability) and of 0.77 (inter-rater reliability). The first is regarded as "almost perfect", the second as "substantial" (Landis and Koch, 1977, p. 165).

2.5. Quantitative Analysis

We valuated all statements equally and examined contingencies between criterion frequencies by computing Pearson's adjusted contingency coefficient *C* (Pearson, 1904). Due to multiple testing, we decreased the alpha level to .005 and treated only contingencies of $C > .200$ as relevant. To avoid bias, we compared the ratio between statement frequencies and number of pages. Both the 9th grade books and 12th grade books did not differ pair-wise (P 9-1 and 9-2: Chi square 0.594; $df = 2$; $p = .640$; P 12-1 and 12-2 Chi square 0.297; $df = 2$; $p = .140$; ratio (statements/page number): P9-1 148/33 = 4.5; P9-2 131/22 = 6.0; P12-1 346/102 = 3.4; P12-2 387/124 = 3.1.

Table I - Definitions, textbook examples and textbook frequencies of all criteria and sub-criteria (sub-criteria headed by the criterion, keywords in textbook statements in *italics*)

Sub-criterion	***Definition***	***Textbook example***	***Textbook Frequencies***			
			P9-1	*P9-2*	*P12-1*	*P12-2*
	S&T (S&T) events and their social contextualization		*49*	*36*	*166*	*126*
	Mentioning and/or suggestion of					
Event per se	*… a scientific or a technological event*	*Watson and Crick presented the tridimensional DNA model (P9-1, p. 78).*	*20*	*12*	*68*	*55*
Event time	*… the time the event took place*	*At the end of the 20th century (P9-1, p. 206)*	*18*	*11*	*63*	*43*
Event place	*… the place the event occurred*	*An English crystallographer (P9-2, p. 66)*	*4*	*7*	*7*	*7*
Underlying problem	*… the social problem that motivated research regarding the event*	*… infertility problems, hereditary diseases (P9-2, p. 76)*	*7*	*6*	*21*	*13*
Favorable factors	*… factors favorable for the event*	*This disease is … well known since it has affected … European royal families (P12-1, p. 111)*	*0*	*0*	*5*	*3*
Obstacles	*… factors representing obstacles*	*Human genetic research faced great difficulties for several years (P12-2, p. 103)*	*0*	*0*	*2*	*5*
	Interplay between S&T		*10*	*11*	*16*	*17*
Distinction	*S&T are distinguished.*	*… genetic engineering, whose aim is the direct manipulation of genes with a practical goal (P12-1, p. 167)*	*6*	*8*	*7*	*6*

T towards S	*A T device or process is useful for achieving S knowledge.*	*In recent years, techniques of molecular genetics have triggered a veritable explosion of knowledge (P12-2, p. 103)*	*1*	*1*	*6*	*3*
S towards T	*S knowledge is useful or even indispensable for T advancements.*	*The success of biotechnology is certainly not irrelevant to the advancement of scientific areas (P12-1, p. 226p)*	*2*	*1*	*3*	*5*
S & applied S	*T is seen as applied S*	*… to the citizens, whom the products of science target (P12-2, p. 56)*	*1*	*1*	*0*	*3*
	S&T as means to solve societal problems		*41*	*22*	*96*	*109*
	Mentioning and/or suggestion of					
Potential applicability	*… potential applicability of S&T in the future*	*While some scientists ensure that the future of human nutrition is in scientists' hands, other … (P9-2, p. 183)*	*7*	*3*	*19*	*38*
Applicability	*… real benefits of S&T processes or devices*	*A Portuguese scientist team developed a pioneer technique … for application in ... (P9-1, p. 86)*	*27*	*13*	*66*	*63*
Costs	*… costs of S&T processes or devices*	*… managed to reduce production costs (P12-1, p. 169)*	*2*	*2*	*2*	*2*
Limitations	*… limitations of S and/or T*	*It is possible within certain limits to improve agricultural production (P12- 2, p. 316)*	*5*	*4*	*9*	*6*
	Risks and impacts of S&T		*22*	*26*	*25*	*60*
	Mentioning and/or suggestion of					
Risks	*… risks of S&T*	*Currently the long-term effects of this practice are still unknown (P9-1, p. 215)*	*11*	*17*	*19*	*29*
Social impact	*… an potential and/or real S&T impact on society*	*Society must be attentive ... and denounce any attempt to put human health at risk... (P9-2, p. 77)*	*7*	*5*	*4*	*20*

Local environmental impact	*… a local potential and/or real S&T environmental impact*	*... others consider [Bt corn], a threat to the ecological balance, compromising the entomofauna (P12-2, p. 298)*	*3*	*0*	*0*	*3*
Global environmental impact	*… a global potential and/or real S&T environmental impact*	*The extent to which GMOs ... can affect the balance of ecosystems? (P12-1, p. 46)*	*1*	*4*	*2*	*8*
	Controversial issues		*22*	*26*	*15*	*40*
	Mentioning and/or suggestion of controversial issues					
Different perspectives	*… given with different perspectives*	*The utilization of embryos for the extraction of stem cells is very controversial (P9-1, p. 86)*	*16*	*10*	*5*	*16*
Conflict values	*… by referring to values interfering with decisions*	*Is it right to modify or create new living beings? (P9-2, p. 77)*	*5*	*10*	*5*	*19*
Involved interests	*… given with potentially involved interests (e.g., social, individual, political and/or economic ones).*	*For doctors, ... means better prevention, … will dominate the debate between environmentalists and the interests of industry … (P12-2, p. 298)*	*1*	*1*	*3*	*4*
Different sources of information	*… presented with different information sources conveyed by media*	*Excerpt from the magazine Visão, 15th January 2009 (P12-1, p. 69)*	*0*	*5*	*2*	*1*
	Decision making process		*12*	*10*	*27*	*35*
	Mentioning and/or suggestion of					
Legislation	*… legislation processes and/or results*	*The establishment of norms and rules that ensure the continuity of research is required … (P9-1, p. 89)*	*7*	*1*	*16*	*9*
International comparison	*… decisions by comparing international realities concerning legislation*	*The Food and Drug Administration ... commissioned the National Academy of Sciences to conduct a survey (P9-2, p. 80)*	*1*	*0*	*4*	*7*

Agents	*… the agents involved in decision making*	*National Ethic Council (P12-1, p. 121)*	*3*	*3*	*2*	*3*
Citizen participation	*… the citizens as participants in decisions (e.g., as consumers, as voters, as informed human beings)*	*As citizens ..., we cannot remain mere spectators) (P12-2, p. 56)*	*1*	*6*	*5*	*16*

3. Results

We identified 1019 STSE statements in all four textbooks (for examples, see Table I). They complied with all the six criteria and at least 26 sub-criteria in each textbook (see Table I).

9th grade textbooks did not differ at the level of either the criteria or the sub-criteria (*C* values with $p \geq .074$). Regarding the criterion *S&T events,* both textbooks lacked the sub-criteria *favorable factors* and *obstacles* (Table 1). With respect to the criterion *risks and impacts of S&T,* P9-2 lacked the sub-criterion *local environmental impact*. Regarding criterion controversial issues, P 9-1 lacked *different sources of information*. Finally, P9-2 lacked the sub-criterion *international comparisons* in *decision making processes*.

12th grade textbooks differed at the level of the criteria and of the sub-criteria ($C = .248$ and $C = .328$; in both cases: $p < .001$, $n = 732$), revealing two different statement patterns. For criterion *S&T events and their social contextualization*, P12-1 showed a higher statement frequency than randomly to be expected (166 observed [o.] vs. 138 randomly to be expected [e.] statements), in comparison to P12-2 showing a lower frequency (126 o. vs. 154 e.); especially in the sub-criterion *event time* (P 12-1: 63 o. vs. 50 e.; P 12-2: 43 o. vs. 56 e.). In contrast, P12-2 provided more statements in the criterion *risks and impacts of S&T* (P 12-1: 25 o. vs. 40 e.; P 12-2: 60 o. vs. 45 e.). In particular, P 12-2 provided more statements related to *social impacts* (P 12-1: 4 o. vs. 11 e.; P 12-2: 20 o. vs. 13 e.) and to *environmental impacts* (P 12-1: 2 o. vs. 6 e.; P 12-2: 11 o. vs. 7 e.). Similarly, P 12-2 scored higher with respect to the criterion *controversial issues* (P 12-1: 15 o. vs. 26 e.; P 12-2: 40 o. vs. 29 e.). Especially P 12-2 out-performed P 12-1 in the sub-criteria *different perspectives* (P 12-1: 5 o. vs. 10 e.; P 12-2: 16 o. vs. 11 e.) and *conflicting values* (P 12-1: 5 o. vs. 11 e.; P 12-2: 19 o. vs. 13 e.). In the criterion *decision making process*, P 12-2 stood out in the sub-criterion *citizen participation* (P 12-1: 5 o. vs. 10 e.; P 12-2: 16 o. vs. 11 e.). Regarding the DSNVST, P12-1 made no reference to the distorted idea *technology as applied science*, contrasting to P 12-1 that offered three indicators of this incorrect idea.

We generally found about two and a half times as many statements within the 12th grade books compared to the 9th grade books (P 9: $n = 287$; P 12: $n = 732$). When relating these differences to the given page numbers (see above), both book pairs also differed ($\chi^2 = 8.387$; $df = 2$; $p = .01$). Analyzing the ratios *statements/number of pages* between the four textbooks (P9-1 4.5; P9-2 6.0; P12-1 3.4; P12-2 3.1; for details, see above) showed higher ratios for the 9th grade books.

9th and 12th grade textbooks differed both at the level of the criteria and of the sub-criteria ($C = .220$ and $C = .301$; in both cases: $p < .001$, $N = 1019$), showing different statement patterns. Regarding the criteria *S&T events and their social contextualization* and *S&T as means to solve societal problems*, P12 textbooks contained more statements (292 o. vs. 271 e. and 205 o. vs. 193 e.), in contrast to P9, whose texts contained fewer statements (85 o. vs. 106 e. and 63 o. vs. 76 e.). P12 textbooks outperformed P 9 textbooks in the sub-criteria *events per se* (123 o. vs. 111 e. and 32 o. vs. 44 e.) and *favorable factors*, neither of which were mentioned in theP9 books. On the other hand, P9 textbooks contained more statements regarding the criterion *controversial issues* (48 o. vs. 29 e.), compared to P12 textbooks with slightly more statements, but fewer statements than randomly be expected (55 o. vs. 74 e.). In particular, we found this in the sub-criterion *different perspectives* (P 9: 26 o. vs. 13 e.; P 12: 21 o. vs. 34 e.). Regarding the DSNVST, P 9 and p12 texts contain only few statements referring to the distorted idea *technology as applied science* (in total, 2 vs. 3 statements).

4. Conclusions

We first discuss STSE approach in textbooks according to their criteria and sub-criteria frequency profiles. Second, we discuss the detected indicators of DSNVS. Third, we look for relationships of our findings in the Portuguese context, both in terms of educational system, and of socio-cultural context. Finally, we consider implications for students' SL.

4.1. Comparison of textbooks

Despite stemming from the same nation and, therefore, being subject to the same official guidelines, the textbooks analyzed revealed somewhat different profiles, but also some similarities. We discuss the main differences and/or similarities vertically between P9 and P12 as well as horizontally between P9-1/-2 and P12-1/-2 ; the first to draw inferences about the differential investment in students' SL in the middle school and in the high school.

4.1.1. Approach to STSE

Regarding the vertical comparison, we identified two remarkable results. Quantitatively, the 12th grade textbooks provided about two and a half times more statements concerning STSE issues than the 9th grade textbooks. That might derive from the decision to treat more superficially both substantive knowledge (genetics) and technological aspects (gene-technology) in the earlier grade, while deepening them in the later one. However, the comparison of the ratios *statements/number of pages* between the different grades suggests that P9 books, in comparison with P12 ones, privileged frequency rather than depth (see below). Qualitatively, examination of statements confirmed that 9th grade textbooks very often provided superficial references instead of detailed reasoning (e.g., regarding transgenic plants; P9-2, p. 183; P12-2, p. 296-298); that is, we found a superficial STSE approach in P9 books, in dissonance with Portuguese 9th grade guidelines.

Turning to the horizontal comparisons, the quantitative analysis showed that 9th grade textbooks yielded similar profiles, while the 12th grade ones displayed two different patterns. This variability might be caused by adding or omitting fundamental information when discussing complex issues.

Subsequently, we discuss compliance with our criteria and sub-criteria in detail. Considering *S&T events and their social contextualization*, P12 books quantitatively out-performed P9 ones, especially in regard to *event per se* and *favorable factors*. However, all the textbooks mostly referred to *events per se* and the *event times* as the mode of social contextualization. The *underlying problem* (that motivated research)was approached by the textbooks in less than a half of the *events per se* (see Table 1). That is, most events were not presented as having been motivated by a social problem. Focusing on scientific and technological achievements without describing the processes that underlie them may lead to the simplistic view that scientific and/or technological problems have been overcome without difficulties (Gardner, 1990). We therefore argue for our sub-criteria *obstacles* (as social constraints) and *favourable factors* as indicators that scientific advancements did not occur by chance, but have been influenced by the socio-scientific situation (Authors, 2015). Factors positively or negatively influencing events were poorly approached by P12 books and completely disregarded by P9 ones. However, we found attempts to connect S&T events to their social milieu.

We considered both historical and contemporary events, though without distinguishing them. Nevertheless, despite the presentation of the historical development of concepts, none of the textbooks provided an adequate contextualization of S&T events. Our results confirm that the history of science as presented does not display an adequate picture of science (Leite, 2002). We previously found a similar pattern in German biology textbooks (Authors, 2015).

We considered *costs* as economic constraints and *limitations* as technical constraints of S&T that have to be surmounted (Authors, 2015). Here, all the textbooks scored quite modestly, when compared with the emphasis given to the positive aspects, such as *potential* and the current *applicability* of products. However, awareness of the benefits of those enterprises, of their constraints, and of their potentially negative implications is required for critically analyzing controversial issues and for objectively judging related economic interests and political decisions (Authors, 2013).

When comparing textbooks vertically, P12 books provided a wider contextualization of events, particularly in terms of the social problems underlying research. The relative relevance they gave to the inputs of society into S&T seems to rest on the curricular option of approaching socio-scientific issues in the context of *Food production and sustainability*, where S&T advancements are explicitly approached as solutions for social problems. P12 textbooks therefore reflect the orientations of Portuguese science education policy enacted during the last decade.

In respect *risks* and *impacts*, all the textbooks approached *risks frequently*, while references to *social impacts* and to *environmental impacts* are seldom, with the exception of P12-2, which provided nearly half of all such statements and more than half of all *social impact* statements (Table 1). .P12-2 especially used the term (social) "impact", and reinforced its meaning using dramatic and emotion-laden expressions; for instance, "Today the markets are invaded by transgenic [organisms]" (p. 141). All the books failed to adequately refer to the environmental dimension, with P9-2 and P12-1 completely neglecting the *local environment*, (Table 1). P12-2, discussed the potential disruption of ecological balance from a biocentric perspective, without connecting threats to human health. That is, potential environmental impacts of gene technology are worthy of improvement. This tendency was also found in other studies (Aivelo and Uitto, 2015; Clément and Castéra, 2013) as "in many cases they don't take environmental effects into consideration" (Kohring and Matthes, 2002, p. 148). A case study approach to"experimental releases of genetically modified (GM) insects" (Reeves, Denton, Santucci, Bryk, and Reed, 2012; p. 1) or transgenic plants resistant to pesticides (Authors, 2015) is recommended in order to awaken awareness about environmental impacts of GM organisms.

Regarding *controversial issues*, we again observed great variability both at the level of the criterion and of its sub-criteria. P9 books and P12-2 gave high prominence to *different perspectives* while judging socio-scientific issues, as well as to *conflicting values* involved. However, *involved interests* were seldom mentioned in P9 and only touched upon in P12 books; the confrontation with *different sources of information* was absent in P9-1, rare in P12 books, and considerable in P9-2 (with 5 records; Table 1). Qualitatively, we found that Portuguese textbooks explicitly referred to the importance of values in judging genetics issues, what seems to result from an attempt to comply with guidelines, but scarcely connected them with values. . However, the controversial character of STSE issues might have been emphasized by textbooks through providing *different sources of information*, thus conveying different points of view. Textbook P9-2, though scoring higher, mostly referred to simple titles of newspaper articles as a starting point for discussion, but lacked potential excerpts of documents illustrating diverse perspectives, interests, and values (e.g., Authors, 2015).

Regarding the criterion *decision-making process,* there is no clear tendency, despite the descriptive differences displayed at the level of the sub-criteria. P12-2 stood out in referring to or suggesting *citizen participation,* while P9-2 lacked *international comparisons* of decision making processes. Both P12 textbooks showed better compliance with this criterion than P9, particularly P12-2 with the sub-criterion *citizen participation*. However, P12-1 qualitatively outlined better the genetics issues in legislation terms, with references to American, European and Portuguese realities. Following the syllabus, P12-1 provided three references to "bio-ethics councils" (e.g. p. 121), but no reference dealt with local reality, remaining therefore abstract to students. All the textbooks scored low regarding *agents* involved in the decision making process, which appears to reflect the lack of Portuguese regulation as well as the unfamiliarity of the Portuguese public with decision making in these domains. Similarly, references to *citizen participation* were rare, with the exception of P12-2. No textbook presented a balanced picture of the regulation of scientific and technological activities in the context of genetic issues.

In summary, all four textbooks revealed similarities regarding references to *events* and information, but 12th grade textbooks complied better with the criteria than 9th grade ones and provided a more complete image of S&T. P9 books disregarded some aspects, like social factors and individual interests, that might have influenced events, while P12 books focused on them. Nonetheless, all the textbooks, though following some of the guidelines, do not follow the corresponding holistic pedagogical principles.

In our qualitative analysis of syllabi and guidelines, we limited our scope to approaching STSE issues in the context of genetics. However, other authors (Calado, Neves, and Morais, 2013) have analyzed the broad guidelines to the middle school, corresponding to the 7th, 8th and 9th school grades (Galvão et al., 2001). On the one hand, they found a relatively high level of conceptual demands (in terms of the complexity of cognitive skills, of scientific knowledge and of inter-disciplinary relations between distinct subjects within biology). On the other hand, they argued that this level has decreased when transposed into the guidelines for teachers and textbooks writers. Moreover, this tendency towards a decreasing level of conceptual demand is even more evident in the re-contextualization in textbooks. In our view, superficial approaches might lack the empirical evidence required for discussing the impact of S&T achievements on society and the environment, representing therefore a limitation for adequately approaching STSE issues. A reductionist representation of phenomena, besides representing a limitation itself, might lack the prerequisites for introducing the context, in which S&T achievements developed.

Our analysis revealed a visible discrepancy between the textbooks' profile and some critical aspects expressed in both syllabi. We suggest that other factors might have intervened in the didactic transposition into textbooks. That might result from an attempt of publishers to address teachers' anticipations (as they are the textbook users) while providing them with learning materials adaptable to their didactical needs, preferences, and constraints. Indeed, some teachers showed that they experience reluctance or difficulty in approaching controversial issues (Chikoko, Gilmour, Harber, and Serf, 2011; Dawson and Venville, 2010); thus, confirming the often claimed urgency in preparing them for performing this task. However, the simplification of contents as observed (Calado, Neves, and Morais, 2013) requires further interpretations. We suggest a strategy to target weaker students or to fit homogenized weaker classes as a way to adapt to inclusion principles. We see this in the fact that 9th grade students did not reach an introductory stage; that is, they are not prepared for university education. In our sample, the abrupt transition from the 9th grade to 12th grade textbooks in terms of page numbers supports such explanations. Similarly, the different depth of approaching STSE issues made clear that final compulsory school grades and final secondary school grades set diverging goals and deal with different student profiles. One might consider the lacks of STSE contents justifiable, since 9th grade students are considered still immature for understanding ethical and epistemological considerations.

4.1.2.2 Indicators of DSNVST

The absence or frequency of certain ideas might help to recognize indicators of DSNVST in a textbook (Gil-Pérez et al., 2005; Authors, 2015). For potentially detecting the incorrect idea *T is seen as applied science*, we considered the criterion *interplay between S&T.* Concerning the sub-criterion *distinction*, all the textbooks more or less explicitly tended to distinguish S&T. However, we found some doubtful statements, mainly in P9-2, for instance, “Science and technology have been able to manipulate genes of living beings”(p. 74). The P12 textbooks showed increased accuracy, for instance, in P12-2, “Biotechnology is an interdisciplinary area, where knowledge and practices coming from several subjects … encounter each other” (p. 199). Especially, we found the DSNVST indicator *T as applied science* in three textbooks, except for P12-1. This absence is consistent with the explicit distinction of both entities interacting with each other “Biotechnology ... can be considered as resulting from the re-union between engineering and life sciences” (p. 226). Despite considering both entities distinctly, rare statements of this DSNVST indicator persist and the mutual support of S&T is under-represented, particularly in P9 textbooks (see Table 1). P12 books adequately contextualized events (see above), P9 books insufficiently; this is one more indicator of DSNVST.

Considering the sub-criteria *potential applicability* and current *applicability* together, we verified that P12 books, placed the emphasis in positive aspects of *S&T as means to solve problems*, in detriment of the negative ones, perhaps based on the explicit emphasis given to this aspect in the syllabus. Specifically, P12-2 contains enthusiastic messages, such as “It seems not to have limits” (p. 132), “Has the genius come out of the lamp?” (p. 132), “sophisticated and amazing techniques” (p. 132), as well as expressions such as “to stop the hunger in the world” (appearing three times; pp. 225, 270 and 300). Together, the emphasis placed in S&T products and the high enthusiasm indicate the presence of DSNVST, probably a reflex of the current industrial stage of Portugal , where positive attitudes towards S&T are dominant and controversies lacking (Inglehart, 1990). This emotional approach might also result from an attempt to trigger emotions, in order to increase motivation (Spitzer, 2007). On the other hand, it seems to mimic the Portuguese sensationalist media discourse, which frequently uses metaphors (Reis and Galvão, 2004), in order to convey (either positively or negatively) powerful messages (Liakopoulos, 2002). Consonant with that enthusiasm, all the textbooks practically disregard the constraints associated with S&T, such as costs of research, of development, and of production, as well as the limitations of S&T, thus once again re-inforcing DSNVST.

As referred to above, all the textbooks stressed risks inherent in using genetic information or applying gene technology. Both P9 books and P12-1 explicitly or implicitly considered the importance of *risks*, but often without providing empirical evidence or referring to the domain of impact; that is, messages remained incomplete. Risks for human health were dominant, but the books provided few links to empirical evidence of social and environmental impacts. Consequently, we recognized a tendency to a socially neutral approach of *risks* and *impacts*, and therefore to DSNVST. Perhaps for the same reasons, the books exclude the opposite view that blames S&T for environmental degradation. Regarding *controversial issues*, P12-1 almost failed to present the human dimension of S&T, pointing out once more its socially neutral approach.

The criterion *decision-making process* provided some variation. The sparse clarification of *agents of decision*, displayed by all textbooks, as well as disregarding *citizens' participation* as their right and duty, displayed by P9 books and P12-1, might implicitly indicate that scientists alone are responsible for the negative implications of S&T, representing also an indicator of DSNVST.

In summary, although introducing the social component, all the textbooks provided a quite incomplete picture in terms of both inputs and outputs of S&T and, therefore, tended to the naive DNSVST. On the other hand, the lack of environmental impact derived from the opposite view of DSNVST. Even P12-2, which scored comparatively high in referring to environmental impact, discharged scientists and technologists to a certain extent from the responsibility of alone deciding socio-scientific issues, while discussing *legislation*, *agents of decision*, and emphasizing *citizen participation*. Results of qualitative analysis of statements referring to environmental impact also excluded the distorted opposite view of DSNVST in P12-2. P9 textbooks in particular presented several indicators of DSNVST, since some social aspects of science were hardly approached and significant ideas were lacking. The simplification of contents referred to above might confirm this assumption, perhaps resulting from the dominance of market dynamics over syllabus. P12 books were much centered on the S&T products and revealed both high expectations, and great enthusiasm towards them. Despite a trace of the DSNVST, P12-2 made an attempt to show the relationship of S&T with the social sphere and the environment. In contrast, P12-1 displayed a different profile, while contextualizing fairly the inputs of society into science and portraying the interplay between S&T in a balanced way, lacking however, or approaching insufficiently, important aspects related to the outputs of science in society and in the environment.

4.1.3. Views of S&T and socio-cultural context

Within P9 textbooks, we found no the reflection of positive attitudes towards S&T, which correlate with public knowledge about science in a country at an industrial stage (Inglehart, 1990). The ratio between positive aspects (*potential applicability* and *applicability*) and negative ones (*risks* and *impacts*) is quite balanced. Indeed, our results seem to reflect more distrust in respect of science (and technology; see Prpić, 2011) than indifference (see Gaskell et al., 2006). Positive attitudes seem to be mirrored in P12-1, where they clearly outnumber the negative ones. In this respect, P12-2 revealed high enthusiasm and expectations towards the achievements of S&T, though having fairly observed the negative aspects in quantitative terms.

Regarding *controversial issues*, P12-1, interestingly, referred explicitly to the "ethic and religious implications [of genetic issues]" (p. 177), "the phantom of eugenics" (p. 69) and the suspicion about eventual "eugenic and discriminatory policies" (p. 177) among the five references alluding to values. Nonetheless, P12-1 lacked concrete and contextualized examples, pointing to a superficial and sensationalist exploration of controversies, devoid of local context. We perceived an attempt to follow the guidelines, mainly by referring explicitly to ethical considerations, but barely presenting cases where such considerations should be applied. Assuming that enthusiastic or sensationalistic messages have the purpose of raising students' interest for S&T, they might reveal commitment to the economical argument for SL, justified by a society struggling for scientific and technological development. The re-incidence of these emotional and explicit statements, lacking evidential support, seems to mirror public inexperience in genetics and in gene-technology as well as in legislation of genetics issues. Similarly, the timid references to *different sources of information* might reflect the unfamiliarity with controversies in these domains as well as with media" specialized in genetic issues. Therefore, assuming that textbooks to some extent reflect the predominant public views, our results suggest the prevalence of a naive perception of S&T of the Portuguese public.

The co-existence of ideas that can be argued as DSNVST indicators and of ideas indicating non-DSNVST views might be explained as follows: First, STSE issues might have been acquired from different sources (e.g., literature) to textbooks; second, some confusion concerning the recent incorporation of the concept SL and its components (e.g., NOS) in educational systems; and third, inconsistency of the teachers' education programs, as textbook writers are frequently teachers.

4.2. Implications for students' SL and recommendations

First, STSE approach in Portuguese 9th grade requires particular consideration. The ninth grade provides a first contact with genetic issues. One may assume that students exposed to learning materials would have the chance of filling remaining gaps and of reconstructing persistent alternative conceptions in the 12th grade. However, the observed gaps in our textbooks are a matter of concern, since at the time of their publication, the 9th grade was the final year of compulsory education. For many students, who dropped out at the end of the middle school, it was the last chance to acquire the knowledge and engage in this kind of reasoning in an academic context. Therefore, if the inclusive system pursues the ideal of

"Schools for all" (César, 2003), aligned with the goals of a civic SL (Miller, 1998), that simplification "contributes to increasing the gap between students with different socio-economic backgrounds" (Calado, Neves and Morais, 2013; p. 20). That is, it moves away from the goal of science for all, and endangers the public's SL.

Second, regarding STSE content, textbook writers may overcome these hindrances by judiciously selecting events in view of their potential for representing the interactions between S&T and between S&T and society and environment. Textbook content and language should elucidate how a certain final concept or product has been achieved, both from the internal (scientific community) and from the external (society and environment) perspectives of the scientific and technological enterprises (Leach, Millar, Ryder and Séré, 2000; Rudolph, 2003). Simple disconnected details should be replaced by complete, structured and diverse case studies, thus providing a more realistic development. A classic example is the Human Genome Project as it provides an overview of those interactions (Authors, 2015). Additionally, links to environmental (local and global) concerns should be considered. Being scientifically literate requires awareness of the global implications of genetics and gene technology events, based on textbook approaches being suitable for the target population.

Third, introduction of STSE issues, despite following an international trend, still represents a challenge to both curriculum developers and teachers (Morris, 2014). The addition of STSE material into textbooks and in science lessons must be accompanied by the awareness that textbook writers' and teachers' views of S&T might influence students' views (Authors, 2015). Moreover, the awareness that one's S&T views have likely been influenced by one's socio-cultural milieu may increase the probability of detection of incorrect views and their replacement by correct views of those human enterprises.

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[1] Direção-Geral da Educação (DGE) [General Direction of Education], Portuguese Ministry of Education

Bibliographic references

Ainscow, M., César, M. (2006). Inclusive education ten years after Salamanca: Setting the agenda. *European Journal of Psychology of Education*, *21*(3), 231-238.

Abd-El-Khalick, F.,Lederman, N. G. (2000). Improving science teachers' conceptions of nature of science: a critical review of the literature. *International Journal of Science Education*, *22*(7), 665–701.

Aguirre, J. M., Haggerty, S. M.,Linder,J., C. (1990). Student-Teachers' Conceptions of Science, Teaching and Learning: a Case Study in Preservice Science Education. *International Journal of Science Education*, *12*(4), 381–390.

Aikenhead, G. S. (1996). Science Education: Border Crossing into the Subculture of Science. *Studies in Science Education*, *27*(1), 1–52.

Aikenhead, G. S. (2006). *Science Education for Everyday Life: Evidence-based Practice*. New York, NY: Teachers College Press.

Aikenhead, G. S. (2007). Humanistic perspectives in the science curriculum. In S. K. Abell, N. G. Lederman (Eds.), *Handbook of Research on Science Education* (pp. 881-910). Mahwah, N J: Lawrence Erlbaum Associates, Publishers.

Aivelo, T.,Uitto, A. (2015). Genetic determinism in the Finnish upper secondary school biology textbooks. *Nordic Studies in Science Education*, *11*(2), 139-152.

Allum, N., Sturgis, P., Tabourazi, D.,Brunton-smith, I. (2008). Science knowledge and attitudes across cultures. *Public Understanding of Science*, *17*(1), 35–54.

Antunes, C., Bispo, M, Guindeira, P. (2014). *Novo Descobrir a Terra 9*. Porto: Areal Editores.

Ávila, P., Gravito, A. P., Vala, J. (2000), Cultura científica e crenças sobre ciência [Scientific culture and believes about science]. In M. E. Gonçalves (org.), *Cultura Científica e Participação Pública* [Scientific culture and public participation] (pp. 19-31), Oeiras: Celta Editora.

Bauer, M.W.Gaskell, G. (2002). Researching the public sphere of biotechnology. In M. Bauer,G. Gaskell,(Eds.), *Biotechnology -The Making of A Global Controversy* (pp. 1–17). Cambridge, UK: Cambridge University Press.

Bencze, L.,Carter, L. (2011). Globalizing students acting for the common good. *Journal of Research in Science Teaching*, *48*(6), 648–669.

Cabral, M. (2005). *Como Analisar Manuais Escolares* [How to Analyse Textbooks]. Lisboa: Texto Editores.

Calado, S., Neves, I. P.,Morais, A. M. (2013). Conceptual demand of science curricula: a study at the middle school level. *Pedagogies: An International Journal*, *8*(3), 255–277.

Candeias, A. (1993). Políticas educativas contemporâneas: Críticas e alternativas. [Contemporary educational policy: criticism and alternatives] Faculdade de Psicologia e Ciências da Educação, Universidade do Porto. Retrieved from http://repositorio.ispa.pt/handle/10400.12/1619

Carter, L. (2007). Sociocultural influences on science education: Innovation for contemporary times. *Science Education*, *92*(1), 165–181.

Castéra, J., Sarapuu, T.,Clément, P. (2013). Comparison of French and Estonian students' conceptions in genetic determinism of human behaviours. *Journal of Biological Education*, *47*(1), 12–20.

César, M.,Santos, N. (2006). From exclusion to inclusion: Collaborative work contributions to more inclusive learning settings. *European Journal of Psychology of Education*, *21*(3), 333–346.

César, M. (2003). A escola inclusiva enquanto espaço-tempo de diálogo de todos e para todos [Inclusive schooling as a dialogical space-and-time of all and for all]. In D. Rodrigues (Ed.), *Perspectivas sobre a inclusão: Da educação à sociedade* (pp. 119-151). Lisboa: Porto Editora.

Chikoko, V., Gilmour, J. D., Harber, C.,Serf, J. (2011). Teaching controversial issues and teacher education in England and South Africa. *Journal of Education for Teaching*, *37*(2), 5-19.

Christidou, V. (2011). Interest, attitudes and images related to science: Combining students' voices with the voices of school science, teachers, and popular science. *International Journal of Environmental Science Education*, *6*(2), 141–159.

Clément, P., Castéra, J. (2013). Multiple Representations of Human Genetics in Biology Textbooks. In D. Treagust, C. Tsui (Eds.), *Models and Modeling in Science Education*, vol. 7, (pp. 147-163). Springer Netherlands.

Cohen, J. (n.d.). Weighted kappa: Nominal scale agreement provision for scaled disagreement or partial credit.

Costa, A. F., Ávila, P. D., & Mateus, S. (2002). *Públicos da ciência em Portugal* [Publics of science in Portugal]. Lisboa: Gradiva.

Dawson, V. M.,Venville, G. (2010). Teaching Strategies for Developing Students' Argumentation Skills About Socio-scientific Issues in High School Genetics. *Research in Science Education*, *40*(2), 133–148.

Elo, S.,Kyngäs, H. (2008). The qualitative content analysis process. *Journal of Advanced Nursing*, *62*(1), 107–15.

Fernández, I., Gil, D.,Vilches, A.,Valdés, P., Cachapuz A., Praia, J.,Salinas, J. (2003). El olvido de la tecnología como refuerzo de las visiones deformadas de la ciencia [Disregard of technology as an endorsement of the distorted views of science]. *Revista Electrónica de Enseñanza de las Ciencias, 2(*3).

Ferreira, S.,Morais, A. M. (2013). The Nature of Science in Science Curricula: Methods and concepts of analysis. *International Journal of Science Education*, *35*(16), 1–22.

Fontes, M.,Novais, A. Q. (1998). The conditions for the development of a biotechnology industry in Portugal: The impact of country specific factors. *Technology Analysis & Strategic Management*, *10*(4), 497–509.

Galvão, C. , Neves, A,Freire,A. M., Lopes, A. M., Santos, M. C., Vilela, M. C., Oliveira, M. T., Pereira, M. (2001). Orientações curriculares para o 3º Ciclo do Ensino Básico: Ciências Físicas e Naturais [Curricular guidelines for the 3rd. circle of basic education]. Ministério da Educação

– Departamento da Educação Básica. Retrieved from http://www.dge.mec.pt/sites/default/files/ficheiros/eb_cfn_orient_curriculares_3c_0.pdf

Gardner, P. L. (1990). The technology-science relationship: Some curriculum implications. *Research in Science Education*, *20*(1), 124–133.

Gaskell, P.J. (1992). Authentic Science and School Science. *International Journal of Science Education*, *14*(3), 265–272.

Gaskell, G., Stares, S., Allansdottir, A., Allum, N., Corchero, C.,Jackson, J. (2006). *Europeans and biotechnology in 2005: patterns and trends: final report on Eurobarometer 64.3*. Retrieved from: https://ec.europa.eu/research/biosociety/pdf/eb_64_3_final_report_second_edition_july_06.pdf

Gericke, N. M., Hagberg, M., dos Santos, V. C., Joaquim, L. M.,El-Hani, C. N. (2014). Conceptual Variation or Incoherence? Textbook Discourse on Genes in Six Countries. *Science & Education*, *23*(2), 381-416.

Gil-Pérez, D., Vilches, A., Fernández, I., Cachapuz, A., Praia, J., Valdés, P.,Salinas, J. (2005). Technology as 'Applied Science'. *Science & Education*,*14*(3-5), 309-320.

Gonçalves, M. E.,Castro, P. (2009). Local is beautiful? Governing science-society relations in Europe. *Portugese Journal of Social Sciences*, *8*(2), 191–207.

Green, W.,Naidoo, D. (2008). Science Textbooks in the Context of Political Reform in South Africa: Implications for Access to Science. *Science Education International*, *19*(2), 235–250.

Harding, S. (1998). Multiculturalism, postcolonialism, feminism: Do they require new research epistemologies? *The Australian Educational Researcher*, *25*(1), 37–51.

Hodson, D (1998) Science fiction: The continuing misrepresentation of science in the science school curriculum. *Journal of Curriculum Studies*, *28*(2), 115–135.

Hollingsworth, S. (1989). Prior Beliefs and Cognitive Change in Learning to Teach. *American Educational Research Journal*, *26*(2), 160–189.

Höttecke, D.,Silva, C. C. (2011) Why Implementing History and Philosophy in School Science Education is a Challenge: An Analysis of Obstacles. *Science & Education*, *20*(3-4), 293–316.

Inglehart, R. (1990). *Culture shift in advanced industrial society*. Princeton University Press.

Jenkins, E. W. (1992). School science education: towards a reconstruction. *Journal of Curriculum Studies*, *24*(3), 229–246.

Kim, M.,Roth, W. M. (2008). Rethinking the ethics of scientific knowledge: A case study of teaching the environment in science classrooms. *Asia Pacific Education Review*, *9*(4), 516–528.

Knain, E. (2001). Ideologies in school science textbooks. *International Journal of Science Education*, *23*(3), 319–329.

Kohring, M.,Matthes, J. (2002). The face (t) s of biotech in the nineties: how the German press framed modern biotechnology. *Public understanding of Science*, *11*(2), 143-154.

Kolstø, S. D. (2001). Scientific literacy for citizenship: Tools for dealing with the science dimension of controversial socioscientific issues. *Science Education*, *85*(3), 291–310.

Kurzer, P.,Cooper, A. (2007). What's for dinner? European farming and food traditions confront American biotechnology. *Comparative Political Studies*, *40*(9), 1035-1058.

Lakin, S.,Wellington, J. (1994). Who will teach the "nature of science"?: teachers' views of science and their implications for science education. *International Journal of Science Education*, *16*(2), 175–190.

Lee, H., Yoo, J., Choi, K., Kim, S.-W., Krajcik, J., Herman, B. C., & Zeidler, D. L. (2013). Socioscientific Issues as a Vehicle for Promoting Character and Values for Global Citizens. *International Journal of Science Education*, *35*(12), 2079–2113.

Liakopoulos, M. (2002). Pandora's Box or panacea? Using metaphors to create the public representations of biotechnology. *Public Understanding of Science*, *11*(1), 5-32.

Matias, O., Martins, P. (2009). *Biologia 12* (Vol. 1 and Vol. 2). Porto: Areal Editores.

Millar, R. (2002). Towards a science curriculum for public understanding. In S. Amos & R. Boohan (Eds.). Teaching science in secondary schools, pp. 113-128. London: Routlege/Falmer and The Open University.

Motta, L., Viana, M. J. (2014) . *Bioterra 9 – Viver melhor na Terra*. Porto: Porto Editora.

Osborne, J. (2000). Science for citizenship. In M. Monk & J. Osborne (Eds.), Good practice in science teaching, pp. 225-240). Buckingham: Open University Press.

Pearson, K. (1904). On the theory of contingency and its relation to association and normal correlation. In *On the General Theory of Skew Correlation and Non-Linear Regression*. Cambridge, UK: Cambridge University Press.

Portdata (2014). Taxa de abandono precoce de educação e formação: total e por sexo [Premature education and training drop out rate].

Retrieved from http://www.pordata.pt/Portugal/Taxa+de+abandono+precoce+de+educa%C3%A7%C3%A3o+e+forma%C3%A7%C3%A3o+total+e+por+sexo-433

Reis & Galvao (2004) FALTA

Selmaoui, S., Agorram, B., Kzami, S., Razouki, A., Clément, P., & Caravita, S. (2012). Cultural and Socioeconomical Dimensions of Human Reproduction and Sex Education in the Biology Textbooks of Eight Countries. *Sociology Study ISSN*, *2*(12), 963–968.

Silva, A. D., Santos, M. E., Mesquita, A. F., Baldaia, L., Félix, J. M. (2006). *Terra, Universo de Vida – Biologia 12º ano*. Porto: Porto Editora.

Spitzer, M. (2002). Lernen. *Gehirnforschung und die Schule des Lebens. Heidelberg: Spektrum*.

Vislie, L. (2003). From integration to inclusion: focusing global trends and changes in the western European societies. *European journal of special needs education*, *18*(1), 17-35.

Weinstein, M. (1998). Playing the Paramecium: Science Education From the Stance of the Cultural Studies of Science. *Educational Policy*, *12*(5), 484–506.

IV - Science-Technology-Society-Environment Issues in German and Portuguese Biology Textbooks: Influenced by the Socio-cultural Context?

Our paper analyses the genetics and gene technology contents of German (Bavarian) and Portuguese biology textbooks, as fields common in science-technology-society-environment (STSE) issues. Our aim was to determine the extent to which textbooks from both countries contribute to students' understanding of the STSE issues and therefore to students' scientific literacy (SL), as well as to detect indicators of the Decontextualized and Socially Neutral View of Science and Technology (DSNVST), as a barrier for achieving that goal. We qualitatively and quantitatively inspected eight textbooks according to previously proposed criteria and sub-criteria: four Portuguese textbooks (two each for the 9th and 12th grade) and four German textbooks (two each for the 9th and the 11th grade). Based on compliance with our set of criteria and sub-criteria, we identified 2390 STSE statements attempting to approach STSE issues, but we also found important lacks in all textbooks and detected DSNVST indicators. Finally, we discuss possible linkages between these indicators and the socio-cultural background underlying textbooks, in terms of both educational policies determining curricula, and prevailing public attitudes towards science. Some similarities within each nationality, as well as some divergences between them endorse our hypothesis that the socio-cultural context from which textbooks emerged determined the choice of STSE content, the discussions employed, and the conception of science and technology displayed by the textbooks.

Key Words: *Textbook analysis, scientific literacy, science, technology, society, environment, STSE issues, misconceptions, socio-cultural context.*

Introduction

Teaching towards scientific literacy (SL) varies according to the economic and the democratic arguments, which seem to derive from underlying visions of science (Authors, 2015). Roberts (2007) defends the existence of two visions of science that may determine different curricular options. Underpinned by traditional views of science education, Vision I sets as its goal the achievement of knowledge and skills such as thinking and acting like a professional scientist. Vision II is consonant with humanistic perspectives of science education (Aikenhead, 2006) and seeks opportunities for students to integrate scientific ideas and scientific reasoning with moral reasoning and cultural considerations that underlie decision-making about socio-scientific issues (Roberts, 2007; Sadler & Zeidler, 2009; Lee et al., 2013). Guided by Vision II, that is the democratic argument, we regard the understanding of the interplay between Science, Technology, Society and Environment, conventionally labeled as STSE issues (e.g., Kim & Roth, 2008, Pedretti & Nazir, 2011) as a fundamental SL component (Authors, 2015).

Introducing STSE contents in classrooms has often been recommended as it confronts students with controversial socio-scientific issues, including those with moral and ethical implications (e.g., Gaskell, 1992; Kolstø, 2001). Particularly, controversial aspects of human genetics and genetic engineering, where decision-making requires complex reasoning, allow students to engage in discussions and to make judgments involving emotive considerations and personal values (Sadler & Zeidler, 2004). As essential curriculum contents, they affect important domains of human lives and frequently generate controversies around genetic processes and products (Bauer & Gaskell, 2002). Therefore, we focus on genetics and gene technology as an adequate field for surveying the way textbooks approach STSE issues, in view of contributing to students' scientific literacy (Authors, 2015).

Textbooks are considered powerful resources for science education and for conveying the notion of the "social context of science" (Green & Naidoo, 2008, p. 249). They are expected to follow the official syllabi and guidelines, but may also "contrast radically with the curricula and other steering documents" of a given country (Gericke, Hagberg, dos Santos, Joaquim, & El-Hani, 2014, p. 408). Even though the incorporation of STSE issues into the curricula seems to be an international trend, most textbooks still fail to include perspectives from social science (Morris, 2014). Moreover, they may still convey distorted views of science and technology (S&T; Authors, 2015; Authors, 2016) deriving from public and individual misconceptions. We have examined the distorted idea of the *Decontextualized and Socially Neutral View of Science and Technology* (DSNVST, Authors, 2015), which is considered the root of other potential misconceptions of science (Fernández Gil, Vilches, Valdés, Cachapuz, Praia, & Salinas, 2003). DSNVST as simplistic conception of the complex relationship between S&T regards technology as a mere product of science and disregards its role in the construction of scientific knowledge (Gil-Pérez, Vilches, Fernández, Cachapuz, Praia, Valdés & Salinas, 2005). We have argued for an integrated treatment of DSNVST and STSE issues because DSNVST is very likely to represent an obstacle to a balanced approach of the relationships between science, technology, society and environment (Authors, 2013). From this view, science is exalted as being the absolute factor of progress in society. Alternatively, S&T (the last one perceived as science's application) are presented as being alone responsible for the environmental degradation, and, therefore, are to be rejected. This simplistic exaltation or rejection of science portraits it as an activity carried out by isolated geniuses and separate from ordinary life. People possessing such a distorted view simply ignore the social context and the implications of S&T in society and in the environment (Roberts, 2007). While science is seen a mean of creating products, the social context in which S&T events take place is disregarded. DSNVST may also encourage the less frequent contrasting misconception, which considers science alone as responsible for environmental degradation, and therefore ignores the responsibility of other agents (Gil-Pérez et al., 2005) such as lawyers, politicians, entrepreneurs, and even citizens. It disregards efforts of S&T in solving problems that affect humanity, and ignores also scientists' concerns with potential risks deriving from their own activity (Kolstø, 2001).

In the following sections, we outline the influence of the socio-cultural context upon public views of science, and upon science teaching in a given community. Than we present arguments for examining that influence though a comparative textbook analysis and explain the reasons for comparing Germany and Portugal. Finally, we present our hypothesis and the study's objectives.

Socio-cultural context and science teaching

Perceptions of the "impact of S&T on individuals and society" vary substantially among different nations (Miller, 1998, p. 205). Local political decisions about what knowledge is of most value to a science curriculum are very likely mostly oriented by economic criteria and may conflict with educationally driven research findings concerning the inclusion of STSE issues into curricula (Aikenhead, 2007). Moreover, they might also be influenced by distorted S&T views of decision makers (Authors, 2016).

The way a community perceives S&T might influence its expectations of science teaching (Höttecke & Silva, 2011), and may define particular STSE syllabi and particular STSE textbook profiles. For instance, political documents frequently urge school systems to prepare students to "compete in the global economy" (Bencze & Carter, 2011; p. 651), thus contradicting the promotion of science education leading to SL (Authors, 2016).

Additionally, as scientific knowledge has arisen from local contexts and in response to local needs, there might be as many sciences as there are contexts and cultures (Harding, 1998), resulting in a *cultural common sense notion of science* (Weinstein, 1998). Public S&T views seem to derive from a combination of "cultural traditions, practical experiences, school learnings and media messages" (Costa, Ávila & Mateus, 2002, p. 43). Both knowledge about and views of the object to be judged influence one's attitudinal judgements; and this perspective has oriented debate in science education (Gaskell, 1992). Despite the necessary caution in avoiding simplistic cause-effect relations, knowing public attitudes in a particular context might help to interpret the S&T views displayed by textbooks (Authors, 2016).

Regardless of the multidisciplinary character of curriculum design teams, some curricular documents display misconceptions about S&T (Authors, 2015). There are mostly teachers who write textbooks based on the curricula (Markert, 2013). As members of the general public having similar levels of education, teachers are likely to hold similarly distorted views (Yates & Marek, 2013), which might be transposed to textbooks in the process of re-contextualization (Ferreira & Morais, 2013). It is therefore legitimate to expect textbook writers to transfer their own views to science education practice and to textbooks (Hollingsworth, 1989). Thus, assuming that teachers' S&T views condition their beliefs about science teaching (Höttecke & Silva, 2011), teachers as textbook writers will transfer their conceptions of science teaching to the pedagogical orientation of textbooks (e.g., Carter, 2007).

Cross-national textbook analyses

Based on these assumptions, cross-cultural textbook analyses are of considerable interest, as they may provide the disclosure of both good practices and aspects requiring improvement in the compared contexts. For instance, comparing biology textbooks among eight countries demonstrated interactions between scientific knowledge and values; cultural, socio-economic, and ethical dimensions were rarely found (Selmaouia, Agorrama, Kzamia, Razoukia, Clément & Caravita, 2012). Additionally, analyses of biology textbooks from 16 countries showed implicit ideological messages, conveyed by representations of social conditions and beyond the messages of scientific content (Castéra, Sarapuu, & Clément, 2013). Implicit messages may have ethical, cultural, and social implications (Clément & Castéra, 2013). Regarding STSE issues in genetics and gene technology, we consider a cross-national analysis as having the virtue of raising conscientiousness about different perspectives and different ways of conceiving the content of science learning materials. Therefore, we agree that “international comparisons in education ... may lead to a better understanding of one's own national peculiarities, and may open up for an awareness of alternatives” (Screiner & Sjøberg, 2004, p. 15) and lead to broad-mindedness in the design of science education programs, to syllabi development and to textbook writing.

In our previous work, we recognized in German biology textbooks (Authors, 2015) and in Portuguese natural sciences and biology textbooks (Authors, 2016) an orientation to provide learning material concerning STSE issues in the context of genetics and gene technology, but we also found some deficiencies and detected some naive and inadequate ideas about S&T, which might contribute to the presence of the DSNVST. Our results supported the supposition that some features of textbooks might be influenced by the socio-cultural background in which they were conceived.

Germany and Portugal: Divergent Perceptions of S&T?

Germany and Portugal have different historical background to the development of S&T and the relationship between S&T and the social sphere. Germany is rather special in terms of civic participation in debate about genetic STSE issues, attitudes towards biotechnologies, and media communication concerning S&T (Eurobarometer, 2006; O' Mahony & Schäfer, 2005; Peters, Lang, Sawicka & Hallman, 2007). Germany was among the countries that displayed the highest percentage of rejecting consumption of genetic modified (GM) foods and of applying gene technology (e.g., pre-natal diagnostics or genetic fingerprint; Eurobarometer, 2006). During the 1980s (Weber, 2009) and 1990s (Kohring 2002), one of the longest-standing debates in Germany concerned biotechnology and genetic engineering in Europe (Hansen 2006), with active public participation in decision making (Bauer, 2002).

Portugal differs radically from Germany. Supporters of GM foods in Portugal outnumber the opponents. Portuguese people buy GM food and are persuaded by the highest number of reasons (Eurobarometer, 2006), with public opinion displaying high optimism towards technology and high acceptance of GM organisms (GMO; Kurzer & Cooper, 2007).

Differences between European countries may predominantly depend on stronger or on weaker scientific and technological systems (Gonçalves & Castro, 2009). Germany is as a very industrialized country at the post-industrial stage (Bonoli, 2004). In the biotechnology domain, Germany is peculiar in Europe, being among the countries that have experienced a long tradition in molecular and cellular biological research and having a strong industry in biotechnological products (Torgersen et al. 2002). Portugal is regarded as a late-industrializing country (Pepinsky, 2012). Scientific competencies at the level of public research have not been as successfully transferred to industry, particularly in the field of genetic engineering (Fontes, 2005).

Recent studies have pointed out that the greater scientific knowledge, the more positive the attitude to science; however, an ambivalent attitude, where relatively high scientific knowledge level may coexist with positive attitudes, but also with readiness to criticism has also been observed (Bauer, 2009). Positive attitudes are strongly related to length of schooling, in particular to the highest school grades (Costa, Ávila & Mateus, 2002). Both countries contrast in this respect: German citizens had been literate for longer (O'Mahony & Schäfer, 2005) with, in 1996, the lowest prevalence of low skills and the fastest progress compared with other European countries (Murray & Steedman, 1998), while Portugal had a long period of only four years of compulsory education (Candeias, 1993), with consequences in the public level of literacy. An OECD study (2008) showed that Portugal was among the countries where more than 50% of the population aged 25 to 64 had not completed upper secondary education.

This long tradition in S&T, as well as public schooling might also explain Germany’s longer and Portugal’s shorter traditions in the communication of science to the public (Gonçalves & Castro, 2009). German co-existence of both catholic and protestant religions prevented the dominance of one confessional world view and morality over the other, fostering plurality of opinion (O’Mahony & Schäfer, 2005). The skeptical views of science and of scientific achievement may be explained by the collective memory of the eugenicist program that raised the level of communication in the field of human genetics (O'Mahony & Schäfer, 2005). Anti-biotechnology activism was supported by an active media (Weber, 2009). In contrast, Portuguese people were for many years subjected to authoritarian politics that disregarded public interests and discouraged capabilities in decision-making (Gonçalves et al., 2007): Portugal continues to experience a still immature democracy (Menezes, 2003). These political constraints prevented the development of a powerful and organized civil society (Roberts 1995) where social movements could defend citizens' interests. Instead, a discrepancy between legislation of citizens' rights and effective access to these rights continues. Despite brief experiences in popular mobilization during the revolutionary period, regime change in 1974 provided no platform for public debate; discussion was confined to the parliament (Santos & Nunes, 2009). However, the emergence of controversies related to STSE issues have also shaken Portuguese society, among them human cloning, and have awoken emotional reactions and caused social tensions. These controversies were triggered by a more sensationalist and less informative media, that might have influenced public conceptions of science (Reis & Galvão, 2004).

In the view of these differences and motivated by our previous results (Authors, 2016), we decided to compare Portuguese and German textbooks, in order to answer our research question:

How do textbooks from countries with different socio-cultural background regarding STSE issues in genetics and gene technology differ?

First, these countries represent two realities at different evolutionary stages in respect to S&T. Second, they have been confronted by two different public experiences concerning the relationship between society and genetics and gene technology issues. And third, we chose both countries for practical reasons, because the co-authors stem from both countries, and, therefore, know the corresponding educational systems from within.

Hypothesis and objectives of the study

We use our study on the following assumptions:

i) The historically based, contemporary socio-cultural context influences the common sense notion of science prevailing in a society.

ii) The socio-cultural context influences arguments for SL, which in their turn determine discussions of curriculum or syllabi content and of guidelines for textbook writing, thus defining the textbook profiles regarding contents and didactic strategies.

iii) The culturally prevailing common sense notion of science is reflected in the S&T views that are intentionally or not transferred to textbooks.

Based on the differences between Germany and Portugal described above, we hypothesize that Portuguese and German textbooks differ in terms of the choice of STSE content, the discussions employed, and the concept of S&T, therefore reflecting the socio-cultural contexts.

Our objectives were:

- to identify potential differences in the way to which German and Portuguese textbooks approach the STSE issues, related to genetics and gene technology, with the intent of relating such differences with the corresponding educational policy; and
- to compare the textbooks in terms of DSNVST indicators and to establish possible linkages between them and the corresponding socio-cultural background.

Methods

We replicated our previous methodology for comparing textbooks from the same country (Authors, 2015; 2016). Again, we framed our study within the parameters of Product Oriented Research, with emphasis on the textbook as a product (Cabral, 2005). As our purpose also concerns how textbooks handle controversial STSE issues, it is important to state that we did not appraise perspectives or values *per se*. We rather appraised the opportunity provided to students to discuss the diversity of perspectives and of values involved in STSE issues.

Criteria for STSE relationships in textbooks

Our analysis based on criteria with each criterion representing ideas required to understand the STSE relationships and ideas that help to confirm or to refute the presence of the misconception DSNVST, as explained below. In order to define our criteria, we revised documents, mostly derived from epistemological debate and from research in science education. We then extracted from this bibliography the ideas concerning STSE issues that we assumed to be likely observable in textbooks and formulated criteria. Altogether, we identified six criteria and 26 sub-criteria (summarized in Table I, Supplemental material), which were, where needed (some are self-explanatory), justified by arguments either found in the literature or formulated by ourselves (for details, see Authors 2015).

The criterion *S&T events and their social contextualization* derived from the evidence that, within science teaching, S&T advances are frequently presented as occurring by chance, detached from their historical and socio-cultural context (Stinner, 1995). However, participative citizenship requires awareness of how scientific work is conditioned by the social, historical, moral and spiritual contexts (e.g. American Association for the Advancement of Science, 1993). Statements complying with the sub-criteria *event time* and *event place* (Gil-Pérez et al., 2005) are examples of attempts to contextualization.

However, references of the *problem* that triggered events, as well as of both, *obstacles* and *factors favorable* to events, provide a more complete view about the way to which science and technology interact with the social sphere. S&T are (interacting) distinct entities with different purposes (Osborne, Collins, Ratcliffe, Millar & Duschl. 2003) However, technology has often been seen as a by-product of applied science (Maiztegui, 2002) in the sense of DSNVST (Gil-Pérez et al., 2005). Therefore, we defined the criterion *interplay between S&T* in order to identify pragmatic definitions of each entity, which offer two possible elations here represented by the sub-criteria *T towards S* and *S towards T*; that is technology helps science or vice versa (Fensham, 2002). We also looked for statements referring to gene technology processes portrayed *as* being *applied S* (i.e., genetics). In contrast, we also consider statements illustrating the usefulness of scientific advancements in transforming resources into goods and services as positive indicators of the role of science. Similarly, we marked statements mentioning a certain technological device or process as necessary for the fulfilment of a certain scientific advancement as indicators of the catalyst role of technology in science.

In respect of the criterion *S&T as means to solve social problems*, two different perspectives may apply: One, where technology is naively portrayed as a mere product of science, may tend to praise science. While science education tends to integrate technology elements, it may focus on applications of technology by promoting products and disregarding technological processes. A balanced compromise may shift away from the above referred paradigm of *T as* being *applied science* (Gil-Pérez et al., 2005), towards a view of technology as an autonomous entity that seeks to overcome problems by invention (Gardner, 1990). Another perspective, catering a deeper contextualization (first criterion, above) beyond *event time* and *event place*, is that, by highlighting *underlying problems* that motivated research, science education may help students to appreciate S&T as a human enterprise committed to satisfy societal needs and solve societal problems. However, besides *applicability*, students should understand both the *potential applicability* and the *limitations* intrinsic to science and technology (Osborne & Dillon, 2008). Additionally, mentioning financial *costs* associated with technologies may convey the message that such processes are somehow socially constrained (American Association for the Advancement of Science, 1993).

The criteria *risks and impacts of S&T* and *controversial issues* complement each other, as many political and moral dilemmas originate in S&T, requiring the need to balance reasons for potential economic benefits and/or real risks (Osborne & Dillon, 2008). Students should appreciate the *social impact* of scientific and technological changes in their daily lives and also analyse *risks'* minimisation and undesired side effects, (Aikenhead, 2000), for instance, *local* and *global environmental impacts* (Aikenhead, G., 2000; Osborne & Dillon, 2008) *Controversial issues* are frequently handled by mass media from a common sense perspective and ignore potential co-existing options (Vazquéz-Alonso, Massanero-Mas & Acevedo-Díaz, 2006). Therefore, citizens need to possess scepticism, open-mindedness, critical thinking, inquiry skills or even skills in the interpretation of data-driven knowledge (Zeidler, Sadler, Simmons & Howes, 2005). In particular, since controversial issues around genetic manipulation tend to be framed by socio-philosophic positions instead of scientific ones, their discussion requires the consideration of *involved interests* and *conflict values* and (needs and beliefs included) as essential factors to be taken into account (Szanto, 1993). While formal science education is centred in conventional non-controversial science, and while the media may tend to emphasize a controversial, superficial, and sensationalist science, textbooks may incorporate both to illustrate *different perspectives* from *different sources of information* (Kolstø, S. D., 2001; Morris, 2014)**.**

The criterion *decision-making process* concerning STSE Issues derived from the perspective that a STSE curriculum should foster the ability to make decisions about science-related social and environmental issues (DeBoer, 2000). Accordingly, five aspects may counteract a student's misunderstanding of the relationship between science and technology in this context: specification of concrete *legislation;* awareness that decisions differ according to their social context, thus requiring the sub-criterion *international comparisons;* personification of decision *agents;* and awareness of the fact that common citizens may influence decisions. This misunderstanding may lead to the misconception that environmental degradation only is caused by science (Roberts, 2007). Therefore, textbooks should also enable students to learn about making choices and participating in political decisions, by giving emphasis to c*itizen participation*.

Textbook Sample

We chose German 9th and 11th grade biology textbooks (G9/11) and Portuguese 9th natural sciences and 12th grade biology textbooks (P9/12) because these grades approach genetic and gene technology contents at a similar level. In Germany, Bavaria, the textbooks need state certification as an opt-in requirement. All the publishers are expected to meet the legal burdens on the textbooks. For instance, they have to fulfill all the requirements of the current syllabus (in our case, genetic education) and of the current education-specific approaches (e.g., in our case, use of adequate hands-on parts in genetic education; BME, 2016c). Due to all biology textbooks having passed this muster, we randomly selected four German (Bavarian) biology textbooks for the *Gymnasium* as a university-preparatory secondary school (Bavarian Ministry of Education [BME], 2016) from two different publishers: G9-1 (Manger, Manger, Moßer & Staudinger, 2007) and G11-1 (Heidenfelder et al., 2009) as well as G9-2 (Jungbauer, 2007) and G11-2 (Bayrhuber et al., 2009). For Portuguese textbooks, we drew a selection from the most adopted textbooks in the school year 2013/2014 (Direção geral de Educação [DGE]), and also from two different publishers: the natural sciences textbook P9-1 (Antunes, Bispo & Guindeira, 2014) and the biology textbook P12-1 (Osório & Martins, 2009) and the natural sciences textbook P9-2 (Motta & Viana, 2014) and the biology textbook P12-2 (Silva et al, 2006).

All German textbooks are similar in layout (e.g., allocation of pictures), and front size (10 pt). Nevertheless, they present different strategies in both the organization of contents as well as the type and sources of non-compulsory information. G9 books allocate the relevant contents to two chapters: G9-1 *Genetics* (22 pp.) and *Applied Biology* (16 pp.), G9-2 *Fundamentals of Genetics* (20 pp.) and, similarly, *Applied Biology* (14 pp.). G11 books present one chapter each: G11-1 *Genetics* (71 pp.); two motivational pages provide an introduction, emphasizing the title and sub-titles for five sub-domains: *Classic*, *Cyto-*, *Human*, *Molecular Genetics*, and *Gene Technology*; G11-2 *Genetics and Gene Technology* (83 pp.) with four sub-chapters: *Molecular Fundamentals of Heredity*, *Cyto-* and *Classic Genetics*, *Human Genetics and Gene Technology*. As non-compulsory information, G11-2 arrange science and technology events by concepts and principles that one should be aware of (e.g., the concept of risk or the human dignity principle). This textbook follows a deductive approach (Prince & Felder, 2006), by presenting explicitly a priori principles and regularities that underlie the S&T relationship with the societal sphere and with the environment. In contrast, textbooks G9-1 and G11-1 confront students with societal problems and challenge them to research regularities by their own, and to infer what is established.

Portuguese textbooks use a bigger font size (12 pt); the number and size of pictures are similar, but the text area is sparser, particularly in the P-9-books. They allocate genetics issues to two chapters. P9-1: *Fundamentals of Heredity* (17 pp.) includes the contributions of genetic engineering to the solution of contemporary problems; *Science and Technology in the Resolution of Individual and Social Health Problems* presents an integrated perspective of previous contents, in connection with non-genetic material. P9-2: *Fundamentals of Heredity* (20 pp.) and *Science and Technology in the Resolution of Individual and Social Health Problems- Assessment and Management of Risks* (4 pp.). P12 books differ in the number of chapters. P12-1: *Genetic Patrimony* (67 pp.), *Changes in Genetic Material* (38 pp.) including *Fundamentals of Genetic Engineering*, and *Food Production and Sustainability,* including genetics in the sub-chapter *Exploration of the Potential of Biosphere* (28 pp.). Here, sections refer to STSE relationships. P12-2: *Genetic Patrimony* (84 pp.) comprises the sub-chapters *Genetic Heritage and Changes in Genetic Material*, the latter including the *Fundamentals of Genetic Engineering*; *Food Production and Sustainability* (104 pp.), including the sub-chapters *Food Obtained by Genetic Manipulation*, *Genetic Engineering and Plants Improvement*, *Genetic Engineering and Animal Breeding* and *Genetic Control* (of pests). There is no notable difference among the eight textbooks in the number, size or allocation of pictures.

Underlying Syllabi and Guidelines

In both countries, textbooks need state-certification, but the Portuguese textbooks corresponding to these school levels have not yet been submitted to certification yet. Consequently, we qualitatively analysed the German (Bavarian) and Portuguese sample-related syllabi, with the purpose of inferring their requirements for approaching STSE issues.

The Bavarian biology syllabus grade 9 (BME, 2004a) begins by emphasizing students' basic knowledge, as a prerequisite both for being able to assess consequences of one's own options in health and in quality of private life, and to assume own positions in scientific as well as in social relevant contexts. Genetics contents (12 lesson hours recommended) are exclusively concerned with basic knowledge, while gene technology content (eight lesson hours recommended) refers to the importance of offering starting points for (perceiving) scientifically and socially relevant applications. Two STSE connections in particular are recommended: one more general concerning medical, economical, and ethical aspects of gene technology applications; and, the other more specific, concerning physical, ethical, and legal questions. Syllabus grade 11 (BME, 2004b) requires an introductory view of genetics and gene-technology contents (48 lesson hours recommended); content-related on topics from molecular basis of life to anthropologist questions, skill-related on understanding the methods of gene technology, and reflection-related on ethical implications of present and future applications (e.g., gene therapy). Potential ecosystem changes, as a consequence of rapid progress in biosciences, are mentioned only once.

The Portuguese curricular guidelines for natural sciences grade 9 (Galvão et al., 2001) and biology grade 12 (Mendes, Rebelo & Pinheiro, 2004) explicitly recommend that the development of student competencies should consider conceptual, procedural, and attitudinal domains of learning in an integrated manner. Since in the Portuguese educational system 12 years' compulsory education began in 2012, at the time of our study, the 9th grade was the final mandatory school grade, and therefore relevant for achieving students' conscious citizenship. A common theme for the 9th grade is *To Live Better on the Earth,* and curricular guidelines repeatedly refer to "contributing to the development of students' scientific literacy" (Galvão et al., 2001, p. 4). The syllabus relies on a multidisciplinary approach, combining biology with physics and chemistry, building upon basic knowledge, and relating the contents to students' daily lives. STSE relationships are extensively recommended through both the exploration of events of history of science, and the analysis of contemporary controversial issues presented by the media.

Especially the curricular guidelines grade 12 (46 lesson hours recommended; Mendes, Rebelo & Pinheiro, 2004) reflect concerns with both the development of students' citizenship and the acquisition of basic biological knowledge combined with the development of scientific skills. Guidelines emphasize the role of basic knowledge for individual decision-making processes, for understanding science as a human endeavor, depending on the context in which it develops, and for the mutual influence between biology and biotechnology and between them and society, including the ethical dimension. They provide methodological suggestions, including “exploring explicit and reciprocal relationships between science, technology and society” (Mendes, Rebelo & Pinheiro, 2004, p. 9). They consider the environment separately, and make some references to risks. Nonetheless, there is scant reference to S&T limitations, and the subjectivity inherent in the scientific truths is disregarded. In particular, genetics and gene technology are presented within the frame of problem solving, starting from the identification of social problems, through contents that are somehow related, to possible solutions.

Textbook Analysis

We applied our set of six criteria and 26 sub-criteria (see Table I, Supplemental material) for textbook analysis, developed, validated and tested in previous studies (Authors, 2015; 2016), in order to determine to what extent STSE issues are approached by the eight textbooks and to detect indicators of potential DSNVST.

We combined qualitative content analysis with quantitative frequency analysis. The whole text of the surveyed chapters was qualitatively analyzed. The identified STSE statements were recognized by identifying the co-variation between the written text and the context in which it is used (Knain, 2001), thus inferring the ideas about S&T conveyed by every statement. After identifying the statements that matched our criteria, we textually recorded them in order to provide an entry for quantitative analysis and to keep the content information available for posterior confirmation of meaning. All statements were scored in the same manner, and contingencies between both criterion and sub-criterion frequencies and the analyzed textbooks were examined by computing adjusted Pearson’s contingency coefficients C (Pearson, 1904). Due to multiple testing, we decreased the alpha level to .005 and assigned only contingencies of $C > .200$ as relevant.

Results

We identified 2390 statements within the chapters containing genetic and gene technology contents in our eight textbooks (for examples, see Table I, Supplemental Material).

Page Numbers and Statements per Page

We compared all the book pairs with regard to both the number of pages devoted to genetics and gene technology issues, and to ratios of statement frequencies to the number of relevant pages (for details of chi square tests, see Appendix). In respect of page numbers, there were no differences in all book pairs. To what concerns the quantitative level of the ratios pages to statement frequencies, neither 9th grade book pairs nor Portuguese P12 books differed. In contrast, German 11th grade book pair did differ (χ = 14.426, p < .001), with G11-1 supplying considerable more statements per page (ratio 6.3) than G11-2 (ratio 3.2) and the P12 books (ratio 3.4 and 3.1).

Overall Compliance with Criteria and Sub-criteria

Concerning the overall compliance with criteria, we found statements for all 26 sub-criteria only in one textbook (P12-2; Table I, Supplemental Material). All seven other textbooks lacked one to three of the sub-criteria (Table I, Supplemental Material). G9-1, P9-1 and P9-2 lacked the sub-criterion *favorable factors;* and P9-1 and P9-2 lacked the sub-criterion *obstacles* (both sub-criteria for criterion *S&S events and their contextualization*). P12-1 presented no reference to *technology as applied science*. Textbook G9-2 lacked the sub-criterion *costs* (of science and technology processes or devices). Textbooks G9-1, G9-2, P12-1 and P9-2 lacked the sub-criterion *local environmental impact* while G11-1 lacked *global environmental impact*; the presentation of *different sources of information* was lacked by G11-2 and P9-1. Finally, the textbooks G9-1 and P9-2 lacked the sub-criterion *international comparisons* (concerning decisions in terms of legislation of science and technology issues).

Criteria and Sub-criteria Differences between the Textbooks

All the eight textbooks differed at the level of the criteria (C = .301, p < .001, N = 2390) and at the level of sub-criteria (C = .451, p < .001, N = 2390), especially in five of the six criteria:

- *Science and technology events and their contextualization* (C = .366, p < .001, n = 815), in particular regarding the sub-criterion *favorable factors* (C = .220 p < .001, n = 24). The Portuguese textbooks (randomly to be expected statements [e.] vs. observed statements [o.]: 347 *vs.* 377) exceeded the German ones (468 e. *vs.* 438 o.). With respect to this sub-criterion, the differences are based on textbook G9-2 (3 e. *vs.* 12 o.), which display half of all statements, while G9-1, P9-1 and P9-2 lacked the sub-criterion.

- *Interplay between science and technology* (C = .589, p < .001, n = 161), in particular regarding the sub-criterion *technology towards science* (C = .236, p < .001, n = 66). The German textbooks (92 e. *vs.* 107 o.) exceeded the Portuguese (69 e. *vs.* 54 o.), in particular G11-1 and G11-2. With respect to the sub-criterion, the German textbooks (38 e. *vs.* 55 o.) similarly exceeded the Portuguese ones (28 e. *vs.* 11 o.).
- *Science and technology as a means to solve societal problems* (C = .291, p = .004, n = 575), especially the sub-criterion *applicability* (real benefits of science and technology processes and devices; C = .220, p < .001, n = 575). The Portuguese textbooks (245 e. *vs.* 268 o.) exceeded the German ones (330 e. *vs.* 307 o.),in particular, P12-1 and P12-2. With respect to the sub-criterion *applicability* our Portuguese textbooks (156 e. *vs.* 169 o.) similarly exceeded the German ones (211 e. *vs.* 198 o.).
- *Risks and impacts of science and technology* (C = .406, p = .004, n = 272). The Portuguese textbooks (116 e. *vs.* 133 o.) relatively exceeded the German (156 e. *vs.* 139 o.).
- *Decision making process* (C = .464, p < .001, n = 248). The German textbooks (142 e. *vs.* 164 o.) exceeded the Portuguese ones (106 e. *vs.* 84 o.).

Cross-National Comparison of the Textbooks

Comparison of the 9th grade books. Detailed horizontal comparison of the German and the Portuguese 9th grade textbooks showed that they differed at the level of the criteria (C = .200, p = .004, n = 936) and of the sub-criteria (C = .409, p <.001, n = 936), especially regarding three criteria:

- *Science and technology events and their contextualization* (C = .372, p < .001, n = 283), especially regarding the sub-criterion *favorable factors (C* = .333, p < .001, n = 12). Germany (196 e. *vs.* 198 o.) and Portugal (87 e. vs. 85 o.) showed no differences; that is, the contingency found at the criterion level is based only on sub-criterion *favorable factors* which we found only in G9-2 (Table I, Supplemental Material). In general, G9 books descriptively achieved higher frequencies in comparison to P9 books, both in the number of *events per se* and in the mention of *underlying problems* that motivated research.
- *Risks and impacts of science and technology* (C = .455, p = .005, n = 118). The Portuguese textbooks (36 e. *vs.* 48 o.) exceeded the German (82 e. *vs.* 70 o.). However, G9-1 in particular, but also G9-2, descriptively exceeded P9 in referring general *risks* of science and technology.
- *Decision making process* (C = .527, p < .001, n = 99). The German textbooks (69 e. *vs.* 77 o.)

exceeded the Portuguese ones (30 e. *vs.* 22 o.). Descriptively, there was particular relevance to the sub-criterion *citizen participation*, with highest frequency of compliance by G9-1.

Regarding the other criteria, we descriptively found (Table I, Supplemental Material):

- *Interplay between science and technology*: With regard to sub-criterion *T towards S*, G9-1 exceeded the other three. German textbooks more frequently presented the inadequate notion that regards *T as* (being) *applied S*.
- *Science and technology as a means to solve societal problems*: German textbooks showed higher compliance with the criteria than P9 in three of the four sub-criteria, such as *potential applicability* of science and technology, real *applicability* and *limitations* (Table I, Supplemental Material). Nevertheless, all textbooks provided only five statements with reference to the *costs* of science and technology.
- *Controversial character of socio-scientific issues*: In general, German textbooks strongly emphasized this criterion, in particular G9-1.

Comparison of the 11th and 12th grade books. At the higher secondary school level, German 11th and the Portuguese 12th grade textbooks differed at both the criteria (C =.298, p <.001, n = 1454), and t the sub-criteria level (C =.388, p <.001, n = 1454) revealing different patterns, especially regarding *Science and technology as a means to solve societal problems* (C =.303, p =.001, n = 368), in particular the sub-criterion *applicability* (C =.236, p =.001, n = 235). The Portuguese textbooks (185 e. *vs.* 205 o.) exceeded the German ones (183 e. *vs.* 163 o.). With respect to the sub-criterion, Portuguese textbooks (118 e. *vs.* 129 o.) similarly exceeded the German ones (117 e. *vs.* 106 o.).

Regarding the other criteria, we descriptively found some notable differences comparing sub-criteria (Table I, Supplemental Material); that is, the textbooks did not show clear differences between nationalities. G11-1 revealed higher statement frequencies in the sub-criteria *science and technology events*, as well as of the sub-criterion *event time*, while G11-2 yielded the lowest frequency of all four textbooks in both sub-criteria. The sub-criteria *underlying problem* that motivated events is referred to considerably more by P12, largely P12-1. References of obstacles, though low in all textbooks, are considerably more frequent in P12-2. Regarding the criterion *interplay between science and technology* textbooks differ slightly in both, but G11 exceeds P12 in mentioning mutual support, particularly, *T towards S*. Textbook P12-1 is the only one where we found no references to *T as* (being) *applied S*, while P12-2 presents three such statements. To what concerns the approach of *controversial issues*, G11-1 stands out in all sub-criteria, especially in presenting *different sources of information*. However, a cross-national tendency towards German textbooks showed higher frequencies of the sub-criteria *conflicting* *values* and *involved interests*. Similarly, the criterion *decision-making process* did not provide a clear distinction between nationalities, since once more G11-1 exceeded the other three in all sub-criteria, except in *international comparisons* of legislation, with emphasis on *legislation* and its *agents*, while P12 ranked second on this criterion.

Discussion of results

As we found considerably different textbook profiles at the level of nationality in terms of STSE extension and of compliance with the most of criteria and sub-criteria, we see our hypothesis as confirmed. Horizontally, 9th grade German and Portuguese textbooks differed more than the 11th and 12th grade pairs. Both quantitative and qualitative analysis detected omissions and inadequate ideas in all the textbooks, especially regarding the DSNVST, though to a different extent and with some variation. The different textbook profiles suggest plausible linkages with socio-cultural contexts. First, we discuss the differences with regard to the extension in approaching STSE issues. Second, we focus on the display of the DSNVST by the textbooks and possible relations to the corresponding socio-cultural context.

Extension of Approaching STSE Issues

Regarding the horizontal comparison of G9 and P9 books, the German textbooks contained more genetics content (36 and 34 pages, front size 10 pt), than the Portuguese (17 and 24 pages, front size 12 pt). Similarly, the ratio frequency of statements expressing ideas about STSE issues per relevant page numbers, is considerably higher in G9 textbooks (9.0; 9.1) than in P9 (4.5; 6.0; see Appendix). This disparity in content amount seems to be a response to the requirements of two different educational systems:

In Germany, the aim of the *Gymnasium* branch of the educational system is to prepare a selected student population to university level (BME, 2016a). This aim may explain the emphasis given to more basic knowledge in genetics and gene technology by the underlying syllabi and guidelines. They point out the goal of preparing students for pursuing scientific and technical carriers which has been argued as an argument for SL (Bencze & Carter, 2011). Regarding the STSE issues in our context, the criteria for biology textbooks' state certification require a balanced representation of controversial points of view on the application of biological research, especially in gene technology (BME, 2009). The criterion bases on the German National Standards for biology education in order to promote students' judgement skills through discussion of controversial issues with consideration of multiple perspectives (OSC, 2005). The Bavarian evaluation committee is seen as very strict (e.g., Brandenberg, 2006) as the state provides textbooks cost-free for the students (BME, 2016b), thus influencing the entire process from production to distribution. However, publishers have experience in dealing with syllabi, guidelines, and evaluation criteria, thus responding rapidly to new developments and determining the education market (Brandenberg, 2006). These characteristics of Bavarian textbook dynamics might explain the relative high proportion in G9 books.

In Portugal, the educational system embraces a considerable diversity of students (Authors, 2016) and tries to adopt inclusive principles (Vislie, 2003), at least in national policy documents (César e Santos, 2006), towards the ideal of *Schools for all* (César, 2003); that is, it is consonant with the democratic argument for SL (Bencze & Carter, 2011). The textbook market, in its turn, has to adapt to those inclusive principles, providing teachers with versatile didactic material. However, textbooks have to be financed by families and to be adopted by teachers' councils. Regarding teachers, evidence points out teachers' reluctance or difficulty in approaching controversial issues (Chikoko, Gilmour, Harber & Serf, 2011). This specific configuration might have led to the simplification of contents observed in P9 textbooks as an attempt to reconcile diverse school contexts and to address teachers' preferences (Authors, 2016). The textbook certification policy, which could regulate this, has been developed and progressively implemented (ME, 2006). However, despite the virtues of the textbook evaluation process, interactions between stakeholders is still required (Rego, Gomes & Balula, 2012).

Regarding the horizontal comparison of the G11 and P12 books, the pairwise quantitative analysis respective to the frequency of statements per number of relevant pages did not reveal any relationship between the preponderance given to STSE issues, in the context of genetic issues, and nationality. However, two different textbook profiles were identified, more particularly in some criteria or sub-criteria. We observed two stronger textbooks, G11-1 and P12-2, and two weaker ones, G11-2 and P12-1, as discussed below.

Indicators of the Decontextualized and Socially Neutral View of Science and Technology: Comparing Nationalities

We examined indicators of the DSNVST, in all eight textbooks, pointed out by the non-compliance of statements with criteria, and, in the case of the inadequate idea *technology as applied science,* rather by the compliance with this sub-criterion. We found indicators of this misconception in all eight textbooks, even though some contrasting ideas coexisted in the same textbook, thus preventing its allocation into one of the two extremes of that misconception. However, the contingency analysis of compliance with criteria and sub-criteria revealed distinct textbooks' profiles according to nationality for some criteria and sub-criteria, while comparing the frequency of observed compliance with the one randomly to be expected.

For certain criteria and sub-criteria, we considered the quantitative compliance *per se* an indicator of the DSNVST. In other cases, however, we descriptively observed compliance, combined with the qualitative analysis of the ideas conveyed by statements. That together helped to confirm or to exclude the tendency towards one of the extremes of the view of the DSNVST. As following, we discuss our results by analyzing the performance of the textbooks in respect of every criterion.

Science and technology events and their contextualization. Textbooks complied with this criterion differently, particularly in providing references to the sub-criterion *favorable factors* for S&T events, with Portuguese textbooks exceeding the German ones. In absolute terms, however, German textbooks contributed with more statements. G9 and P9 differed at the level of this criterion and sub-criterion, too. The high performance of G9-2 dominated in discussing *events*, in mentioning the *underlying problems* that motivated research but especially in referring to *favorable factors* that promoted research advancements. G9-2 connects events to their social context and helps students to understand how S&T evolve; as example, the statement "*As the composition of rapeseed oil did not always correspond to the requirements of industry, one wanted to change its composition of fatty acids.*" (p. 106). It implicitly suggests the interest of industry in promoting research. The latter sub-criterion, *favorable factors,* was lacking in the other 9th grade textbooks and was poorly referred in G11 and P12 ones. P12-1 stood out by providing references to the *underlying problems* that triggered research, but it failed to discuss *favorable factors* that promoted events, for instance, social acceptance, financial support, etc. Though not directly connected to nationality, the historical contextualization beyond references of *event time* is achieved well in G9-2, weakly achieved in G11 and P12 and very insufficiently achieved in P9, which constitutes a first DSNVST indicator. The copious mention of historical and contemporary S&T *events per se* by the German sample, accompanied by the high quality of G9-2, are consonant with the German tradition in biological research and the strong industry in biotechnological products (Torgersen et al. 2002). In contrast, the disregard for contextualizing *events per se,* obviously in P9 and moderately in P12, might be a consequence of the lacking sensitization for this criterion, second suggesting the presence of the DSNVST.

Interplay between science and technology . The contingency analyses pointed to a difference between nationalities for this criterion in favor of German textbooks, while the Portuguese ones scored lower than as to be expected; particularly regarding the sub-criterion *T towards S* with German textbooks, in particular G11-1 and G11-2, exceeding the Portuguese ones. This focus on the effects of technological developments in scientific progress might reflect the public familiarization with S&T in Germany, and the fact that technologists play a preponderant role in communicating with media (O'Mahony & Shäfer, 2005). The role of science in technology advancements, *S towards T,* was barely represented in our whole sample. That is probably due to the firm idea that scientific events culminate in technological ones and that technology is mere *applied science*. Actually, even though some statements distinguishing between S&T were found in all textbooks, the naive idea suggesting that *T is applied S*, considered the root of the DSNVST, still persists as third indicator for DSNVST. We found it in all the textbooks except for P12-1 and particularly frequently in G9-2, however the contingencies analysis pointed out no clear relation to nationality.

Science and technology as a means to solve societal problems . The compliance with this criterion differed and was relatively higher for the Portuguese textbooks compared to German books. It was particularly evident for the sub-criterion *applicability* of S&T processes and devices in Portuguese books, mainly due to the high contribution of P12 relative to G11. However, G9 presented a better balance than P9 between expectations, real benefits and limitations of genetics and gene-technology applications. Considering mainly the frequent references to current *applicability*, but also to *potential applicability* and the qualitative appreciation of such statements, P12 placed considerably higher emphasis on the positive aspects of *S&T as means to solve problems* than G11. In contrast, the less positive aspects, such as *costs* and *limitations*, despite having been explicitly formulated by P12-1, were better elucidated by the examples in G11-1. The other textbooks missed the balance between the expectations in S&T and their constraints, particularly regarding the *costs* of processes or devices, which are inadequately approached or completely lacking. With the exception of G11-1, all textbooks placed emphasis on the products of science rather on the processes, pointing as fourth indicator to the DSNVST.

In order to appreciate the extent of enthusiasm towards S&T, we qualitatively examined the statements complying with the sub-criterion *potential applicability* and found three different ways:

- Pragmatic references to expectations placed in S&T, providing examples and somewhat restrained comments on expectations. This style was dominant in all 9th grade textbooks, containing expressions such as, "*Though gene-therapy will be possible (...)" (P9-1*, p. 88); and in G11-2, very carefully, "*one might, in principle, expect (...)*" (p. 128).
- References to positive social effects occurred mostly though examples, as we found in G11-1, but used some promotional and emotional statements, such as "*Biotechnology and its modern sub-field, Gene-technology will be the key technologies of 21 century*" (p. 112).
- References revealing an emotional involvement, were found in P12-1, such as "*thousands of people were hopeful*" (p. 69). Similarly, P12-2 conveys enthusiastic messages, such as, "*Has the genie come out of the lamp*?" (p. 132), as well as expressions such as "*to stop the hunger in the world*" that appeared three times (pp. 225, 270 and 300).

Together, the emphasis placed in S&T products and the high enthusiasm revealed by statements confirmed the four already detected DSNVST indicators as fifth one. This approach probably reflects the industrial stage in which Portugal finds itself (Inglehart, 1990), where positive attitudes towards S&T and high acceptance of GM organisms (GMO; Kurzer & Cooper, 2007) prevail, and controversies did not make history (Authors, 2016). It seems to mimick the sensationalist media (Reis & Galvão, 2004), that frequently use metaphors (Lakoff & Johnson, 1980) to convey (either positive or negative) strong messages (Liakopoulos, 2002). One other possible reason for such an emotional approach might be an attempt to convey strong messages in order to trigger emotions and open a motivational channel for learning (Spitzer, 2007).

Risks and the impacts of science and technology . A difference between nationalities was found at the level of this criterion. Statements complying with this criterion were relatively more frequent in Portuguese textbooks compared to the German ones, in particular in P12-2 and in P9 books. At the level of the sub-criteria we did not find any clear differences, However, German textbooks, in particular G9-1, descriptively scored higher in referring to sub-criterion *risks*. Considering this expression of concern, G9-1 may tend to the opposite extreme of the DSNVST as first indicator for this view.

In general, *social impacts* were more explicitly approached than *environmental impacts*. In P12-2 the term *impact* was often used or embedded in dramatic and emotion-laden expressions, such as, "*The overwhelming advances of genetic engineering over our everyday life*" (p. 132). *Environmental impacts* were given slightly more attention than in any other textbook. *Risks* are approached by regarding the disruption of ecological balance and the impacts on biodiversity, but not with connecting to possible threats to human health (Authors, 2016). In contrast, the German textbooks emphasized human-health-related *risks* related to the detriment of *social impact*, except for G11-1, which places emphasis on impacts, in terms of both the individual and the community. G11-2 explicitly pointed to a scientists' ethical code: "*Scientists have the responsibility to assess risks as accurately as possible*" (p. 138); a second indicator to the presence of the opposite extreme of the DSNVST. However, concern with environmental degradation is missing, since (with the exception of P12-2, which revealed great concern towards all aspects of these criteria) little attention was dedicated to *environmental impacts*.

Controversial issues . The controversial character of STSE issues is strongly considered by German textbooks, exceeding the Portuguese books, what is emphasized by the qualitative appreciation of statements. The German books provided multiple references and concrete examples of *conflicting values* demonstrated by the *social application* of genetics knowledge and of gene technology products. The involvement of opposite interests in genetics or gene technology solutions is also often well illustrated. In particular, G11-1, followed by G9-1, stood out, mainly through the presentation of *different* *sources of information*, thus clarifying the different positions of societal entities. This fact may be justified by the particular interaction between science, technology and general public experienced in Germany (O'Mahony & Schäfer, 2005).

The Portuguese textbooks refer explicitly to the importance of considering and integrating *values* into judgements of genetics and gene-technology issues. Interestingly in P12-1, we found the expressions "*ethical and religious implications (of genetic issues)*" (p. 177), "*the ghost of eugenics"* (p. 69) and „*eugenic and discriminatory policies*"(p. 177) among the five references to *conflict values*. However, despite the relevance of these considerations, concrete and contextualized examples were lacking, which pointed once more to a sensationalist exploration of controversies, devoid of local context, and represented a very modest contribution to the real problematic of genetic STSE-scientific issues (Authors, 2016).

German textbooks, in contrast, presented references to *conflict values*, while approaching concrete cases of genetic and gene-technology. G11-2 approached them infrequently, but explicitly in a more deductive mode (Authors, 2015). Human genetics, ethics and religious values are distinguished and the positions of the catholic and the evangelic churches in relation to the issues are explained. Both G11 books consider social and individual aspects, the relevance to human dignity and to the preservation of the private sphere. These concerns may well reflect the tradition in research in human genetics and the memory of eugenics (Harwood, 1987; O' Mahony & Schäfer, 2005). Reflecting similar concerns, G11-1 approached the historic problem of the eugenic interventions in Germany: "*In the Action T4 in 1942 more than 70 000 of "sick" people were killed by SS doctors"* (p. 111), followed by the allusion to the threat of genetic determinism contained in the statement: "*Discuss why in this textbook the term "hereditary" but always "genetic" disease" is never mentioned* "(p. 111). This textbook approached controversial aspects by exploring its examples and by raising open questions, thus prompting debate and research. The variety in the provision of *external information sources* by G11-1 was remarkable and reflected the active debate on genetic issues in Germany (Eurobarometer, 2006; Hansen, 2006; O'Mahony & Schäfer, 2005; Peters, Lang, Sawicka & Hallman, 2007). Particularly significant is the establishment of connections between the S&T outputs and society. Therefore, despite the weak performance concerning S&T inputs, their outputs and implications in society were well illustrated (contextualized and socially referenced), deviating from the DSNVST. For all of that, in contrast with the Portuguese sample, which was more successful in mentioning the inputs of science, the German one presented the outputs of science and their implications in the social sphere well, both at the pragmatic and at the spiritual level.

Decision making processes . No clear differences between nationalities were found in respect of this criterion. Descriptively, the German textbooks scored higher for this criterion than the Portuguese ones, attributable to the performance of the G9 books and G11-1, in particular concerning the sub-criterion *citizen participation,* which was highly rated in G9-1. This concern with the engagement of public in *decision making* contradicted the above suggested indicators for the opposite extreme view of the DSNVST. P9-1, however, though referring to *legislation* and *agents* of decision, as a way of controlling technologies, missed attempts to engage citizens in the *decision-making process*, thereby, though inadvertently, placing the responsibility on scientists, a third indicator of the opposite extreme of the DSNVST. An explicit statement however, prompted debate: "*to understand that taking decisions involves debate about environmental, economical and social factors*" (p. 202), even though the role of public debate is not expressly mentioned. This lack of ideas might also be attributed to the attempt to reduce content.

At the G11 and P12 levels, our quantitative analysis yielded no clear distinction between nationalities regarding this criterion. Nonetheless, we see the concerns expressed by G9-1 and G11-1 with *legislation* on genetics issues, as well as their multiple suggestions and appeals to *citizen participation,* as possibly representing an expression of the German public's maturity in relation to the confrontation with genetic STSE issues and the necessity of regulating them. In respect of *international comparisons* and references of *legislation,* P12 books performed better, possibly a strategy for overcoming the inadequacy of Portuguese regulation, but no reference to local reality was provided, remaining therefore abstract to students. Only P12-2 revealed awareness of the public role in influencing decisions, by providing explicit statements such as, "*we are all required to follow and reflect about the news (...) and constantly think about the options and decisions we take*" (p. 141). G11-1 used a more inductive approach, suggesting discussion and further research, and clearly bettered the others in quantitative terms. Having ascribed relevance to *citizen participation,* German textbooks were consonant with the public attitude of rejection towards GM foods and the uses of genetic information (Eurobarometer, 2006). The German textbooks also revealed more concern in conveying to students the rights and the duties of society in respect of the regulations and control of the social use of genetics and gene-technologies, probably reflecting the tradition of active public participation in decision-making, and that also at the institutional level (Kohring & Matthes, 2002, O'Mahony & Schäfer, 2005).

Summarizing, the potential conveyance of the DSNVST by textbooks was perceivable through the detection of the following indicators:

- S&T events are disconnected from the social context, in which they took place, and inputs of society into S&T are ignored.
- The interplay between S&T is disregarded and technology is considered as a mere application of scientific knowledge.

- Social applicability of S&T (main T products) is overemphasized and high expectations towards S&T are expressed, without mentioning the constraints of processes, such as, costs of achievements and the current limitations of S&T. We consider pragmatic references of risks of S&T products, as a contra-indicator of this misconception. *iv*) Another indicator of DSNVST is the disregard for the non-consensual outputs of S&T, thus avoiding controversial issues, or presenting them from one single perspective.

With the same root of DSNVST, but on the opposite extreme, S&T are seen as alone as responsible for environmental degradation, and therefore ignores the responsibility of other agents of decision. We here consider:

- beyond frequent and sensationalistic references of environmental impacts, also sensationalistic references of risks in general, as indicators of this contrasting view.
- Oppositely, references to legislation in different contexts, mention of the agents of decision and citizen participation, while distributing decision-making responsibility to society institutions or individuals, represent indicators of a deviation from this view.

Limitations of the Study

For our study, we see two limitations of our results. The first limitation is given by our eight-book sample. As we analyzed only four textbooks per country, our results would require a larger textbook sample to be confirmed. Additionally, we focused on genetics and gene technology as our only one content regarding STSE issues. That is, we cannot exclude that analyzing other contents connected with STSE issues would result in other comparisons, for instance actual themes like climate change or marine pollution with plastics.

Conclusions

Comparing German and Portuguese textbooks revealed differences which might based on differing socio-cultural contexts. Although the German syllabi contain no prescribed outline concerning STSE issues, they are nonetheless quite well approached by textbooks: We conclude that their discourse might have been influenced to a considerable extent by the public S&T image, which in its turn may be resulted from social experience in STSE issues. In contrast, the attempt to contextualize events in respects of the inputs of science, detected in the Portuguese high school textbooks, might be attributable to the recommendation of curricular guidelines to approach STSE relationships through the exploration both of events in the history of science, and the analysis of contemporary controversial issues published by the media. The Portuguese political commitment to approaching STSE issues expressed in syllabi might result from the academic research and debate emphasising science education as a requirement for a conscientious citizenship in the last two decades (Galvão, 2001; Galvão & Abrantes, 2002), which were transferred to syllabi and guidelines in the most recent curricular reforms (2001 and 2004). On the other hand, the persisting disregard for contextualizing events by P9 books suggests, besides an attempt at simplification, an indicator of the DSNVST, and might reflect the absence of a social background in science and technology underlying the approach to the social dimension.

More generally, our findings provided evidence about the tenuous impact of research of humanistic science education on teaching practice. Despite its apparent influence on some official curriculum policies, science textbooks still impose some obstacles for the effective implementation of those principles (Abell & Lederman, 2007). The differences between nationalities among textbooks intended to serve the same purpose highlighted the influence of social factors intervening in the transference of scientific ideas to syllabi (Quessada & Clemént, 2006) as well as from syllabi to textbooks during the process of re-contextualization (Ferreira & Morais, 2013). As factors, we see the educational policies as defining curricula design, the misconceptions of science and technology that are likely to be transferred to textbooks, the monitoring or its absence of evaluation committees, and the textbook market dynamic (Brandenberg, 2006; Rego, Gomes & Balula, 2012;). This appraisal calls for the need to provide official guidance to the process of textbook writing, which in its turn, should be based upon scholars' contributions to science education and be updated according to research developments.

Our results confirm that the methods and criteria used here provide a basis for detecting the influence of these factors on discussion of STSE issues in textbooks. We expect that our outputs, when incorporated into science education and further education programs, may promote self-observation among teachers, may raise consciousness of curricula makers and textbook writers, and may sharpen the awareness of textbook reviewers. Nonetheless, similar research should be conducted, involving multiple contexts and more extensive samples, in order to confirm the suggested linkages.

Bibliografic references

Abd-El-Khalick, F., Lederman, N. G. (2000). Improving science teachers’ conceptions of nature of science: A critical review of the literature. *International Journal of Science Education*, *22*(7), 665–701.

Aikenhead, G. S. (1996). Science education: Border crossing into the subculture of science. *Studies in*

Science Education, *27*(1), 1–52.

Aikenhead, G. (2000). Renegotiating the culture of school science. In R. Millar, J. Leach & J., Osborne (Eds.), *Improving Science Education: The Contribution of Research* (pp. 245–264). Buckingham, Philadelphia: Open University Press.

Aikenhead, G. S. (2006). *Science education for everyday life: Evidence-based practice*. New York, NY: Teachers College Press.

Aikenhead, G. S. (2007). Humanistic perspectives in the science curriculum. In S. K. Abell, N. G. Lederman (Eds.), *Handbook of Research on Science Education* (pp. 881-910). Mahwah, N J: Lawrence Erlbaum Associates, Publishers.

Aivelo, T., Uitto, A. (2015). Genetic determinism in the Finnish upper secondary school biology textbooks. *Nordic Studies in Science Education*, *11*(2), 139-152.

Allum, N., Sturgis, P., Tabourazi, D., Brunton-smith, I. (2008). Science knowledge and attitudes across cultures. *Public Understanding of Science*, *17*(1), 35–54.

American Association for the Advancement of Science (1993). *Benchmarks for Science Literacy.* New York: Oxford University PressBauer, M.W. Gaskell, G. (2002). Researching the public sphere of biotechnology. In M. Bauer, G. Gaskell, (Eds.), *Biotechnology -The making of a global controversy* (pp. 1–17). Cambrigde, UK: Cambridge University Press.

Bavarian Ministry of Education (2004a). Lehrplan Gymnasium Biologie, Jahrgangsstufe 9 [Syllabus *Gymnasium* biology, Grade 9]. Wolznach: Kastner.

Bavarian Ministry of Education (2004b). Lehrpläne Gymnasium Biologie, Jahrgangsstufe 11 [Syllabus *Gymnasium* biology, Grade 11]. Wolznach: Kastner.

Bavarian Ministry of Education (2009). Hinweise für einzelne Fächer im Gymnasium [Criteria for approval of subject-specific learning materials]. Retrieved from https://www.km.bayern.de/download/11481_gymnasium_2009.pdf.

Bavarian Ministry of Education (2016a). The Bavarian school system. Retrieved from https://www.km.bayern.de/education-in-bavaria.html.

Bavarian Ministry of Education (2016b). Verordnung über die Zulassung von Lernmitteln [Regulation on approval of learning materials]. Retrieved from http://www.gesetze-bayern.de/Content/Document/BayZLV .

Bavarian Ministry of Education (2016c). Kriterien zur Begutachtung von Lernmitteln [Criteria for approval of learning materials]. Retrieved from https://www.km.bayern.de/download/7432_allgemeiner_kriterienkatalog_stand_mai_2016.pdf .

Bencze, L., Carter, L. (2011). Globalizing students acting for the common good. *Journal of Research in*

Bonoli, G. (2006). New social risks and the politics of post-industrial social policies. In K. Armingeon & G. Bonoli (Eds.), *The politics of post-industrial welfare states: Adapting post-war social policies: adapting post-war social policies to new social risks*, (pp. 3-26). Oxon: Routlege.

Brandenberg, V. (2006). *Rechtliche und wirtschaftliche Aspekte des Verlegens von Schulbüchern – mit einer Fallstudie zum bayerischen Zulassungsverfahren* [Legal and economic aspects of publishing textbooks – with the Bavarian approval system as a case study]. Nürnberg: AllesBuch.

Calado, F., & Bogner, F. (2013). A reflection on distorted views of science and technology in science textbooks as obstacles to the improvement of students' Scientific literacy. European Journal of Educational Research, 2, 51–68.

Calado, F., Scharfenberg, F., & Bogner, F. (2015). To what extent do biology textbooks contribute to scientific literacy? Criteria for analysing science-technology-society-environment issues. Education Sciences, 5, 255–280.

Calado, F., Scharfenberg, F., & Bogner, F. (2016). To what extent does genetics content in textbooks contribute to scientific literacy? Analysis of STSE issues in textbooks. Revista Portuguesa de Investigação Educacional, 16, 253–287.

Candeias, A. (1993). Políticas educativas contemporâneas: Críticas e alternativas. [Contemporary educational policy: criticism and alternatives] Faculdade de Psicologia e Ciências da Educação, Universidade do Porto. Retrieved from http://repositorio.ispa.pt/handle/10400.12/1619

Carter, L. (2007). Sociocultural influences on science education: Innovation for contemporary times. *Science Education*, *92*(1), 165–181.

Castéra, J., Sarapuu, T., Clément, P. (2013). Comparison of French and Estonian students' conceptions in genetic determinism of human behaviors. *Journal of Biological Education*, *47*(1), 12–20.

César, M., Santos, N. (2006). From exclusion to inclusion: Collaborative work contributions to more inclusive learning settings. *European Journal of Psychology of Education*, *21*(3), 333–346.

César, M. (2003). A escola inclusiva enquanto espaço-tempo de diálogo de todos e para todos [Inclusive schooling as a dialogical space-and-time from all and to all]. In D. Rodrigues (Ed.), *Perspectivas sobre a inclusão: Da educação à sociedade* [Perspectives about inclusion: from education to society] (pp. 119-151). Lisboa: Porto Editora.

Chikoko, V., Gilmour, J. D., Harber, C., Serf, J. (2011). Teaching controversial issues and teacher education in England and South Africa. *Journal of Education for Teaching*, *37*(2), 5-19.

Christidou, V. (2011). Interest, attitudes and images related to science: Combining students' voices with the voices of school science, teachers, and popular science. *International Journal of Environmental Science Education*, *6*(2), 141–159.

Cohen, J. (1968). Weighted Kappa: Nominal scale agreement with provision for scaled disagreement or partial credit. Psychological Bulletin, 70, 213-220.

Costa, Ávila Mateus (2002). Públicos da ciência em Portugal [Public(s) of science in Portugal]. Lisboa: Gradiva.

DeBoer, G. (2000). Scientific Literacy: Another Look at Its Historical and Contemporary Meanings and Its Relationship to Science Education Reform. *Journal of Research in Science Teaching*, *37*, 582–601.

Elo, S., Kyngäs, H. (2008). The qualitative content analysis process. *Journal of Advanced Nursing*, *62*(1), 107–15.

Fensham, P.J. (2002). Time to Change Drivers for Scientific Literacy. *Canadian Journal of Science, Mathematics and Technology Education*, *2*, 9–24.

Ferreira, S., Morais, A. M. (2013). The nature of science in science curricula: Methods and concepts of analysis. *International Journal of Science Education*, *35*(16), 1–22.

Fontes, M. (2005). The process of transformation of scientific and technological knowledge into economic value conducted by biotechnology spin-offs, *Technovation*, *25*, 339–347

Galvão, C. , Neves, A, Freire, A. M., Lopes, A. M., Santos, M. C., Vilela, M. C., Oliveira, M. T., Pereira, M. (2001). Orientações curriculares para o 3º ciclo do ensino básico: Ciências físicas e naturais [Curricular guidelines for the 3rd. cycle of basic education: Natural and physical sciences]. Ministério da Educação - Departamento da Educação Básica. Retrieved from:

http://www.dge.mec.pt/sites/default/files/ficheiros/eb_cfn_orient_curriculares_3c_0.pdf

Gardner, P. L. (1990). The technology-science relationship: Some curriculum implications. *Research in Science Education*, *20*(1), 124–133.

Gaskell, P.J. (1992). Authentic science and school science. *International Journal of Science Education*, *14*(3), 265–272.

Gaskell, G., Stares, S., Allansdottir, A., Allum, N., Corchero, C., Jackson, J. (2006). *Europeans and biotechnology in 2005: patterns and trends: final report on Eurobarometer 64.3*. Retrieved from https://ec.europa.eu/research/biosociety/pdf/eb_64_3_final_report_second_edition_july_06.pdf

Gericke, N. M., Hagberg, M., dos Santos, V. C., Joaquim, L. M., El-Hani, C. N. (2014). Conceptual variation or incoherence? Textbook discourse on genes in six countries. *Science & Education*, *23*(2), 381-416.

Gil-Pérez, D., Vilches, A., Fernández, I., Cachapuz, A., Praia, J., Valdés, P., Salinas, J. (2005). Technology as 'applied science'. *Science & Education*,*14*(3-5), 309-320.

Gonçalves, M. E., Castro, P. (2009). Local is beautiful? Governing science-society relations in Europe. *Portuguese Journal of Social Sciences*, *8*(2), 191–207.

Green, W., Naidoo, D. (2008). Science textbooks in the context of political reform in South Africa: Implications for access to science. *Science Education International*, *19*(2), 235–250.

Hansen, J. (2006) Operationalising the public in participatory technology assessment: A framework for comparison applied to three cases. *Science and Public Policy*, *33*(8), 571–584.

Harding, S. (1998). Multiculturalism, postcolonialism, feminism: Do they require new research epistemologies? *The Australian Educational Researcher*, *25*(1), 37–51.

Harwood, J. (1987). National styles in science: Genetics in Germany and the United States between the World Wars. *Isis*, *78*(3), 390-414.

Hodson, D (1998). Science fiction: The continuing misrepresentation of science in the science school curriculum. *Journal of Curriculum Studies*, *28*(2), 115–135.

Hollingsworth, S. (1989). Prior Beliefs and Cognitive Change in Learning to Teach. *American Educational Research Journal*, *26*(2), 160–189.

Höttecke, D., Silva, C. C. (2011). Why implementing history and philosophy in school science education is a challenge: An analysis of obstacles. *Science & Education*, *20*(3-4), 293–316.

Inglehart, R. (1990). *Culture shift in advanced industrial society*. Princeton University Press.

Institute, E. T. U. (2012). *Benchmarking working Europe 2012*. ETUI. Retrieved from http://www.etui.org/Publications2/Books/Benchmarking-Working-Europe-2012

Jenkins, E. W. (1992). School science education: towards a reconstruction. *Journal of Curriculum Studies*, *24*(3), 229–246.

Jungbauer, W. (2007). *Netzwerk – Biologie 9*. Braunschweig: Westerman Schroedel Diesterweg.

Kim, M., Roth, W. M. (2008). Rethinking the ethics of scientific knowledge: A case study of teaching the environment in science classrooms. *Asia Pacific Education Review*, *9*(4), 516–528.

Knain, E. (2001). Ideologies in school science textbooks. *International Journal of Science Education*, *23*(3), 319–329.

Kohring, M., Matthes, J. (2002). The face (t) s of biotech in the nineties: how the German press framed modern biotechnology. *Public understanding of Science*, *11*(2), 143-154.

Kolstø, S. D. (2001). Scientific literacy for citizenship: Tools for dealing with the science dimension of controversial socioscientific issues. *Science Education*, *85*(3), 291–310.

Kurzer, P., Cooper, A. (2007). What's for dinner? European farming and food traditions confront American biotechnology. *Comparative Political Studies*, *40*(9), 1035-1058.

Lakin, S., Wellington, J. (1994). Who will teach the “nature of science”?: teachers’ views of science and their implications for science education. *International Journal of Science Education*, *16*(2), 175–190.

Lakoff, G., & Johnson, M. (1980). The metaphorical structure of the human conceptual system. *Cognitive Science*, *4*(2), 195–208.

Landis, J. R., Koch, G. G. (1977). The measurement of observer agreement for categorical data. *biometrics*, 159-174.

Leach, J., Millar, R., Ryder, J., Séré, M.-G. (2000). Epistemological understanding in science learning: the consistency of representations across contexts. *Learning and Instruction*, *10*(6), 497–527.

Lee, H., Yoo, J., Choi, K., Kim, S.-W., Krajcik, J., Herman, B. C., Zeidler, D. L. (2013). Socioscientific issues as a vehicle for promoting character and values for global citizens. *International Journal of Science Education*, *35*(12), 2079–2113.

Leite, L. (n.d.). History of science in science education: Development and validation of a checklist for analysing the historical content of science textbooks. *Science & Education*, *11*(4), 333–359.

Liberg, C., af Geijerstam, Å., Folkeryd, J. W. (2007). A linguistic perspective on scientific literacy. In C. Linder, L. Östman P. Wickman (Eds.), *Promoting Scientific Literacy: Science Education Research in Transaction* (pp.42-46). Proceedings of the Linnaeus Tercentenary Symposium. Uppsala: Geotryckeriert. Retrieved from http://uu.diva-portal.org/smash/get/diva2:40649/FULLTEXT01.pdf#page=40

Manger, A., Manger, J., Moßer, H., Staudinger, J. (2007). *Natura 9 – Biologie für Gymnasien* [Natura 9 Biology for *Gymnasien*]. Stuttgard: Ernst Klett Verlag.

Markert, M. (2013). History of science in school biology textbooks: Characteristics and consequences. In P. Heering, S. Klassen, D. Metz (Eds.), *Enabling scientific understanding through historical instruments and experiments in formal and non-formal learning environments* (pp. 313–322). Flensburg: Flensburg University Press.

Maiztegui, A. (2002). Papel de la tecnología en la educacoón científica: Una dimensión olvidada [The role of technology in science education: A forgotten dimension]. *Revista Iberoamericana de Educatión*, *28*, 129–158.

Mendes, A. M. P., Rebelo, D. H. V., Pinheiro, E. J. G. (2004). Programa biologia 12o ano. [Biology Syllabus 12th grade] Retrieved from

http://www.dgidc.min-edu.pt/data/ensinosecundario/Programas/biologia_12.pdf

Menezes, I. (2003). Civic education in Portugal: curricular evolutions in basic education. *JSSE-Journal of Social Science Education*, *2*(2).

Miller, J. D. (1998). The measurement of civic scientific literacy. *Public Understanding of Science*, *7*(3), 203–223.

Miller, J. D., Pardo, R., Niwa, F. (1997). *Public perceptions of S&T: A comparative study of the European Union, the United States, Japan, and Canada*. Bilbao: Fundación BBV.

Portuguese Education Ministry (ME). (2007). Diário da República, 1.ª série — N.º 136 — 17 de Julho de 2007. Retrived from

http://www.dge.mec.pt/sites/default/files/ManuaisEscolares/2007_decretolei_261.pdf

Morris, H. (2014). Socioscientific issues and multidisciplinarity in school science textbooks.

International Journal of Science Education, *36*(7), 1137–1158.

OECD. (2008). Education at a glance 2008: OECD Indicators. Retrieved from https://www.oecd.org/education/skills-beyond-school/41284038.pdf

Osborne, J., Collins, S., Ratcliffe, M., Millar, R., Duschl, R. (2003). What ”ideas-about-science” should be taught in school science? A Delphi study of the expert community. *Journal of Research in Science Teaching*, *40*(7), 692–720.

Osborne, J.; Dillon, J. (2008). *Science Education in Europe: Critical Reflections.* London: The Nuffield Foundation.

OSC (Office of the Standing Conference of the Ministers of Education and Cultural Affairs of the Länder in the Federal Republic of Germany, 2005). *Bildungsstandards im Fach Biologie für den Mittleren Bildungsabschluss* [Standards of biology education for secondary school]. Munich, Germany: Luchterhand.

Pedretti, E., Nazir, J. (2011). Currents in STSE education: Mapping a complex field, 40 years on. *Science Education*, *95*(4), 601–626.

Pepinsky, T. B. (2013). The global economic crisis and the politics of non-transitions. *Government and Opposition*, *47*(02), 135–161.

Pingel, F. (2010). *UNESCO guidebook on textbook research and textbook revision*. Unesco. Retrieved from http://unesdoc.unesco.org/ulis/cgi-bin/ulis.pl?catno=117188&gp=1&mode=e&lin=0

Prpic, K. (2011). Science, the public, and social elites: How the general public, scientists, top politicians and managers perceive science. *Public Understanding of Science*, *20*(6), 733–750.

Quessada, M.-P., Clément, P. (2006). An epistemological approach to french syllabi on human origins during the 19th and 20th centuries. *Science & Education, 16*(9-10), 991–1006.

Reeves, R. G., Denton, J. A., Santucci, F., Bryk, J., Reed, F. A. (2012). Scientific standards and the regulation of genetically modified insects. *PLoS Neglected Tropical Diseases*, *6*(1), e1502. http://journals.plos.org/plosntds/article?id=10.1371/journal.pntd.0001502

Reis, P., Galvão, C. (2004). The impact of socio-scientific controversies in Portuguese natural science teachers' conceptions and practices. *Research in Science Education*, *34*(2), 153–171.

Roberts, R. (1995). 'Public involvement: from consultation to participation'. In F. Vanclay D.A. Bronstein (eds.), *Environmental and Social Impact Assessment* (pp. 221-46). New York: Wiley.

Roberts, D.A. (2007). Scientific literacy. In S. K. Abell, N. G. Lederman (Eds.), *Handbook of research on science education* (pp. 729–780). Mahwah, NJ: Lawrence Erlbaum Associates.

Rudolph, J. L. (2003). Portraying epistemology: School science in historical context. *Science Education*, *87*(1), 64–79.

Sadler, T. D., Zeidler, D. L. (2004). The morality of socioscientific issues: Construal and resolution of genetic engineering dilemmas. *Science Education*, *88*(1), 4–27.

Sadler, T. D., Zeidler, D. L. (2009). Scientific literacy, PISA, and socioscientific discourse: Assessment for progressive aims of science education. *Journal of Research in Science Teaching*, *46*(8), 909–921.

Santos, B. D. S., Nunes, J. (2004). Introduction: Democracy, participation and grassroots movements in contemporary Portugal. *South European Society and Politics*, *9*(2), 1–15.

Stinner, A. (1995). Contextual settings, science stories, and Large Context Problems: Towards a more humanistic science education. *Science Education*, *79*, 555-581.

Sturgis, P. J. and Allum, N. C. (2001) "Gender differences in scientific knowledge and attitudes toward science: Reply to Hayes and Tariq," *Public Understanding of Science*, *10*(4), 427–30.

Szanto, T. (1993). Value communities in science: The recombinant DNA case. In T. Brante, S. Fuller, & W. Lynch (Eds), *Controversial Science: From Content to Contention* (pp. 241–263). New York: State University of New York Press.

Transgénicos fora: plataforma por uma agricultura sustentável [Transgenics out: Movement for a sustainable agriculture]. Retrieved from http://www.stopogm.net/

Turner, S. (2008). School science and its controversies; or, whatever happened to scientific literacy? *Public Understanding of Science*, *17*(1), 55–72.

Vazquéz-Alonso, Á.; Massanero-Mas, M.; Acevedo-Díaz, J. (2006). An Analysis of complex multiple-choice Science-Technology-Society items: Methodological development and preliminary Results. *Science Education*, *90*, 681–706.

Wellington, J. (1991). Newspaper science, school science: friends or enemies? *International Journal of Science Education*, *13*(4), 363-372.

Yates, T. B., Marek, E. A. (2013). Is Oklahoma really OK? A regional study of the prevalence of biological evolution-related misconceptions held by introductory biology teachers. *Evolution:*

Education and Outreach, *6*(1), 1-20.

Zeidler, D.; Sadler, T.; Simmons, M.; Howes, E. (2005). Beyond STS: A research-based framework for socio- scientific issues education. *Science Education*, *89*, 357–377.

Appendix

Chi square tests of comparing national textbook pairs regarding page numbers and ratio statement frequencies per relevant page numbers

Textbook pair	Comparison of			
	page numbers		ratio statement frequencies per relevant page numbers [b]	
	Chi square	*p* value	Chi square	*p* value
G9-1 / G9-2	0.222	.890	0.001	.999
G11-1 / G11- 2	0.923	.630	14.426	< .001
P9-1 / P9-2	2.200	.330	0.594	.640
P12-1 / P12-2	2.142	.340	0.484	.780

[a] *df* = 2 in each case. [b] Ratios: G9-1 341/38 = 9.0; G9-2 308/34 = 9.1; G11-1 452/72 = 6.3; G11-2 270/84 = 3.2; P9-1 148/33 = 4.5; P9-2 131/22 = 6; P12-1 346/102 = 3.4; P12-2 387/124 = 3.1.

Own Contribution

The first sub-study (A) was conceived and developed by myself. This included the concept analysis, the extraction of contents and misconceptions as well. In the second sub-study (B), I conceived autonomously the research questions and hypothesis, and developed a set of criteria for supporting both a qualitative and a quantitative science textbook analysis in the domain of STSE issues, as well as an excel tool for supporting the analysis technically. The same is true for two German textbooks. For obtaining the inter-rater reliability I have involved a biology teacher, my colleague Isidoor Gijsbrechts. The sub-studies C and D were again designed by myself. I determined the theoretical frame, the research questions and the hypothesis, as well as the recording of data and the corresponding posterior analysis and interpretation. Of course, all sub-studies were undertaken under the supervision of Prof. Bogner. The computation of the Cohen's Kappa coefficient for obtaining reliability scores, as well as the computation of adjusted Pearson's contingency was carried out by Dr. Scharfenberg, while the analysis and the interpretation of results were carried out by myself.

(§ 5 Nr. 4 PromO)

Hiermit erkläre ich, dass keine Tatsachen vorliegen, die mich nach den gesetzlichen Bestimmungen über die Führung akademischer Grade zur Führung eines Doktorgrades unwürdig erscheinen lassen.

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Hiermit erkläre ich mich damit einverstanden, dass die elektronische Fassung meiner Dissertation unter Wahrung meiner Urheberrechte und des Datenschutzes einer gesonderten Überprüfung hinsichtlich der eigenständigen Anfertigung der Dissertation unterzogen werden kann.

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Bayreuth, 17. 12. 2018

Florbela Calado