Cultural History of Science: A Possible Path for Discussing Scientific Practices in Science Teaching?

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Several researches in Science Education have pointed to the importance of teaching both the scientific content and the issues about the building process of science. A path indicated to concretize this aim is the introduction of History, Philosophy and Sociology of Science (HFSC) in basic education. More recently, proposals have brought the study on science practice to the center of this debate, bringing issues that advance in relation to methodological approaches guiding the study on Science in Science education. To contribute to the debate on this subject, this work aims to explore paths to approach the History of Science, supporting pedagogical interventions, in which scientific practices are key elements. To fulfill this goal, we developed a theoretical paper that, based on the literature of the field, discusses Science Teaching objectives in basic education; then, it brings considerations regarding the concept of scientific practice and how it fits into the goals of science education. Finally, we turn to historical contemporary studies, which point out the historiographical approach named as Cultural History of Science could be a path to include issues related to scientific practices, aiming a Science Education that promotes citizenship link to public issues focused on social welfare.

Keywords: Cultural History of Science; Scientific Practices; Science Teaching.

Introduction

Over the last decades, several researches related to science education have pointed out the relevance of teaching both the scientific contents and the issues concerning building process of science (OSBORNE et al, 2003; LEDERMAN, 2007; McCOMAS, 2008; ALLCHIN, 2011; 2014; HODSON, 2014). These studies were highly influenced by the so-called "Science studies" (RUDOLPH, 2014)[1], and brought to science education the debate on what teaching about science (OSBORNE et al, 2003) or otherwise, about the so-called "Nature of Science", which, according to McComas (2008, p. 249) can be

1 "Science Studies" or "Science and Technology Studies" (also known by the acronym STS) is a subject dedicated to understand science and how it functions, as well as its interactions with society. They are qualified as a subject in a more evident manner from the 1960's. (RUDOLPH, 2014)

defined as:

> ....NOS is defined as a hybrid domain which blends aspects of various social studies of science including the history, sociology and philosophy of science combined with research from the cognitive sciences such as psychology into a rich description of science; how it works, how scientists operate as a social group and how society itself both directs and reacts to scientific endeavors (McCOMAS, 2008, p. 249).

From this line of studies with a relevant effect on the *curriculum* development in several countries (AAAS, 1993/2009; NRC, 2012; LEDEN; HANSSON, 2015), one of the emerging proposals was that it was possible to teach about the Nature of Science (NOS) from a synthesis on scientific endeavor, which is translated into a list of tenets. Even acknowledging the lack of consensus on what science is and how it develops, those who support this approach argue that these are consensual principles among specialists in the subject and, for this reason, they can guide the science study (OSBORNE et al, 2003; McCOMAS, 2008; LEDERMAN, 2007). This list was known as the consensus view concerning NOS, and empirical researches were developed from this theoretical approach (DURBANO; CARVALHO; PRESTES, 2013; EL-HANI; TAVARES; ROCHA, 2004). However, over the last years, researches criticized this model (IRZIK; NOLA, 2011; 2014; ALLCHIN, 2011, 2014; MARTINS, 2015a; 2015b; DAGHER; ERDURAN, 2014; 2016), thus raising a debate on the subject.

Along with the debate about which aspects to approach on NOS, the research in the educational field points out that History, Philosophy and Sociology of Science (HFSC) are relevant paths to enable NOS study in basic education. Thereby, in the literature, we find different proposals using HFSC: historical controversies (BRAGA; GUERRA; REIS, 2012; DURBANO; CARVALHO; PRESTES, 2013), which highlight different views on a specific experiment or scientific fact; historical narratives (KLASSEN, 2007; SCHIFFER; GUERRA, 2015), where episodes of the history of science are explored by way of literary texts; historical experiments (HEERING, 2015; SOUZA; SILVA; ARAUJO, 2014), where one aims to approach the historical development of science by reproducing and discussing historical experiments; specific historical episodes (SILVA; MOURA, 2008; SOUZA; PORTO, 2012), among others. Whether in accordance or not with the consensus view, almost all these works and the implementation of these strategies were guided by the relevance of building paths to enable NOS study. In a sense, one could say that the research on the use of the history of science in the classroom has been intensely associated to discussions about NOS over the last decades. However, one should accept that this connection is not mandatory.

To discuss this issue, one should highlight that, at the time, the debate on what teaching about NOS faces some issues, such as the relevance of the NOS term itself. Authors like Irzik and Nola (2011) say that the consensus view perspective assumes the existence of an essence for science, which is deemed as problematic if we understand the differences between sciences and find them within a process of historical development. Like Allchin (2011), we believe that the term "Nature of Science" brings such characteristic itself. In addition to this review, many other were addressed to the consensus view. Some of them focused on the incoherence between the own tenets: how science can be self-correcting without a standard path by which it is built? If science has a subjective element, does it preclude objectivity? If not, why? (IRZIK; NOLA, 2011; MARTINS, 2015a; 2015b). Other reviews were specifically addressed to the functionality and practical usefulness of the assertions included in the consensus view for scientific decision-makings. Example: how distinction between law and theory can lead to an assessment on the reliability of science information in real-life situations for decision-making? (ALLCHIN, 2011)

These considerations show that the link between the History of Science and the Teaching to discuss about NOS is not trivial, even when we support that introducing History of Science is important to set pedagogical practices, whose main purpose is encouraging debates about science. In addition, current curricular developments such as the "*Next Generation Science Standards*"[2] (NGSS) point out to the insertion of scientific practices in the *curriculum* as a key component of science teaching. It indicates changes regarding the previous readings of these documents, whose emphasis was on NOS when dealing with science subjects (LEDERMAN; LEDERMAN, 2016). In our view, this referral of shift in emphasis brings issues to be addressed by the works focused on history. That is, considering this curricular movement to occur in the sciences' teaching community, the studies focused on the historical approach in science teaching should observe the study about which strategies based on science's history should be used in science teaching to promote discussion on scientific knowledge output.

Even considering that having scientific practices as a driving shaft for teaching may be a temporary trend, we still believe that discussions on the problematic of scientific practice may lead to relevant considerations about science teaching. In the first place, it is worth highlighting that there are several possibilities to choose when the emphasis is on scientific practices. One of them – which we chose here – would be building paths that highlight its dynamic feature based on a historical view (GALISON, 1987; DASTON, 2008; PIMENTEL, 2007). Therefore, we believe that the emphasis on scientific practice can bring a successful perspective to the debate about science issues, as it may address to it alternate ways that follow essentialist characterizations of scientific knowledge.

However, changing the focus from the essence of science to scientific practices pose challenges regarding the development and implementation of historical approaches within the classroom. It occurs because shifting the focus changes a common practice in many empirical works of this field, that is: highlight the aspects about science building that would be applied and aligned to the pedagogical goals aimed in the classroom (FORATO; MARTINS; PIETROCOLA, 2011; 2012), and create the narrative on such

2 NGSS (Next Generation of Science Standards) are standards or goals that indicate what a student show know about sciences and what it should be able to do. These standards were published in 2013 based on the frameworks for Science Education in Basic Education. (Framework for K-12 Science Education). Source: <http://www.nextgenscience.org/get-to-know>

aspects (SILVA; MOURA, 2008; SCHIFFER; GUERRA, 2015).

To contribute to the debate on the subject, this study aims to create inputs able to answer the question: which approach of the History of Science can support pedagogical interventions that consider scientific practices as a key element to implement in science education?

To achieve this aim, based on the literature of the field, firstly we set our assumptions on the goals of teaching science in basic education. Then, we clarified our knowledge about scientific practice and how it fits into the goals of science education that we support in this paper. Finally, we turned to historical and historiographical contemporary studies to outline answers to the main issue of this article.

Teaching Science in XXI century: calling a debate

Recent studies (MARTINS, 2015b; MARTINS; RYDER, 2014) set a triad of relevant questions to science research and teaching, which would be: "why", "what" and "how" teaching sciences, taking into account the need of thinking about metascientific issues in science teaching.

In these triad, "how" refers to the methodological issues of teaching, didactic and practice; "what" refers to the selection of subjects, issues and contents that should be included the science *curriculum*, and "why" relates to the reasons of studying sciences in basic levels of general education. Studies of Martins (2015b), and Martins and Ryder (2015), without building a values scale between the three questions concerned, focus on the question "what" teaching about sciences. Thereby, if the purpose is studying meta-scientific issues, they address discussions about the criteria to choose the contents that should be included in the *curriculum*. Just like the authors, we believe that the three questions are inseparable and that in specific studies, such as the ones they developed; it is possible to focus on one of the questions, without subordinating or neglecting the others.

In this paper, we thought important focusing on "why" teaching sciences in basic education. Most of the time when this question is asked, the answers, in a specific consensus of the field, are directed toward the citizenship link, that is, training youths so they can deal with science-related issues (RUDOLPH; HORIBE, 2016). Therefore, as indicated by Rudolph and Horibe (2016), there is lack of clarity and consensus on what citizenship link means when dealing with scientific issues.

In the literature about science teaching and NOS, there are many different comprehensions on this regard. Allchin (2011; 2014), for example, argues that science education for citizenship should create ways that enable students to "interpreting the reliability of scientific claims in personal and public decision making" (ALLCHIN, 2014, p.521). According to him, many controversial issues about science show that students need to understand how science works, whether as citizens or consumers. Vesterinen, Tolppanen and Aksela (2016) point out that there is a profusion of dissimilar views regarding science education for citizenship, but they support that the most common rhetoric in these studies is that learning sciences should apply to decide on issues within science. Unlike the majority of studies that state what is a citizen scientifically informed, Rudolph and Horibe (2016) argue that civic engagement, which is typical of citizenship, should only relate to decision-making of public interests that aims to promote commonwealth, instead of relating to strictly personal decisions. In this sense, science education should focus on an in-depth study on rationalization and skills related to decision-making of public interest issues, what would be different from the skills used to make personal decisions and not decisions necessarily intended to the commonwealth (RUDOLPH; HORIBE, 2016). According to the authors, it would imply a shift of focus in science teaching, which should turn both to promote understanding on how scientists and specialists get meanings from evidences in their studies, and to highlight the role of social and institutional context in the building of science (*idem*).

Like the other studies, we support as a key goal for teaching sciences (and teaching about sciences), the formation of citizens able to make decisions involving scientific subjects, specifically about public interest issues, such as indicated by Rudolph and Horibe (2016). We consider that one of the starting points for that formation is the knowledge of its cultural heritage. To operate in the world in a conscious manner, it is necessary to know the origin of the questions asked in the time and space we are immersed in. These issues are linked to the culture where we live, which in this study means a net to which men and women are connected, and while this net determines the actions of these men and women, it is formed by them (GEERTZ, 1989). In this perspective, to decide consciously on public interest issues, the citizen needs to recognize what are the basis – connected to the culture it is immersed – to answer the questions of its time and space.

We assume that the paths to formulate the answers to the questions of our time and space are connected to a dynamic network, where historical features are included, but that are also formed by active actions from agents of the present time. Like Galison (1999), we believe that there are historical conditions of possibilities that outline how behaviors and concepts depend on each other. These are specific conditions to each historical time. However, they are associated to cultural heritage, which makes the historical study essential to discuss which historical contingencies are present in each historical moment. As we agree with authors like Milne (2011) and Reis, Guerra and Braga (2006) that sciences are part of the culture of our time and space, we believe that sciences are part of these dynamic basis that develop questions and answers that we face in our world. Thereby, we argue that contextual study **about** sciences in basic education is essential, so that classrooms (and other educational spaces) can be places to think about the issues addressed by sciences and on the answers built over time, highlighting the possibilities and limits of this knowledge. We support that it is essential to arrange a space for critical thinking about science in the classroom, enabling the application of its practices as an instrument to see the problems and dilemmas of the contemporary society, as well as to discuss, in a more comprehensive way, the own scientific practices and the relations that science builds with other institutions and with the world.

From this argument about why studying sciences in basic education, we agree with the authors who support that science education purposes should exceed the conceptual and even the epistemological knowledge, thus going to a social and political knowledge (RUDOLPH; HORIBE, 2016). This approach could consolidate the humanistic vision of science teaching (AIKENHEAD, 2006), to which we agree.

As we argue that science is a cultural product, science study should be based on its dynamic character, thus surpassing the so-called methodological science approaches (McGUIRE; TUCHANSKA, 2013), which used to take science out of context and create theoretical frameworks by which the scientific development of any period could be understood. We support that the focus of science studies in basic education is on the changes that this knowledge faced, thus underlining that there is space for changes in how to develop scientific researches, and that they may occur even by the influence of non-scientists, that is, of citizens (RUDOLPH, HORIBE, 2016).

For this reason, we think that, both the proposals for implicit science teaching, the so-called "teaching with NOS" (ABD-EL-KHALICK, 2013), and the idea of authentic science (CRAWFORD, 2012; 2013); do not include all goals of citizenship link in the sense that we previously supported. Crawford (2012; 2014) says that the term "authentic science" refers to the building of educational experiences that comprise more characteristics of the true scientific endeavor. In other words, "to using data and logic to create an explanation for something not known or understood, and use skepticism about the best explanations or applications to society" (CRAWFORD, 2014). Gilbert and Justi (2016) add that it would mean "to approach science education as close as possible to the process of science itself" (p.43). Therefore, such perspective would encourage students to engage in the thought and practices related to the validation of this knowledge, highlighting the creativity role and promoting the understanding of phenomena and entities in the "real world" (GILBERT, JUSTI, 2016). The application of this perspective would lead to a transformation of traditional and static classrooms into classrooms with more dynamic interactions between the students and the professor (CRAWFORD, 2012).

Although we do not deny the advantages of such perspective, including the ones related to the in-depth study on the ability to develop the critical role to science – which is essential to scientifically informed decision-makings – we argue that approaching practices in classrooms as most as possible to the real scientists' practices do not ensure, by itself, its epistemological perception, nor enables the understanding of science as sociohistorical and cultural constructs. Thereby, we support the relevance of an external view to scientific practices that enable to analyze how science functions and the effect of its products on the society, in addition to the reliance on the products created for society´s demands.

In this sense, it is essential to explore historical context of scientific output, as well as its relations with other cultural productions that are part of this context, so as to bring thoughts about scientific practice by means of the history of science. We will develop this argument later. For now, it is important to define what we believe as scientific practice.

Considerations about scientific practice

In a recent essay, Stroupe (2015) points out that today there is a centrality of the discussion about scientific practices in science education. This centrality is found in several proposals of national *curricula*, such as the Next Generation Science Studies (2013) and the Organic Law on the Improvement of Educational Quality (LOMCE)[3], and it is also found in research findings about this problematic, which are published and analyzed in several countries.

According to some authors (STROUPE, 2015; ERDURAN, 2015), there is little consensus on this subject. For this reason, one needs to explain the scientific practices idea guiding this study. We will build this approach by bidding elements from several views regarding the subject that we intend to converge in several points with the science education perspective previously supported.

Within this context, Collins (2015) argues that after the World War II, there was a process that raised scientific argument and, as a result, took scientists to an authority level when it comes to "natural world". This particularity raised a question: what makes scientific endeavor special before other human cultural productions? Even if it comes to a problematic initially related to epistemology, it reflects in science teaching, which aims teaching about sciences. Despite all science knowledge be necessarily transformed before reaching classrooms (FORATO, MARTINS, PIETROCOLA, 2011), we consider that this type of discussion, because of its complexity, cannot be reduced – in cases of didactic mediation – to guide students to the right views about scientific practice. Even because it is not possible setting a list able to provide accurately what matters in respect of scientific practices (FORD, 2015). According to Stroupe:

> Merely exposing students to definitions of scientific practice, or having students complete activities in which the sole purpose is to confirm canonical information, is not the same as providing opportunities for students to learn scientific practice by engaging in authentic disciplinary work over time. (STROUPE, 2015, p. 1036)

For this reason, we consider that any pedagogic intervention aiming to discuss scientific practice should promote dialogue, thus changing classrooms into privileged spaces for debates about science and its practices. This dialogical attitude suits best to the belief that scientific practices are not completely susceptible to description. They have some regularity and are characterized mainly by the ongoing process of assessment and reviews on the explanations that science provides (FORD, 2015). As comprehensive sets

3 LOMCE is a Spanish acronym of "*Ley Organica para la Mejora de la Calidad Educativa*". It is a set of measures to improve education quality in Spain. In particular, there is a publication of January of 2015 setting skills, contents and criteria to assess several educational levels, among which there are many mentions to scientific practices or their elements. Source: <http://www.boe.es/buscar/act.php?id=BOE-A-2015-738>.

of behaviors and social practices, scientific practices include performances, which are acts of thinking or action that may be assessed by the rules as being part of a practice, that is, they are measured according to their ability of working with another performances to produce meaning and progress knowledge (*op. cit.*). Measurements made by using scientific argument, for example, are performances that are part of scientific practices as they produce results that, when linked to other knowledge already built, will produce new meanings in the science.

However, scientific practices are not restricted to experimental activities. Science is work and, as such, scientific practices are generally similar to other labor practices. Mody (2015), for example, points out that if we look to the skills that seem to belong to successful scientists, we will note that much of them are specific to science field, but many others are not. Scientists read, write, speak and discuss with their colleagues in scientific meetings. In these places, they join the debates to teach and convince other scientists and spread their ideas. Therefore, a recurring action of scientific practices is formulating questions about other scientists' arguments and build-up arguments to support their ideas (MODY, 2015).

Thereby, Mody's (2015) argument confirms our view that studying scientific practices is only possible by means of debate. In addition, as the author highlights, researches show that science, as it is usually introduced to the students – as widely rational, ruled and oriented to demonstrate settled knowledge – is much more welcomed by male, heterosexual and white students or, otherwise, is separated for the students who do not fit this profile. In this case, it is worth reminding what we supported above: school science should not aim the education of mini-scientists, but of citizens. Some of these citizens may probably become scientists. In any case – whether becoming scientists or not – students should be able to perform several activities in their careers, such as reading, managing uncertainties, expressing arguments in a clear and convincing manner, persuading colleagues, working in groups, subjecting both their own ideas and the ideas of colleagues to analysis and even learn new skills (MODY, 2015).

When addressing scientific practices in sciences teaching, we consider that epistemic issues involved in scientific development do not separate from cultural and social-institutional matters of scientific endeavor (DAGHER; ERDURAN, 2014). Thereby, as we saw before, scientific practices are not limited to performing skills, such as instruments and variables handling or the interpretation of data and graphics, but they are limited to the association between these performances and the cultural and social - institutional factors able to produce valid meanings in the scientific community. This articulation is historical par excellence, once culture, institutions and their roles change over the time and space where they are built. By considering scientific practices as a set of actions immersed in this space-time in which sciences are developed, we agree with Pimentel (2007) in the sense that these practices necessarily change through the history.

Thereby, not only the issues addressed by sciences change. The strategies to answer the questions and the ways of exposing these answers also change. As the experiments, for example, one may note substantial changes (as the creation of new techniques and instruments), leveraging different research possibilities in each context. The advancement of spectroscopy in the 19´s was an example. According to Jensen (2005), the use of gas burners in science date from the 20´s of XIX century, when gas lighting starts to be used in the major cities of Europe. This alone already brings a new element that changes practices, which become feasible and/or ordinary in the laboratories of that context. However, by mid-XIX century, Robert Wilhelm Bunsen (1811 – 1899), in cooperation with Henry Enfield Roscoe (1833 – 1915), proposed a gas burning apparatus – the Bunsen Burner – which, unlike the previous ones, produced a hotter, colorless, soot-free flame having an approximate constant length (JENSEN, 2005). Such apparatus enabled an in-depth research in spectroscopy, thus raising new questions about experiments and new performance types in scientific practice.

In addition, communication between scientists is essential to sciences formation. Moreover, communication changes over time, thus changing scientific practices. Galison (1987) points out that, unlike many years ago, when letters had an important role in the communication among scientists, for example, today is the e-mail that plays the role of this type of communication. We would also add the use of social networks (academic networks – such a *Research Gate*, *Academia.edu*, *Edmodo* – or non-academic networks) and instant messaging programs for mobile platforms, such as smartphones. Internet revolutionized media and the access to scientific information; and definitely, practices are not the same as those of the last decades. Likewise, changes in science dissemination bring material changes to it.

For this reason, in our opinion, analyzing and exploring scientific practices in educational situations without properly considering the historicity of such practices would make us back to the reductionism science problem related to essentialist issues, something present in the reviews of certain views about the Nature of Science (IRZIK; NOLA, 2011; ALLCHIN, 2011).

To summarize, one may consider scientific practice as a set of assessment processes and review of the scientific practices themselves by which science is built. The practices include, but they are not limited to performances, that is, concrete acts or thought that are part of the daily routine of the scientist, such as measurements, data analysis, etc. There are many other actions that are part of science, but not only of it, they are also part of other labor activities, like reading, writing, talking and debating with colleagues, building social relationships, building arguments and counter-arguments for your scientific propositions and propositions of others. This set of practices – that aims consensus, even if temporary ones – is completely immersed in social-institutional relations and surrounded by the culture of a specific space-time, so without them, the study and analysis of these practices makes no sense.

Cultural History of Science and its effects on teaching

As argued in the previous section, scientific practices approach in science education should not waive thoughts able to highlight the temporary character of such practices. Thereby, the history of sciences shows itself to be an important tool to consider. However, due to the plurality of perspectives of applying the history of sciences in science education, one may ask: which historiographical approach would enable us to develop the issues raised on scientific practices and science teaching? What focus for introducing history of sciences could increase the work with science issues and discussions on scientific practices? To propose answers for these questions, we firstly present some perspectives of the history of science, which, in our view, do not fit the perspective that we support for science teaching.

Thereby, the first historiographical look that we can reject relates to the history of linear science, of the "winners", which introduces sciences as a result of the work of scientists who work isolated from the world where they live, performing activities exclusively associated to a laboratory, to plant collecting, to fossils hunting, etc. Such perspective is opposed by the New Historiography of Science (KRAGH, 2001; PORTO, 2010), which is concerned on the approach of the context in which science is developed, including biographies, social relationships in which they are built and the diverse aspects that influence science and are influenced by it.

That said, if we take as an example the episode of proposing new nomenclatures for chemical compounds in France in the end of XVIII century, from the point of view of the old history of science, we could consider Lavoisier as the great agent of this process. In this perspective, Lavoisier is appointed as having created, by his own, a new nomenclature for chemistry able to separate it from the practices of pharmacists, barbers and of alchemists, thus developing an objective nomenclature that improved chemistry. Before this idea by Lavoisier, we would have a biographical description of the natural philosopher, indicating all places where he studied, his interests, how emerged the idea of creating a nomenclature standard for the existing compounds, etc. Thereby, one builds a triumphalist and one character-centered narrative. Triumphalist narratives about Lavoisier were widely used in the first half of XIX century by "historian chemists", who tried to recover isolated facts from the past to validate their own ideas, such as Adolphe Wurtz (1817 – 1884), who, by using a narrative similar to the one described above, used to argue that chemical science was eminently French. On the other hand, Jean-Baptiste Dumas (1800 –1884) used this narrative to support the dualist theory of Jacob Berzellius (MOCCELIN, 2003). At one point, such historiographical perspective of exalting specific achievements with the supposed purpose of registering specific names in the History was widely used by historian-scientists (VIDEIRA, 2007).

Another possibility of (re) construction of the history about Lavoisier would be to deny the explicit triumphalist idea about the natural philosopher, focusing the historical analysis on its academic production to highlight the paths that the author followed to build the new nomenclature. This way, the view would be exclusively on its published papers and the letters exchanged between Lavoisier and other natural philosophers of that period. Therefore, the historical analysis would be limited to epistemic issues involved in Lavoisier´s work, highlighting its thesis, theories and experiments, without privileging aspects of sociocultural context in which such scientific output occurred.

In the debate about the ways of narrating the history of science, it is important to consider the issues from philosophy of science with the reviews on the logical empiricism propositions. In the beginning of XX century, logical empiricism argued that science was a knowledge exclusively built based on empirical aspects and logical formalism, without considering issues related to scientists' beliefs and values, that is, of what they considered as subjectivism (MARCONDES, 2007). Scientific propositions should be logical and formal, and mathematics, par excellence, should be the universal language of science. For logical empiricists, in the study of building and validating scientific knowledge, the society in which the scientists were immersed was not a relevant element to be considered (*op. cit.*).

In the review made on logical empiricism, many philosophers of science, like Imre Lakatos (1922 – 1974) and Thomas Kuhn (1922 – 1966), believed that one should not separate science thinking from the social context of its production (McGUIRE; TUCHANSKA, 2013). The building of this look into the scientific endeavor was associated to the settlement of a universalist view on the building process of science. In this sense, these philosophers developed general analysis on science that used to address diverse structural explanations on how scientific knowledge was and is built. On the way of setting these frameworks, the History of Science was recurrently used as an approach able to support the frameworks built (McGUIRE; TUCHANSKA, 2013).

Still considering Lavoisier as an example, it is possible classifying specific episodes based on one or another theoretical matrix. The advancements produced by Lavoisier in the chemistry of XVIII century are always referred to as a "Chemical Revolution", in Kuhn´s sense. Authors (JENSEN, 1998; CHAMIZO, 2014) even argue that this one would not be the unique revolution that chemistry went through, but we could point out at least three revolutionary periods in this science history. According to interpretations based on Kuhn´s point of view, Lavoisier built a new paradigm, which is incommensurable to the previous one; and its incommensurability is particularly "measured" by the conceptual difference between pre and post-revolutionary theory. As Filgueiras (1995) argues, when talking about Stahl and Lavoisier´s descriptions on calcination and combustion processes: "One sees [...] the huge conceptual ditch that separates both systems, involving the idea of elementary and compound substances. According to Kuhn's opinion, a conceptual change would be a paradigm shift". That is, to reach this conclusion, a documental analysis of Lavoisier´s publications seemed to be enough. In other publications with the same viewpoint described in this study, one may note that the mere conceptual view is surpassed, including social and technical factors[4], but they end supporting the strength of the conceptual frameworks created by

4 In this regard, Chamizo (2014), for example, highlights the role of instruments in the three chemical revolutions categorized by Jensen (1998).

philosophers like Kuhn and his contemporaries.

In another perspective, historians of science of the end of XX century, aimed to develop studies not to create or support conceptual frameworks about "what science is" or "what it should be", but to describe the dynamics of the building process of the scientific knowledge. In this path, there are studies about the history of science particularly dedicated both to scientific practices and the representation forms of scientific knowledge developed in a specific context, believing that these studies reveal key issues about the science developed over there (KLEIN, 2003; GALISON, 2010; DASTON, 2008). This historiographical perspective called Cultural History of Science is based on Cultural History.

The Cultural History[5] focus on everyday practices, looking for narratives highlighting the cultural standards of a specific period. That way, it is common for us to find within this perspective, historiographical analysis focused on the history of manners, such as the ways of sitting at the table, or the history of objects, like fork and handkerchief – by which Norbert Elias (1897 – 1990) analyzes the civilizing process, for example – or even the history of popular cultures (BURKE, 2008). The Cultural History is opposed to the history of ideas, that is, the history that aims general views to explain a specific historical context is replaced by a history that, based on daily activities, aims to work these activities with more general topics about culture and society, or, as pointed out by micro historians (a cultural history´s perspective), aims to highlight the relation between the community analyzed and its external world (BURKE, 2008).

In the case of sciences, with this historiographical approach, the focus of the analysis to be implemented moves from the study of the big ideas and from scientists who set big theories, to a study considering the actions produced by the diverse agents of science. However, one includes in the historical study of science the practices on instruments and techniques used in the laboratory, the ones developed for data registering, the communications agreed among scientists to discuss the issues and publish their studies, the development of mathematical tools for analysis, representation and construction of models, among others. Such attitude should lead to the comprehension of how scientists spread their ideas, how they establish social relationships and what role the reading, writing and discourse play in scientific output (MODY, 2015). Even if these activities are typical of science, they are overshadowed by approaches that aim generalized frameworks.

At last, the focus would be on the historical analysis about cultural and material aspects of the development of scientific models and theories (KLEIN, 2003). In this line, one values the interchange among all those who direct or indirectly joined in the building of the scientific knowledge studied (GALISON, 1987, 2010). An approach of this kind, when bringing considerations about daily scientific practices of that context, does not aims to untie the epistemological issues studied from the sociocultural context of its production and settlement.

5 Here we refer to Cultural History what Burke (2008) designates as New Cultural History, considering the historicity of this own historiographical line.

According to Pimentel (2010), in the perspective of the Cultural History of Science, modern science is believed as an

> ...activity that undergone a number of social and material contigencies and that was no longer fixed to the writing and theory. It shifted from being exclusively a textual story or a story found in the books, to become a story on how such experiment was made and how it was reproduced in another space and another time, under another circumstances[6] (PIMENTEL, 2010, p. 420, our translation)

When analyzing the settlement of modern science in the light of the cultural approach of the history of science, Pimentel (2007) uses representations and mainly the scientific practices set in that period named as "Scientific Revolution", by Kunhian's viewpoint. In this sense, not only the main characters of this history stand out, but also instruments like the microscope and lunette, as well as practices like dissection and sky observation. In this historiographical perspective, these issues are essential to understand the change in scientific frameworks that occurred in that moment.

In the process that we know today as Scientific Revolution, Pimentel (2007) points out as fundamental the horizon broadening of human knowledge in three directions. With regard to the human body, microscopes and bodies dissection practice reach great proportions, thus changing the way of medical practice and the study of the human body in that period. Physicians gradually take a more practical position, by taking up duties such as the cutting of human tissues, which was previously made by barbers, specialists in bleed stop. In a second front, the use of lunette starts a new age for astronomy and knowledge production about the sky and the planetary system in which we are located. At last, great navigation bring innovation in terms of instruments (specifically nautical instruments) and the contact with new cultures, as well as the recording of new plant and animal species, what ends up improving new research fields.

All these changes – that are part of old phenomena otherwise observed, or even of new phenomena – are wrapped by an attitude rescued from classical humanism: the curiosity. In the Middle Age, curiosity was considered as vanity and sin; but in XVI century, this belief was rearranged, thus changing the attitude on the research about the natural world (PIMENTEL, 2007).

Juan Pimentel (2007) also points out new places and ways to scientific practice emerging within the context of the so-called Scientific Revolution. The anatomical amphitheaters, described one of the first times by Alessandro Benedetti in his work of 1502 (*Historia Corporis Humanis sive Anatomice*), for example, become so clearly relevant that ends up portrayed by Rembrandt in his famous painting "The Anatomy Lesson of Dr. Nicolaes Tulp" (1632). Its gradual incorporation to medical practice can be noted by the inclusion of information on these practices in the medicine treaties

6 "*actividad sometida a una serie de contingencias sociales y materiales. Y también dejaba de estar fijada a la palabra escrita y la teoría. Dejaba de ser exclusivamente una historia textual o libresca para convertirse también en la historia de cómo se realizó tal o cual experimento y cómo se replicó en otro espacio o en otro momento, bajo otras circunstancias*".

of XVI century. The botanical gardens of Universities also emerge in XVI century and maintain several new species in their collection for study, which were obtained by the European maritime expansion that started in the previous century. The cabinets of curiosity maintained by collectors expressed "the confluence between the ideas and the material culture" (PIMENTEL, 2007, p. 220, our translation), when turning into repositories of artworks, furniture, products and natural beings.

Pimentel (2007) also brings the relevance of scientific academies role in the establishment of a scientific community that led the science output through a systematic and mainly collective and social making. The laboratory, the publications and the science images, in addition to other several practices and artifacts that we directly associate to scientific practice today, arise out of this context named Scientific Revolution. With that, the author supports that more than a sudden break explained by punctual episodes centered in Nicolau Copernico or in Galileu Galilei, scientific revolution occurs in a gradual manner and mainly in the practices field, although it is evident the relevant individual contribution and even the conceptual re-elaboration that a history of ideas could bring to this scenario.

As asserted before, the Cultural History of Science developed by authors like Pimentel, does not support generalized positions about how scientific endeavor is or what it should be. In its rich description, there is space for the history of individual or collective actions of those material "agents" – like instruments and the scientists their selves – and non-material "agents" – spaces like laboratories or institutions such as academies, in certain times getting close to a very in-depth history of science that we classify as microhistory. In works such as Galison's (1987), such perspective is even more pronounced. In his work *How Experiments End* (1987), the author, by means of a study on specific experiments, explores several issues about measurement techniques production, the building of the own experiments and the accuracy of data obtained from the measurements. What is believed as an experiment result and what is interpreted as a simple noise are called into question. With that, Peter Galison explores relevant issues about scientific practice, that is, how several performances associated to scientific practices mutually shape to indicate results of experimental actions, reaching consensus about the physical meanings of such results and then pronouncing their conclusion.

At this moment, the issue that arises concerns the supposed dichotomy between historiographical studies where a microhistorical viewpoint is proposed and those who support the need of analysis leading to more general conclusions about science, in order to promote scientifically informed decision-makings by students.

At first, one should resume our major assumption, which was based on the argument supported in the beginning of this paper: the purpose of including the History of Science in Science Teaching in basic education should be to promote discussion about the key points of scientific knowledge production. There being, it is more important building discussions than assertions about science in the classroom. In addition, we adopted Ginzburg, Tedeschi and Tedeschi´s assumptions (1993), according to which microhistorical approach, by looking to a more local and in-depth history, aims to clarify the production context of historical narratives, but without forgetting to associate particular facts to a broader context.

At last, one should remember that some scholars have highlighted as relevant the recent turnover of science studies into a local perspective (GALISON, 2008; KUUKKANEN, 2011), before the previous approaches considered as more generalizing. In general, for authors who have supported this approach, the science built in a place reflects that place and includes diverse characteristics of a science built in another place (KUUKKANEN, 2011). Therefore, such support of science output locality does not deny the evident current globalization of scientific discourse, which philosophers of science have been explaining through the processes of relocation of this knowledge (KUUKKANEN, 2011; GALISON, 1997).

However, applying Cultural History of Science in Science Teaching would imply the development of historical narratives for teaching, moving from its main core the big names of science and how they operated to set new theories, to replace them by scientific practices and how these practices changed overtime, including how they operated to change the scientific knowledge itself. Through the Cultural History of Science, there is an alternative to generalized historiographical viewpoints or to the so-called methodological approaches (McGUIRE; TUCHANSKA, 2013), then changing the intention of characterizing ruptures, or the advances and declines of research programs, to the description of how scientific knowledge is gradually reconfigured from new practices and representations (KLEIN, 2003). These gradual reconfiguration processes include actions for the training of new scientists generations, the creation of new scientific cultures[7] and disputes and controversies within science, as well as their relations with a broader culture through the operation of non-scientists in the science, the dissemination of this knowledge to the wide public, the socio-institutional relations developed in the culture and the own explanation of more general historical contexts where such scientific practices were developed. At last, by avoiding looking for structural approaches for science, it is possible to avoid essentialist and monolithic characterizations for science, which aim to structurally determinate what science was and standardize what science is and what it will be. In the viewpoint developed in this study, the discussion about science remains the main purpose for the history of science in teaching.

The Cultural History of Science brings contributions to science teaching, by enabling the emergency of discussions on the gender, ethnicity, among others, insofar as a study centered on scientific practices may ease the visibility of agents who take part in scientific practice and are neglected in the history of science of big ideas and, that way, raise discussions about these viewpoints (MOURA; GUERRA, 2014; 2016).

We also support that historical approaches for teaching based on the Cultural History of Sciences may highlight the political and social role of science teaching in

7 Ursula Klein (2003) uses the term "scientific culture" to describe relatively coherent relations between different collective social, material, symbolic elements and practices of a science.

basic education, then being in line with postcolonial studies (LANDER, 2005). That is because as we focus our attention on collective practices over the science development, we highlight agents in the scientific output that enable to dialogue with interpretations brought by postcolonial studies, when they question the eurocentrism and the thesis of an "self-generating and aseptic" Europe, a process where the role of European colonies would have been relevant to build European culture (CASTRO-GÓMEZ, 2005) and, as a result, the modern science. To go further in this perspective under the view of Cultural History of Science and Social Studies of Science looks promising in the sense of giving further clarity on topics involving science and power, which today are often neglected in Science Education.

Final Remarks

In this study, based on the dialogue with the literature of the history of science, of science teaching and the perspectives of cultural studies for science, we aimed to discuss possible paths for historical approaches in science teaching, whose main axis was the thinking about scientific practices.

From the discussion of the recent literature related to science teaching, we questioned the consensus view, by showing the most prominent reviews and pointing out recent demands of the field related to the discussion on scientific practices in science teaching.

In this sense, we raised the debate about the relevance of teaching science in the school and particularly the science teaching that aims the citizenship link. In line with Rudolph and Horibe's (2016) study, in respect of redirecting citizenship link to public issues focused on social welfare, we added to this view a historical-cultural element to justify the need of the history of science as a guide to build this citizenship perspective.

By recognizing the lack of consensus on the scientific practice idea, we aimed to build an own view that would guide this work based on theorization with shared grounds in the literature. We presented Cultural History of Science as an alternative to scientific practices' approach. By giving examples and opposing this approach against other possible historical approaches, we outlined characteristics, perspectives of the Cultural History of Science itself and key assumptions of this historiographical viewpoint. Then, we discussed the study implications to historical approaches in science education.

One should note that the ideas supported in this study may be connected to other perspectives of the own tradition of the field of History of Science and teaching, such as the approaches by historical cases studies (PORTO, 2010) and other approaches exemplified in the beginning of this article. The viewpoint described in this paper does not describe methods to include the history of science in the classroom or other teaching situations, nor initially excludes any method, except the ones widely rejected in the literature, such as, for example, the method related to content or anecdotal approaches of the history of science. We discussed in this study a historiographical view by which we supported the study of scientific practices in the sense established in this paper as being the most suitable.

To expand the scope of the discussions raised by this study, it will be important to combine findings of empirical researches, based on the creation and implementation of didactic sequences or modules to formal or informal teaching spaces, by which one may investigate parameters to apply the perspective of the Cultural History of Science presented in this paper in varied situations, or also strategies to work the training of teachers in this subject. The research group in which we work is developing some empirical researches with this purpose. One of them relates to a pedagogical practice in High School in Biology subject about the study of the controversy between Mendelian and Biometrician focused on discussions about Eugenia (MARQUES, 2016). Among the researches in progress, it is under data analysis the one developed in classes of eight year of elementary school, regarding the study of the human body developed in Europe in XVI and XVII centuries.

In addition, one deems relevant the studies addressing the perspective exposed in this paper to other research lines such as argumentation, language and discourse, the students' cultural identification with strategies developed in this line, the implications for science dissemination and popularization, and many other paths.

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