The History of Science in an interdisciplinary approach in the curriculum: broadening horizons for building and mediating learning from the nature of scientific knowledge

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Abstract: Going through the dialogues that interconnect the construction of teacher training based on the History of Science, allows us to broaden the view on the curriculum in Basic Education, through reflections that guide the construction of knowledge itself. From an initial training course on the History of Science in Chemistry Teaching, the research aims to evaluate the initial conceptions of Science in a perspective of interconnection between science, technology and society, as well as to reveal some conceptions of future teachers on the construction of Science and scientific knowledge intertwined with the Curriculum. The results guide the need to insert the History of Science in an interdisciplinary approach in the curriculum, especially the construction and mediation of learning through the very nature of this scientific knowledge. Concluding that the investigated undergraduates bring a difficulty to understand the very nature of this scientific knowledge in recognizing it as interdisciplinary.

Keywords: History of Science. Interdisciplinary. Scientific Knowledge. Curriculum.

La Historia de la Ciencia en un enfoque interdisciplinario en el currículo: ampliando horizontes para la construcción y mediación del aprendizaje desde la naturaleza del conocimiento científico

Resumen: Recorrer los diálogos que conectan la construcción de la formación docente desde la Historia de la Ciencia, permite ampliar la mirada sobre el currículo en la Educación Básica, a través de reflexiones que orientan la construcción del propio conocimiento. A partir de un curso de formación inicial sobre la Historia de la Ciencia en la Enseñanza de la Química, la investigación pretende evaluar las concepciones iniciales de la ciencia en una perspectiva de interconexión entre ciencia, tecnología y sociedad, así como revelar algunas concepciones de los futuros profesores sobre la construcción de la ciencia y el conocimiento científico entrelazado con el currículo. Los resultados orientan la necesidad de la inserción de la Historia de la Ciencia en un enfoque interdisciplinario en el currículo, especialmente la construcción y mediación del aprendizaje a través de la propia naturaleza de este conocimiento científico. Concluyendo así que los estudiantes de grado investigados traen una dificultad en la comprensión de la propia naturaleza de este conocimiento científico para reconocerlo como interdisciplinario.

Palabras clave: Historia de la Ciencia. Interdisciplinar. Conocimiento Científico.

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Curriculum.

A História da Ciência em uma abordagem interdisciplinar no currículo: ampliando horizontes para a construção e mediação das aprendizagens a partir da natureza do conhecimento científico

Resumo: Percorrer os diálogos que interligam a construção da formação docente a partir da História da Ciência, permite ampliar o olhar sobre o currículo na Educação Básica, mediante reflexões que norteiam a construção do próprio conhecimento. A partir de um curso de formação Inicial sobre a História da Ciência no Ensino de Química, a pesquisa objetiva avaliar as concepções iniciais de Ciência em uma perspectiva de interligação entre a ciência, a tecnologia e a sociedade, bem como revelar algumas concepções dos futuros docentes sobre a construção da Ciência e do conhecimento científico entrelaçadas ao Currículo. Os resultados norteiam a necessidade da inserção da História da Ciência em uma abordagem interdisciplinar no currículo, principalmente a construção e mediação das aprendizagens por meio da própria natureza desse conhecimento científico. Concluindo assim que os licenciandos investigados trazem uma dificuldade de se compreender a própria natureza desse conhecimento científico em reconhecer o mesmo como interdisciplinar.


1 Introduction

Through the history of things it is possible to understand the evolution and identification of different concepts. When we seek to understand the origin of something, it is through its history that we will be able to visualize its various forms of expression in the world (BACHTOLD; GUEDJ, 2014). In Science Teaching, in the same way, scientific knowledge undergoes several transformations over time, so these changes should be accessible, without trivializing previous ideas, for understanding it (MOURA; GUERRA, 2016). Thus, it is the teacher’s role to provide the student with an understanding of this process, favoring their learning.

In this context, the History of Science (HC) plays an important role in teacher education, although this is not the current scenario, as we will discuss below. According to Gomes (2020), knowledge about the past, as well as the understanding of its evolution, allows the teacher to understand the role of science and its relationship with reality, thus being able to use it as a didactic resource in the classroom. For Mccomas, Clough and Nouri (2019), the difficulties in the conception of the construction of

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4This article is an excerpt from a master's thesis defended at the Graduate Program in Teaching in Basic Education, at the Federal University of Espírito Santo, written by Rodrigo da Vitória Gomes and supervised by Ana Nery Furlan Mendes.
Science that a teacher comes to present can significantly influence the way they will teach Science, as well as the decisions they will make in their classroom.

Bachelard (1996) states that a critical sense must be awakened in future teachers, which he calls a scientific spirit, can be developed using HC: “Against this intellectual indolence that gradually takes away from us the sense of spiritual novelty, the teaching of discoveries throughout scientific history can be of great help” (BACHELARD, 1996, p. 303). In this way, discussions of teaching that allow us to address historical and philosophical issues allow for the occurrence of a conceptual change. This conceptual change will lead the student from a “common sense philosophy”, in the words of Bachelard (1996), to a scientific way of thinking and, therefore, more suited to the profile of the teacher training.

Despite being so important in science teaching, the History of Science is still not included in most educational programs. Thus, it should appear first at higher education and teacher training, and after reaching high school and elementary school (LACIN-SIMSEK, 2019; GOMES, 2020). The lack of specialized teachers in the area can cause major problems. The point here is that with the lack of research professors in the area, professors with less experience take risks in the subject, which can lead to disservice, since, because they do not have great knowledge, they may not distinguish good sources and may pass on wrong knowledge about the nature of science, as well as a fragmentation of scientific ideas.

In this context, conceptions about the nature of science are directly related to what we call teaching epistemology, and come to guide the various pedagogical practices in teacher training (GIL-PÉREZ, et al, 2001; EL-HANI, 2006). However, in our current scenario, measures for the insertion of a historical-philosophical perspective in the curricula of undergraduate courses in Chemistry, both for the licentiate and for the baccalaureate are incipient (MORTIMER; MACHADO; ROMANELLI, 2000), although the need to of its incorporation. In this way, strong theoretical approaches to the proposals have been identified, making the possibility of a practical application unfeasible, as well as the absence of didactic materials with this focus, which also makes it impossible to mediate between theory and concrete learning situations (MARTINS, 2006; PORTO, 2011; GOMES, 2020).

In this context, as one of the problems mentioned so far, the fragmentation of
historical knowledge produces in students the false impression that knowledge and the world itself are compartmentalized. Such a vision implies a formation that ends up being, in reality, a deformation. To overcome this compartmentalization, an interdisciplinary work is needed to approach the History of Science in its essence (BELTRAN; SAITO 2017).

Therefore, the construction of an interdisciplinary teaching proposal must be permeated from an approach that privileges the understanding of the knowledge production process, be it historical, philosophical or sociological, as stated by Gomes (2020, p. 67) “allowing thus structuring a more concrete and correct look at the real nature of science, its procedures and its limitations, in addition to contributing to the formation of a more critical view, demystifying scientific knowledge without denying its value”.

In order for us to understand the nature of science as a historical process and not just as a finished product through its current conceptions, we have to change the content view that is excessively concerned with the amount of curriculum to be completed (BARBOSA; AIRES, 2019). It is necessary to develop a new approach that, without completely canceling out other areas of knowledge, treats the themes from a historical-philosophical point of view. In this sense, Guerra et al. (1998) point out that each content must be worked on according to its importance in terms of the construction of great conceptual structures and their relationship with the fundamental issues of each time.

Studies with undergraduates in chemistry (CHELONI; LEME; PORTO, 2006; OKI; MORADILLO, 2008; VIANA; PEREIRA; OKI, 2011; GOMES, 2020), revealed that after studying History of Science subjects in an interdisciplinary approach, they presented more contextualized, valuing epistemological issues; not presenting common-sense views about science, such as the belief in the existence of a scientific method, the idea of scientific theories as being unquestionable truths and that scientific models are equivalent to reality. These authors also emphasize that all these conceptions are rooted in students and are difficult to change spontaneously.

This study was carried out with a view to planning an Initial Training Course on the History of Science in Chemistry Teaching, offered by a Master's student of the Graduate Program in Teaching in Basic Education (PPGEEB/UFES/São Mateus) in
the year 2019. It aims to evaluate the initial conceptions of Science in a perspective of interconnection between science, technology and society, as well as revealing some conceptions of future teachers on the construction of Science and scientific knowledge. The results contribute to reflections in Chemistry Licentiate courses regarding the insertion of the History of Science in an interdisciplinary approach in the curriculum.

2 Interdisciplinarity: A Historical, Epistemological and Educational Dialogue

The emergence of interdisciplinarity began in Europe, to the detriment of conflicts that erupted in universities in the late 1960s (MANGINI; MIOTO, 2009). During this period, there was a discussion that schools and universities formed specialists, the market worked under the support of a technical and social division of labor, thus requiring partially prepared workers, from the perspective of a Taylorist/Fordist paradigm (MUELLER; BIANCHETTI; JANTSCH, 2008). To the detriment of this scenario, knowledge was fragmented, broken into crumbs, in a perspective that limited the way students could expand their gaze at the whole (MANGINI; MIOTO, 2009; FAZENDA, 1994).

In summary to this impasse, the claims in the universities guided a reflection that the knowledge that was being developed in these spaces did not prepare the student for life “out there”. The project presented by George Gusdorf to the United Nations Educational, Scientific and Cultural Organization — UNESCO in 1961, focused on reducing the distance established between theory and the human sciences, through a review of the relationships that were established between the disciplines and among the problems of society (FAZENDA, 1993).

In this scenario, a discussion about curricular changes began, and from this period on, interdisciplinarity is announced as a form of opposition to alienated knowledge, as a symbol of man’s return to the world (TRINDADE, 2008). To the detriment of such considerations, in Brazil there was a certain need to research more on interdisciplinarity.

The first significant production took place in 1976, by the Brazilian researcher Hilton Japiassu when he published the book “interdisciplinarity and pathology of knowledge”, punctuating the experiences, concepts and reflections carried out until then (TRINDADE, 2008). In 1979, the Brazilian researcher Ivani Catarina Arantes Fazenda, publishes it seeking to establish a construction of a concept for
interdisciplinarity. In his book, “Integration and interdisciplinarity in Brazilian education: effectiveness or ideology”, he awakens the need for a new look that allows understanding and transforming the interdisciplinary process to restore the unity of knowledge (TRINDADE, 2008).

In this way, Hilton Japiassu discussed interdisciplinarity in the field of epistemology, while Ivani Catarina Arantes Fazenda in the field of Education. Discuss interdisciplinarity, it is to think beyond curricular training, as Fazenda (2012) points out, it has to be thinking as an attitude of daring, not keeping knowledge isolated, seeking reflection from the subjects, such as students and teachers. It aims at the passage of a knowledge that is sectored to a total knowledge, aiming at the formation of the complete man (FAZENDA, 2012).

Mediating this path, Japiassu (1976) argues that the specific role of interdisciplinary activity is to build bridges between disciplines, in order to ensure disciplinary knowledge that is not carried out in isolation. In this sense, the role of epistemology does not dialogue with a single epistemological sense, but that must arise with the need for a reflection, about a study that permeates a constituted Science.

Paraphrasing with Fazenda (1994) in this sense, Education becomes transformative as it considers the total formation of man, leading the student to reflect and act on facts that plague their reality. According to Trindade (2008) interdisciplinarity emerged in the view of some to gather knowledge, for others, as a phenomenon of correcting possible problems arising from fragmentation.

To characterize an interdisciplinary process is to seek a unified knowledge, preserving the integrity of thought, promoting a reflection on knowledge as a result of dissatisfaction with its fragmentation in Education (JAPIASSU, 1976). In his research, Fazenda (2013, 1998, 1993) shows that for the realization of interdisciplinarity it is necessary to develop a sensitivity. In this sense, it must understand the “subject” involved in the process, through a pedagogical relationship guided beyond a curricular structure.

Through such reflections, permeating the teaching and learning process, Fazenda (1993) concludes that interdisciplinarity is born from people’s attitudes when faced with knowledge. Having said that, it still claims that
the true interdisciplinary spirit is not always well understood. There is a danger that interdisciplinary practices either become empty practices, products of a fad in which, because there is nothing to discuss [...] or they become mere ideological propositions, preventing the questioning of real problems (FAZENDA, 1994, p. 49-50)

Therefore, it is necessary to impose oneself in order to understand and restore the lost unity of different knowledge (FAZENDA, 2012, 1994, 1993). In which a practice that is dialogic predominates, in the sense not only of eliminating the barrier that exists between the disciplines, but of overcoming the barriers that exist between people (FAZENDA, 2012).

Therefore, based on studies carried out by Japiassu (1976), there is a certain need to fill in the gaps between theoretical and practical articulation. Due to the distance between the different knowledges, so that one could actually arrive at a thought that culminated in the beginning of a dialogue of an interdisciplinary process (JAPIASSU, 1976). When transposing this reflection to the different areas of knowledge, it is of substantial importance to build a broad view and at the same time aimed at enabling interdisciplinary dialogues to actually take place (MARQUES, ESPÍNDOLA, SAUERWEIN, 2020).

In this way, the reflection on the History of Science (HC) has gradually been constituted and updated as an interdisciplinary and specific field of knowledge (BELTRAN; SAIITO, 2017). In line with this dialogue, Beltran (2013) argues that HC establishes an interface between the Sciences and the Humanities, since such an approach makes it possible to reflect on issues capable of seeing the world in a different perspective.

The notes made by Trindade (2008) go through the same path, when stating that

the History of Science makes possible the construction and a dynamic understanding of our experience, of the harmonious coexistence with the world of information, of the historical understanding of the scientific, social, productive life of civilization, that is, it is a learning with practical and critical aspects of a participation in the novel of scientific culture, a primordial ingredient in the saga of humanity (p. 65).

Based on such considerations, reflections on interdisciplinarity in HC should emerge as an instrument to rescue the human being (TRINDADE, 2008). Therefore, the interdisciplinary field HC and Teaching dialogue with from the possibility of building
interfaces between HC and Teaching (BELTRAN; SAIETO 2017). Beltran and Saito (2017) question that the possibility of this interdisciplinary field is based on epistemological grounds, since they transit through interconnected conceptions to the elaboration, transformation and communication of scientific knowledge.

Therefore, Trindade (2008) when stating that the interdisciplinary character of HC does not annihilate the necessarily disciplinary character of scientific knowledge, but that it complements it, expands possibilities for an increasingly articulated teaching. In this bias, it is proposed that activities involving HC be an integral part of teaching specific content. At the end of this discussion Almeida et. al (2022) discuss the importance of expanding the discourse of the perception of science more contextualized from the historical context, thus promoting a more critical and epistemological look at scientific knowledge.

3 History of Science in Chemistry Teaching: A Path of Possibilities

History has a great importance within Science, because it is through it that we can reflect on the evolution of man over time, acquiring experience, investigating and discovering facts that made the way of life of successive generations could be improved, attributing to science its social character and a role in the development of society (LAÇIN-SIMSEK, 2019). So,

the elaboration of the periodic table as it is known today is a good example of how man, through science, seeks to systematize nature. The table thus reflects, in a very intense way, the way in which man reasons and how he sees the Universe that surrounds him (TRASSI et al., 2001, p. 1335).

In this way, knowledge must be built in the classroom as students understand how science developed and arrived at what we know today. According to Mccomas and Collaborators (2019) the proper study of some episodes of the History of Science helps us to understand different conceptions of Science such as: the understanding that science is not isolated, being part of a historical development, of a culture, of a human world, being influenced and in turn influencing many aspects of society. In addition to the perception of the social, collective and gradual process of construction of scientific knowledge, allowing to form a more concrete and correct view of the real nature of science, its procedures and its limitations.

From this perspective, to reflect on interdisciplinarity is to look at a vast path of
possibilities, requiring a true connection with the essence of the subjects involved (PERIN; MALAVASI, 2019), thus making the History of Science an interdisciplinary area.

Guiding a discussion for the area of Chemistry Teaching (EQ), due to the nature of its object, it allows establishing interfaces with other areas of knowledge, thus configuring an interdisciplinary approach (BELTRAN, 2013). Santos and Porto (2013) emphasize that the challenge for chemistry educators is how to help students understand chemistry. In the search to present possibilities to overcome this difficulty, Santos and Porto (2013) argue that the approximation between HC and EQ is one of the possible ways, in order to break this barrier.

Beltran (2013) argues that valuing HC is an important component in the training of both students and teachers. Paraphrasing with the author, Santos and Porto (2013) state that

the History of Science can help to understand aspects of the complexity of chemical knowledge and its construction process, helping to understand some of the difficulties faced by students, and thus offering contributions to the improvement of learning. The analysis of the historical process of the development of science can help the student to give meaning to chemical knowledge, by envisioning the questions that motivated the proposition of concepts and the characteristic look that the chemist casts on reality [...] (p. 1573).

Thus, the interdisciplinary approach in this scenario is part of the dialogues permeated from the HC itself. Therefore, it is necessary to create interfaces between the chemical knowledge developed in the classroom based on its own historical conception. Therefore, this approximation between the HC and the EQ allows leveraging and meaning the construction of learning, which makes it possible to insert students in this teaching process.

In this case, bringing these areas together does not go through a very easy path (SANTOS; PORTO, 2013). Since, in the light of these reflections, leveraging these interdisciplinary issues does not mean to aim only at overcoming a fragmentation in teaching in general. But to bring to the surface subjects more capable of reflecting on their own self. Fazenda (1994) states that the true interdisciplinary spirit is not always understood, often bringing completely distorted realities.

Therefore, it becomes necessary to reflect more on the teaching practices that
permeate these areas. Trindade (2008) resorts in this scenario that the interdisciplinary teacher must go through the flexible regions where the "I" coexists with "the other" without giving up their characteristics, thus enhancing a relationship of sharing, dialogue and transformations.

Finally, when conducting these reflections, it is possible to consider that as subjects we are not unique, each one carries perspectives and questions that are supported by their own experience, inserted in an interdisciplinary world. In this format, even without realizing these issues, it happens to us.

In addition to this reflection, the debate about the HC itself and its interdisciplinary relationships in teaching leads to the questioning that in a work context in which students and teachers have the same environment, it allows to approach different realities and questions. Therefore, bringing the student the possibility of building knowledge based on their own reflections guided by Science provides an opportunity for a broader formation on their social context.

4 Methodology

In order to verify the conceptions brought by future professors, a study was carried out with undergraduates in Chemistry from the Federal University of Espírito Santo (UFES) in order to investigate the previous knowledge about the social (collective) and gradual process of science and its nature brought for them.

We used the VOSTS — Views questionnaire on Science-Technology-Society (AIKENHEAD; RYAN, 1992a; 1992b; 1989), as a data collection instrument. This is a multiple choice questionnaire that seeks to assess the conceptions of science in an interdisciplinary perspective of the interconnection between science, technology and society. The use of this questionnaire seeks to reveal some conceptions of future teachers about the construction of Science and scientific knowledge. The complete questionnaire consists of 114 questions, which for this research would be very extensive. Thus, we used an abbreviated version with three questions taken from the official questionnaire in full and translated into Portuguese with appropriate adaptations according to the research needs. The questions and the category referring to each one of them are presented in Table 1.
Canavarro (2000) makes it clear that the use of the VOSTS questionnaire does not seek numerical results, but rather to integrate conceptions regarding topics related to Science and Technology in a perspective of interconnection with society.

With this questionnaire it was possible to gather information for the planning of a course entitled “History of Chemistry: A proposal for an approach to Teaching the Periodic Table”. This theme was chosen due to the fact that 2019 was the international year of the periodic table of chemical elements, proving to be an important moment to reflect on the many aspects of this instrument, including its history. The Course took place from May to June 2019 in 8 meetings, each meeting lasting 2 hours, totaling 16 hours of initial training and research. This was registered as an extension activity in the Extension Information System (SIEX) of the Federal University of Espírito Santo and at the end of the activities the students received a certification.

The concepts collected in the questionnaire were used to outline the profile of the undergraduates who would participate in the course as well as to elaborate the activities of discussions on the historical construction of the periodic table, dynamics, reproduction of historical experiments, in addition to readings of texts, contemplating recent discussions on the teaching of Science, in order to provoke dissatisfaction with the traditionalist teaching model.

A total of 12 undergraduates participated in this study, 6 of whom had previous contact with the classroom acting as occasional teachers and developing various activities aimed at Teaching Chemistry and the other 6 had never taught and only had experience in teaching situations. and learning as students, totaling 12 questionnaires collected. To preserve the identities of the participants, we chose to adopt fictitious names: Marcela, Poliana, Breno, Marina, Lúcia, Ricardo, Gustavo, Maria, Karen, Antônio, Roberta and Leonardo.
5 Results and discussion

Due to the great difficulty in establishing categories for the undergraduates in the sample, a general analysis was carried out in order to identify each conception of them in relation to each of the questions answered. The diversity of responses identified in the questionnaires and often contradictory responses presented by them was notorious. Even so, the use of this questionnaire proved to be of great importance in order to identify the starting point for the proposal here related.

Thus, the categories of answers that were used for the analysis were those of the VOSTS questionnaire itself, as described in Chart 1, and not the answers of the undergraduates, in which we will identify that in some questions there are alternatives that were not selected. It is also worth noting that the purpose of this research is to analyze the process as a whole, without reducing the individuality of each licentiate.

It is important to highlight that these are undergraduate students who are in the process of training and it is precisely this characteristic that makes the essence of this research. Thus, it is not appropriate to generalize the VOSTS results to the group of undergraduates in the sample, due to the fact that there are some of them who have most of the conceptions consistent with what we want to investigate.

Table 2 reveals the students' conception of the definition of science referring to question 1 of the VOSTS questionnaire, number 10111 in the original questionnaire.

Table 2: Conception of undergraduates on the definition of science

<table>
<thead>
<tr>
<th>Sample Licensees</th>
<th>Sample Licensees</th>
</tr>
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<tbody>
<tr>
<td>Marcela</td>
<td>Poliana</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>a) A study of fields such as Biology, Chemistry and Physics.</td>
<td>X</td>
</tr>
<tr>
<td>b) A body of knowledge, such as principles, laws, theories, that explain the world around us (matter, energy and life).</td>
<td>X</td>
</tr>
<tr>
<td>c) Explore the unknown and discover new things about our world and universe and how they work.</td>
<td>X</td>
</tr>
<tr>
<td>d) Conduct experiments in order to solve problems of interest about the world around us.</td>
<td>X</td>
</tr>
<tr>
<td>e) Inventing or designing things (e.g. artificial hearts, computers, space vehicles).</td>
<td>X</td>
</tr>
<tr>
<td>f) Finding and using knowledge to make this world a better place to live (e.g. curing diseases, solving pollution problems and improving agriculture).</td>
<td>X</td>
</tr>
<tr>
<td>g) An organization of people (called scientists) who have ideas and techniques for discovering new knowledge.</td>
<td>X</td>
</tr>
<tr>
<td>h) Nobody can define Science.</td>
<td>X</td>
</tr>
</tbody>
</table>

Source: Prepared by the Authors
For the definition of science, the majority of seven undergraduates chose alternative B, in which they characterized science as a body of knowledge that explains the world around us. Two of the undergraduates in the sample chose alternative C, characterizing science as an exploratory and discovery concept. One of the undergraduates characterized science as a means of inventing things and another graduate pointed as the use of knowledge to solve problems, thus presenting a conception of science as a way of improving people's lives, alternatives E and F. One of the undergraduates presented the conception that no one can define science, marking alternative H. And finally, none of the future teachers related science as a specific area of knowledge (alternative A), or with a social conception of knowledge construction (alternative G).

In general, science is taken by most future teachers as an encyclopedia of already established knowledge and they do not admit the relationship with society for its construction. According to Gil-Pérez et al. (2001),

> it is necessary to understand the social character of scientific development, highlighted not only by the fact that the starting point, a given prevailing paradigm, is the synthesis of the contributions of generations of researchers, but also by the fact that research increasingly gives response to questions posed by institutions (p. 137, authors’ emphasis).

In this bias, Japiassu (1976) states that the interdisciplinary process is a reflection of the preservation of the integrity of thought. But what has been done is to seek to reconstitute the knowledge that has been fragmented, resulting from the lack of understanding of interdisciplinarity, in which at times it has been wrongly understood as an integration of disciplines.

Such questions elucidate that the understanding of Science, by most students, guides the questions that intertwine the theories and laws that bring us questions about the world we live in, as discussed in item B (TABLE 2). Such reflexes enhance that the undergraduates weave a relationship by identifying themselves with this issue, as it enhances that knowledge is broad and articulated, however, it was possible to perceive in the students that the absence of an interdisciplinary perspective does not allow them to see that Science itself is understood at the same time. from interdisciplinarity.

In this scenario Trindade (2011) states that

> the interdisciplinary practice presupposes a deconstruction, a rupture with the
traditional and with the daily school work. The interdisciplinary teacher travels through flexible border regions where the “I” lives with the “other” without giving up their characteristics, enabling interdependence, sharing, encounter, dialogue and transformations. This is the interdisciplinarity movement characterized by attitudes towards knowledge (263).

Therefore, establishing a focus on the molds that guide HC implies proposing training in undergraduate courses that bring an approach that provides a critical analysis that guides the creation and appropriation of scientific knowledge (TRINDADE, 2011).

Table 3 reveals the students’ conception of the nature of scientific knowledge regarding question 2 of the VOSTS questionnaire, number 91011 in the original questionnaire. This question sought to verify whether future teachers believe that scientific knowledge is ontological, that it expresses the reality of the universe; or epistemological, being a creation of the mind.

Table 3: Conception of undergraduates about the nature of Scientific Knowledge

<table>
<thead>
<tr>
<th>2. For this question, consider that the prospector “discovers” gold and that the artist “invents” sculpture. Some people think that scientists discover scientific theories. Others say that scientists invent scientific theories. What is your opinion on the matter?</th>
<th>Sample Licensees</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scientists discover scientific theories:</td>
<td>Marcela</td>
</tr>
<tr>
<td>a) Because the idea was already there to be discovered.</td>
<td>X</td>
</tr>
<tr>
<td>b) Because scientific theory is based on experimental facts.</td>
<td></td>
</tr>
<tr>
<td>c) But scientists invent methods to find the theories.</td>
<td></td>
</tr>
<tr>
<td>d) Some scientists may stumble upon a theory by accident, discovering it. But other scientists can invent theories from facts they already know.</td>
<td></td>
</tr>
<tr>
<td>e) Scientists invent scientific theories:</td>
<td></td>
</tr>
<tr>
<td>f) Because theory is an interpretation of experimental facts that scientists have discovered.</td>
<td>X</td>
</tr>
<tr>
<td>g) Because inventions (theories) come from the mind – we create them.</td>
<td></td>
</tr>
</tbody>
</table>

Source: Prepared by the Authors

Three undergraduates in the sample were the only ones who presented a coherent conception regarding the nature of scientific knowledge, characterizing it as a human construction, as well as the identification of a current epistemology (alternatives E and F) brought by some philosophers of science such as Fleck (1986), Bachelard (1996), Popper (1986) and Kuhn (1989), which despite the epistemological differences, converge in questioning some of the conceptions of Modern Science that correspond to a current epistemology: the objectivity of phenomena and the neutrality of the subject in the act of knowing.
From this perspective, analyzing this issue, most undergraduates have an ontological view of the nature of scientific knowledge, so six marked options A, B and C, believing that the reality of things already exists and is about to be discovered. Finally, three of the undergraduates present the conception that discoveries in the scientific environment occur by chance, marking option D. Thus, a total of nine undergraduates presented a view contrary to the nature of scientific knowledge. For Aikenhead and Ryan (1992a; 1992b) this notion may have been influenced by the media and even by historians of science.

We live in a techno-scientific society where Science occupies a prominent role as a legitimizing discourse for other forms of knowledge, as well as functioning as a discourse of power for specialists who speak in the name of Science (GUERRA et al, 1998). In this sense, we must implement an interdisciplinary practice from the understanding of the processes of construction of scientific knowledge which, keeping its specificities, is the same as any other form of knowledge.

This view of confrontation identified in the undergraduates corresponds to science influenced by external factors. In addition, it is widely discussed in the literature, especially in recent decades, it has gained prominence in the media when news about the harmful effects of scientific and technological innovations were evidenced, as Krupczak (2019, p. 134) points out,

the negative environmental implications of the use of combustion cars, the large production of plastic waste, the exaggerated use of pesticides, among others. These are news and facts that show the influence of science and technology on society. In the same way, the opposite influence also occurs. For example, when the Heliocentrism Theory was refuted during the Middle Ages due to the religious beliefs of the time. Scientists who defended this theory were even executed for it, indicating the great influence of the social and historical context on science and technology.

In this context, these influences external to science were highlighted worldwide, especially with Thomas Kuhn, with the publication of the book “The Structure of Scientific Revolutions” in 1962. Although Ludwik Fleck had already made these discussions long before Kuhn in his book “Genesis and Development of a Scientific Fact” in 1935.

In general, graduates believe that there is no uniformity in scientific knowledge, reducing science to chance discoveries and experiments, while some of them have totally opposite views.
Table 4 reveals the students’ conception of the importance of consensus in science regarding question 3 of the VOSTS questionnaire, number 70231 in the original questionnaire. In this question, the diversity of the undergraduates’ answers was also noticeable, as in the previous question.

Table 4: Conception of undergraduates on the importance of Consensus in Science

<table>
<thead>
<tr>
<th>Scientists proposing a new theory MUST CONVINCE other scientists:</th>
<th>Sample Licensees</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Showing them conclusive evidence that proves the theory is true.</td>
<td>Marcela</td>
</tr>
<tr>
<td>b) Because the theory is useful to Science only when the majority of scientists believe in this theory.</td>
<td>X</td>
</tr>
<tr>
<td>c) Because when a number of scientists discuss a theory and their new ideas, the scientists are likely to revise or update the theory. In short; to reach consensus, scientists make theories more precise.</td>
<td>X</td>
</tr>
</tbody>
</table>

Scientists proposing a new theory MUST NOT CONVINCE other scientists:

d) Because the proven evidence speaks for itself. | X | |

e) Because scientists, as individuals, will decide for themselves whether or not to use that theory. | | X |
f) Because a certain scientist can apply a theory until it explains results and is useful, no matter what other scientists think. | | X |

Source: Prepared by the Authors

In question 3, it was evidenced that four of the undergraduates have a conception that there should be a consensus among researchers for the production of scientific knowledge, expressed in alternatives B and C. On the other hand, three of the undergraduates refuse this idea and believe that there should be no a consensus in the scientific environment, positioning arranged in alternatives D, E and F.

It is interesting to note that five graduates have a naive view of the importance of consensus in science, and believe that consensus is obtained if scientists who propose a new theory convince other scientists by showing them conclusive evidence, in which they prove that the theory is true.

At this point, a misconception of consensus in science is identified, presenting the so-called “credulous experimentalism”, in which, through experiments, conclusive proof of hypotheses for a theory is always possible (AIKENHEAD; RYAN, 1992a; 1992b). Many philosophers of science are against the idea that many researchers have that Science is based on the empirical method, which is carried out with observations, experiments, laws, theories and postulates (SILVA, 2013). From this we can conclude
that there is not only one path in science, but several possibilities, and that Science
does not start only from observation, but from theory.

It is also important to draw attention to the issue of the neutrality of science.
Despite being a widely discussed subject, for students it is far from having been
overcome. They show respect, almost even submission, to the so-called sciences,
namely Chemistry, Biology and Physics. In this way, students tend to accept the
concepts and not understand them. This whole view of neutrality must be questioned
with students, since it is false and inhibits scientific thinking.

Corroborating these notes, through this process of understanding and reflecting
on science itself, the understanding of interdisciplinarity is lost amid so many doubts
and questions. Fazenda (1994) transposes this interdisciplinary process as a rescue
of the neutral man, to a more reflective subject. In this way, weaving considerations in
which science is interdisciplinary, makes a mediation between this knowledge that is
necessary.

In this scenario, to discuss the nature of science is to understand how it has
been constructed over time. From this point of view, this immersion enables a
construction and understanding of our experience with an increasingly integrated world
and with a knowledge that is shaped within interdisciplinary parameters (TRINDADE,
2008).

Science seeks general theories that explain as many phenomena as possible
and that are consistent with other theories already known by the community. Many
years ago, those works or practices that were not consistent with what was established
by the scientific collective were rejected and considered as non-scientific knowledge.
Today, in a modern conception of science, we have a different idea as proposed by
Gil-Pérez et al. (2001):

In fact, one of the most important ends of science is to establish links between
apparently unconnected domains. Indeed, in a world in which the existence of
a great diversity of materials and beings subjected to continuous changes is
salient, science seeks to establish general theories that are applicable to the
study of the greatest possible number of phenomena. The atomic-molecular
theory of matter, electromagnetic synthesis, the principles of conservation and
transformation, the theory of global tectonics, that is, the efforts made to unify
the different types of interaction existing in nature, etc., are good examples of
this search. of coherence and globality, even if this has to be done on the
basis of particular (initially) concrete problems and situations. In this way, the
process that leads to scientific development aims to establish, albeit
tentatively, generalizations applicable to nature. (p. 137)
In general, on this question, half of the undergraduates believe in consensus in science and the other half have opposite ideas.

For Reis (2009), science is based on rationality and cooperation, but there is also competitiveness and antagonisms within it, which do not end only in internal academic disputes, but also involve STS (Science, Technology and Society) interactions, which are called socio-scientific controversies (CSC). In this context, Chalmers (1993) points out the need to deconstruct the idea that science is only a rational activity. Throughout the history of science, there have always been intellectual controversies between groups of scientists, in which each one tried to prove his theory and diminish the credibility of the opponent. However, it is in the midst of these scientific controversies, restricted to the community of specialists, that knowledge is born.

For all these reasons, the history and philosophy of science must be present so that students can understand the entire process of building scientific knowledge in a non-fragmented way. It is important not to confuse the presence of history and philosophy in science teaching with the teaching of history and philosophy of science. And through such assumptions, consider that the reflections that were built throughout this research guide the way that make us question the need and increasingly expand the look at teaching and science, in order to shape us as subjects increasingly with a thought and interdisciplinary attitudes.

What we are proposing here is a change in the perspective of science teaching. It is the teaching of science from an interdisciplinary historical-philosophical conception and not the replacement of topics from the science program by others from its history or philosophy. It will be from teaching with this conception that students will realize that the scientific theories they are learning are not a "portrait" of nature, but a theoretical construction that starts from nature as a constructed reality and not the other way around.

6 Final Considerations

From the registered considerations, by intertwining the interfaces of the History of Science as an interdisciplinary field, it allows discussing how such an appointment has been constructed and discussed epistemologically, thus considering the need to expand the dialogue and the vast knowledge that permeates Science itself. And in this
sense, when it is known that there is knowledge beyond the disciplinary, even not despising it, she allows herself to surrender more to the details of the process.

And this discussion is necessary, since dialoguing with the Licentiate students it was possible to perceive that interdisciplinarity is not seen within Science, but integrated within a set of knowledge that converge in this space.

In this context, it was possible to identify that undergraduates bring many difficulties in relation to conceptions about the nature of scientific knowledge, thus concluding that they do not present a coherent notion about what they intend to teach. Therefore, with this difficulty in understanding the very nature of this knowledge, we are faced with the problem of students in recognizing it as interdisciplinary.

Finally, in the light of the theoretical considerations that have been elucidated throughout this work, it brings this reflection of the importance of the approach of the History of Science in the condition of providing the creation, reflection and appropriation of scientific knowledge in teacher education.

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