
Epistemology in science teacher training: Conceptual tools of logical positivism and the Vienna Circle

Epistemología en la formación del profesorado de ciencias: Herramientas
conceptuales del positivismo lógico y del Círculo de Viena

科学教师培训中的认识论:逻辑实证主义和维也纳学派的概念
工具

Эпистемология в подготовке учителей естественных наук: концептуальные
инструменты логического позитивизма и Венского кружка

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Abstract

This article seeks to review the movement known as Vienna Circle, and especially its fundamental theses of logical-positivistic character, with the aim of identifying conceptual contributions to the philosophical and epistemological debate within science teacher education. It constitutes a part of a larger study on the current state of the foundations provided by the philosophy of science in two programmes of teacher preparation in a public University in the north-east of Brazil. The chosen methodology is bibliographic research: primary and secondary sources around logical positivism are analysed with the aim of recognising possible traces of its ideas in the formulation of a curriculum of teacher training in the aforementioned institution. Results show that, in spite of the marked influence that logical positivism had on constructing Anglo-Saxon philosophy of science in the 20th century, in the careers of teacher education in the interior of the state of Bahia, there are only very feeble references to the analytic mode of understanding science that this school proposed.

Keywords: logical positivism, science teacher education, main contributions, epistemological foundations of curriculum, analytic perspective.

Resumen

El presente trabajo busca indagar en el movimiento denominado Círculo de Viena, especialmente en lo que se refiere a sus tesis fundamentales de carácter positivista lógico, con el fin de identificar contribuciones conceptuales al debate filosófico y epistemológico dentro de la formación del profesorado de ciencias naturales. Hace parte de un estudio más amplio sobre el estado actual de los fundamentos epistemológicos propuestos para la formación docente en dos programas académicos de una Universidad pública del nordeste brasileño. La metodología elegida es la de investigación bibliográfica: se analizan fuentes primarias y secundarias vinculadas al positivismo lógico y se busca reconocer posibles trazas de sus ideas en la formulación del currículo de formación de profesores en la mencionada institución. Los resultados muestran que, a pesar de la notable influencia que el positivismo lógico tuvo en el moldeado de la epistemología (o filosofía de la ciencia) anglosajona del siglo XX, en el ámbito de las carreras de formación docente en el interior del estado de Bahía existen solo débiles referencias al modo analítico de entender la ciencia propugnado por esta escuela.

Palabras claves: positivismo lógico, formación del profesorado de ciencias, contribuciones principales, fundamentación epistemológica del currículo, perspectiva analítica.

Аннотация

В данной работе предпринята попытка исследовать движение, известное как Венский кружок, особенно в отношении его фундаментальных тезисов логического позитивизма, чтобы определить концептуальный вклад в философские и эпистемологические дебаты в рамках естественнонаучного педагогического образования. Это часть более широкого исследования, посвященного текущему состоянию эпистемологических основ, предлагаемых для подготовки учителей в рамках двух академических программ государственного университета на северо-востоке Бразилии. В качестве методологии выбрано библиографическое исследование: анализируются первичные и вторичные источники, связанные с логическим позитивизмом, и ставится задача выявить возможные следы его идей в формулировке учебной программы подготовки учителей в вышеупомянутом учебном заведении. Результаты показывают, что, несмотря на заметное влияние, которое логический позитивизм оказал на формирование англосак-

сонской эпистемологии (или философии науки) в двадцатом веке, на курсах подготовки учителей во внутренних районах штата Баһіа имеются лишь слабые упоминания об аналитическом способе понимания науки, пропагандируемом этой школой.

Ключевые слова: логический позитивизм, научное педагогическое образование, основной вклад, эпистемологический фундамент учебной программы, аналитическая перспектива.

摘要

本研究旨在调查被称为维也纳学派的运动,特别是关于其逻辑实证主义性质的基本论点,以便确定对自然科学教师培训中的哲学和认识论辩论的概念贡献。一部分研究对巴西东北部一所公立大学的两个学术项目的教师培训提出的认识论基础现状进行了扩展研究。所选择的方法是书目研究:分析与逻辑实证主义相关的主要和次要资源,并试图在上述机构的教师培训课程的制定中识别他们的想法的可能痕迹。结果表明,尽管逻辑实证主义对塑造 20 世纪的盎格鲁-撒克逊认识论(或科学哲学)产生了显著影响,但在巴伊亚州内陆的教师培训职业领域,只微弱参考了该学派提倡的理解科学的分析方法。

关键词:逻辑实证主义,科学教师培训,主要贡献,课程认识论基础,分析视角。

Introduction

The general aim of this piece of research is to gather conceptual elements from the philosophy of science of the second quarter of the 20th century in order to incorporate them into the current international debate that is taking place around the necessary epistemological foundation for training programs of science teachers. More specifically, this article deals with some of the fundamental ideas of the intellectual movement called "Vienna Circle," ideas of a logical positivistic nature. These ideas are reviewed to recognize possible echoes and impacts on teachers' pre- and in-service education in a public university in the Brazilian northeast.

The present work has two specific aims. The first consists in understanding the nature, constitution, context, and legacy of the aforementioned philosophical school. For this, bibliographical research is undertaken from primary and secondary sources (articles, chapters, and books). The research tries to recognize (productive and counterproductive) core aspects of the legacy of logical positivism that reflect in the training of science teachers offered in the interior of the state of Bahia. The proposed research, therefore, involves a review of the most central logical positivistic ideas carried out *by examining documents of clearcut educational nature*.

The second specific aim is to recognize the philosophy of science present in two careers aimed at teacher training at the Universidade Federal do Vale do São Francisco (UNIVASF), namely: the Bachelor's degree in Natural Sciences (in the city of Senhor do Bonfim) and the postgraduate course Master in Physics Teaching (in the city of Juazeiro). Classic documentary analysis is carried out on a corpus of the selected official documentation in light of the theoretical keys provided by the first bibliographical review. Thus, we want to recognize the meta-scientific content *present and absent* in pedagogical projects, curricula, programmes, instructional materials, etc.

To establish substantive relationships between the philosophy of science and science teacher education, we start from the thesis that the primary function of that discipline

in science teaching has to do with enabling critical *metatheoretical* reflection for educational purposes, that is, providing students with progressive conceptual elements to think *about* science (Adúriz-Bravo, 2004, 2005b, 2006, 2007a). In light of this thesis, science teachers must be acquainted with philosophical concepts that have been formulated that will help them understand the validity and justification of scientific knowledge (since this constituted precisely the explicit foundational purpose of the “theory of science” of the Vienna Circle from its very foundation in the early 1920s: Klimovsky, 1994).

Methods

Starting point

Many publications have highlighted the value of meta-scientific knowledge as a central theoretical element to provide foundations for science teacher education (Giere, 1992, 1999; Matthews, 1994, 2012; Adúriz-Bravo, 2001, 2002, 2004, 2006, 2007a, 2007b; Hodson, 2009; Allchin, 2011). The primary focus in this article is on the epistemological dimension; it excludes analyses from the history or sociology of science.

It is also assumed that logical positivism, as a foundational school of professional philosophy of science (Moulines, 2006), continues to be crucial, despite the fact that many of its theses have already been overcome, as a “system of theoretical coordinates” to understand the conceptualization of scientific knowledge underlying science teacher education programs.

Therefore, from didactics of science, it is considered important to review this movement that shook the structures of reflection on science in its historical moment and that continues to inspire metatheoretical questions a hundred years later. The Vienna Circle provided a very rigorous analytical conceptualization that is unavoidable to think about the science that is taught to teachers today.

Methodological decisions

The methodological design of the work presented here has the following features: (1) it is an *exploratory* study, since, according to Gil (2007), it aims at producing initial knowledge on a defined and identified phenomenon; (2) it has a *qualitative* approach, since, as Pizzani et al. (2012) point out, the bibliographical survey and review of the main meta-theories that guide the teaching of science can be carried out more sophisticatedly from this perspective; (3) data are collected through classic bibliographical research, which, according to Gil (2002), is developed from already prepared material, composed mainly of scientific books and articles; (4) from the technical point of view, the present review is “documented” through compiling and systematizing important data from the selected bibliographical corpus; and (5) content analysis is instrumentally done by identifying units of meaning, exploring their consistent appearance and the relationships that emerge between them.

Godoy (1995) claims that, in documentary and bibliographical research, there are three aspects that should deserve special attention: the *selection* of documents, the *access* to them, and their exhaustive *analysis*. This work’s corpus was constituted using well defined selection criteria. The phase of study of the Vienna Circle used a number

academic texts that were intentionally chosen for their sustained presence in spaces of philosophical education, and that are easily accessible. Thus, it was decided to work with standard (neo)positivistic materials that presented and disseminated this movement in society, university textbooks from the second half of the 20th century introducing the philosophy of science, and recent scientific articles that apply a historical and didactical approach to current analysis.

On the other hand, in the phase of analysis of official documentation, “regulations” for the courses, programs for the different subjects, and lists of recommended bibliographical references are intentionally compiled, understanding that it is there where more explicit references to the philosophy of science can appear expressing a conception of science for science teacher education. Access to these official documents does not generate difficulties, as they are public pieces of information complying with Brazilian higher education legislation.

Furthermore, finally, it is necessary to adopt a solid procedure that uses a variety of methods and techniques for apprehension, comprehension, and analysis (Sá-Silva et al., 2009) of the very varied textual documents in the compiled corpus, paying attention to recurrences and singularities and to the structure that the surveyed content takes.

The two sources (historical and educational) of the texts analyzed here are diverse and propose two “worlds of meanings” to investigate. Considering this, we seek to implement a fine-grained qualitative approach, understanding that the mere quantification of data occurrences cannot capture the dimension of intentional human activity that involves the choice of a philosophy of science to teach to science teachers.

Thus, the interpretations proposed in this work intend to closely follow the canonical norms of content analysis, which, due to its great flexibility, is applicable to different discourses and to all forms of communication, whatever the nature of its support (Godoy, 1995). Here, analyses are “iterated” until significant results are obtained; their validity is triangulated with colleagues.

Results and discussion

Results of the theoretical analysis of the Vienna Circle

This first section displays the main results of the critical bibliographical review on logical positivism of the Vienna circle, organized under an expository-narrative structure.

In a general form, positivism was a movement of thought present in Europe since 1840, with representatives such as Auguste Comte (1798-1857) and Claude Bernard (1813-1878) in France, and John Stuart Mill (1806-1873) and Herbert Spencer (1820-1903) in England. Positivism connected with two different cultural conventions: the French, which was predominantly rationalist (since Descartes), and the English, which was firmly empiricist (since Bacon). The movement had an enormous influence on the cultural life of other countries, such as Germany, where it took the form of *materialist* scientism (Verneaux, 1967; Echeverría, 1995; Castañón, 2008; Artigas, 2009; Gadea et al., 2019).

In the 20th century, positivistic ideas expanded in continental Europe in three main intellectual spheres: the Vienna Circle (participants of the so-called Ernest Mach Society,

who grouped around the Austrian philosopher Moritz Schlick), the Society of Empirical Philosophy from Berlin and, finally, thinkers from other European countries, who were influenced or interacted with members of the first two groups.

The Austrian historian and philosopher Friedrich Stadler (2010), in his book *The Vienna Circle: Logical Empiricism, Science, Culture and Politics*, portrays in detail the period between 1848 and 1918 to better contextualize the Vienna experience at the beginning of the 1920s, when the Circle constituted itself. That long period was marked by revolutions, wars, industrial and economic development, alternations of liberal governments, and, finally, a prolonged recession that heralded a grave economic crisis. This context shapes the political parties competing for power in the life of logical positivism: the Social Democratic Party, the Christian Social Party, and the German Nationalists.

At the beginning of the 20th century, philosophy of science was still deemed a sporadic occupation of some scientists and philosophers. However, this situation changes with the constitution of the Vienna Circle (Echeverría, 1995; Artigas, 2009), promoting its development as an autonomous and professional discipline, with a recognizable place in universities (Lorenzano, 2011).

For the most active participants in the Circle, philosophy of science had to be firmly rooted in logic and mathematics; they relegated the study of historical and psychological aspects related to knowledge evolution, the social circumstances surrounding knowledge production, and the contexts in which scientific ideas arise. In short, these philosophers set themselves the task of reconstructing an authentic “logic of science” (Cupani, 2009).

Besides the aforementioned Schlick, Carnap, Neurath, Hahn, Ayer, Feigl and Hempel in Vienna and Reichenbach in Berlin, the foremost articulators of this conception of science were Grelling, Dubislav, Lewin, von Mises and Oppenheim. However, as stated before, logical positivism was not limited to these latitudes; it reached the United States of America. In fact, from the second half of the 1930s on, the United States progressively became the center of logical positivistic production, given the exodus of many founders due to central Europe’s political events.

Inside the Vienna Circle existed interesting dissents. According to Kraft (1986),

there was a radical orientation, represented above all by Neurath, which therefore often acted as a stimulus and sometimes misled. Hahn and also Carnap frequently adhered to this orientation. A more moderated orientation was also present, to which Schlick belonged. [...] Nor was the position unanimous regarding Wittgenstein’s theses, nor was it unanimous in probability theory.

Pablo Lorenzano (2011) considers that logical positivism begins the “classical period” of disciplined philosophy of science, while Ulises Moulines (2006, 2011) characterizes its emergence as a “hatching phase.” In this first moment, philosophy of science focused on the *justification* of scientific knowledge, and hence the value of logical positivism for this article, as an input to think together with teachers about the nature of the science to be taught.

The first point logical positivism wanted to combat was the increased “distance” between the different empirical sciences and a philosophy conceived as isolated and with few analytical and critical functions (qualified by Carnap as metaphysics). The empiro-positivists were eager to rescue a conception of philosophy that would prove to

be scientific, firmly adhering to analytic, syntactic, and logicist approaches, following, for example, Bertrand Russell (1956). Thus, they sought to answer the question about the scientific method, and for this they chose the “verificationist” path. Therefore, logical positivism provides some key ideas in this respect that are useful to critically review the epistemological foundations of teacher education.

A manifesto entitled “The scientific conception of the world” was published in 1929, and authored by three of the most important members of the Vienna Circle: Carnap, Hahn, and Neurath (1986). This Manifesto functioned as a “founding act” of the Circle, publicizing its formation, operation, and project. Furthermore, it detailed the philosophical program undertaken, including sections such as historical backgrounds, grouping around Schlick, scientific conceptualization of the empirical world and its problematic areas, and finally, a retrospective and perspective of the epistemological task.

As it is well explained in the Manifesto, Moritz Schlick, appointed professor of philosophy of inductive sciences in Vienna, becomes the center of the Circle:

Around Schlick, there gathered in the course of time a circle whose members united various endeavours in the direction of a scientific conception of the world. This concentration produced a fruitful mutual inspiration. Not one of the members [of the Vienna Circle] is a so-called ‘pure’ philosopher; all of them have done work in a special field of science. Moreover they come from different branches of science and originally from different philosophic attitudes. But over the years a growing uniformity appeared; this too was a result of the specifically scientific attitude: “What can be said at all, can be said clearly” (Wittgenstein); if there are differences of opinion, it is in the end possible to agree, and therefore agreement is demanded. It became increasingly clearer that a position not only free from metaphysics, but opposed to metaphysics was the common goal of all. (Carnap et al., 1986/1929; p. 304 of the English translation in: <https://canvas.uci.edu/courses/16536/files/5887303/download?verifier=uzP7uzaI9XBi5kUhGpLX-zoOCGxLctf5sDmjkBjz1&wrap=1>)

Following Grajales and Negri (2017), this founding document focuses on establishing as a goal for logical positivism to achieve a unified and consolidated explanation of science, whose path would be a rigorous epistemology (anti-metaphysics) under the aegis of the notion of *verifiability*. The Circle took over as its main theoretical instruments the symbolic logic of Russell’s *Principles of Mathematics*, the contributions of Whitehead and logical atomism in Wittgenstein’s *Tractatus Logico-Philosophicus* (Grajales y Negri, 2017). According to Javier Echeverría (1995), members of the Circle tried to produce an authentic philosophical revolution, appealing to Comte’s project of a unified science and the empiricist epistemologies of Mach and Wittgenstein.

At the same time, the Manifesto presents other concerns of the Circle, such as the need to reorganize the economy and change social conditions, the search for unification in humanity and the urgency of renewing education. Its authors point out that the Vienna Circle is not based so much on the originality of its theses but rather on its fundamental attitude, points of view and directions of research (Carnap, 1981). The document provides an overview of the epistemological foundations of different disciplines (arithmetic, physics, geometry, biology, psychology, and social sciences) with the intention of achieving systematic unity between them.

The original purpose of the Vienna Circle -to form a heterogeneous group of thinkers committed to fulfilling the epistemological task of formally analyzing science- seems

to have been successful in the first decade and a half of its operation. This was possible in such a short time because there were strong direct antecedents, such as a “proto-circle” (in the first decade of the 20th century) formed by Hahn, von Mises and Neurath (Echeverría, 1995; Castañón, 2008; Artigas, 2009). About them, Stadler (2010) points out that, with the exception of the intensive analysis of language after the “linguistic turn” and the systematic application of logic, it can be said that the essential basic elements of logical empiricism are already found prefigured in that discussion group. In turn, the proto-circle built on earlier achievements, from the end of the 19th century: substantive contributions by the German physicist Ernst Mach, who, in the words of the authors of the Manifesto, was particularly anxious to cleanse empirical science of all metaphysical thought, especially in the field of physics. Still in 1883 Mach announced in his book *The Science of Mechanics: A Critical and Historical Account of Its Development* that, where neither confirmation nor refutation is possible, science is not involved (Mach, 1960). Such statement had been accepted as a *sine qua non* condition for a good meta-theoretical reflection on science (Moulines, 2011).

On all these grounds, Schlick’s 1926 article, “Experience, Cognition, Metaphysics,” “condemns” metaphysics for attempting to falsely express as logically structured cognition what is merely the inexpressible qualitative content of experience (Schlick, 1979); for the Circle, it is not possible to indicate procedures to verify metaphysical propositions, since they cannot be reduced to experiment (Kraft, 1986).

In the same way, in its first paragraphs of historical background, the Manifesto chooses, as one of its main theses, to distance itself from metaphysical thought, which is pejoratively called a “speculative” way of thinking.

When, at the end of 1929, Wittgenstein proposes, in conversations with Schlick and Waismann, strict verificationism as a basis for identifying the legitimate parts of discourse, the logical positivists identify there a very attractive tool for leaving aside the unscientific parts of their philosophical analysis (Schlick, 1981). The verification principle is based on the idea that a statement only has meaning if it can be, at least in principle, verified empirically. This analytical method will become a hallmark of the “new empiricism and positivism,” with enormous consequences for science education.

Logical positivists proposed a bellic metaphor to characterize this period of emergence: they saw themselves as “warriors” who fought from their own conceptions. The metaphysical and theological trends that still persisted were nothing to them more than social and economic struggles that corresponded to the past, resorting to outdated “attitudes”. The positivist “fighters,” oriented towards modernity, distanced themselves from these attitudes and dealt strictly with experimental science, which seemed to leave little room for metaphysical representations.

The philosophy of science in science teacher education

This second section presents considerations and results around the analysis of official public documentation of UNIVASF related to pre- and in-service education of teachers for primary and secondary education.

Science education for citizenship has been a topic of debate for two centuries now; Comte himself planned to introduce a strong component of scientific education in the formation of individuals, discussing the possibilities of understanding the domains of science from a historical approach or from the perspective of the essence of each one of them.

In Brazil, the educational reform carried out in 1890, at the height of classical positivism, was substantially influenced by these ideas and, accordingly, placed enormous emphasis on the relevance of science education.

Didactics of science as a consolidated area of knowledge has concentrated a large part of its efforts on two specific lines of work: the configuration of curricula and teacher education (Adúriz-Bravo, 1999; Nardi, 2005). It is this second emphasis that is addressed in this article, which uses the contributions that meta-sciences can make to educational research and innovation.

The institutionalization of science teacher education in Brazil dates back to 1943, with the creation of the Natural History course at the University of São Paulo (USP). Much has changed during the eighty years that followed this milestone, and the advances are at plain sight. The strong socio-cultural changes (and, to a lesser extent, the growing incorporation of technologies) have modified the ways of living and coping with everyday life, crumbling the certainties of yesteryears. That is why science education needs a more sophisticated philosophy of science, away from common sense images of science and of scientists.

Thinking of a quality science education for the exercise of citizenship (cf. Bybee, 1997) requires explicitly analyzing the so-called *nature of science* (internationally known as NOS: Acevedo-Díaz, 2000). Teaching science in the new millennium implies positioning oneself in a particular way of understanding science as a complex social practice in times of pseudo-science and denialism.

All this has clear implications for teacher education. For Fontoura and collaborators (2020, p. 119; translated from Portuguese by the authors):

Thinking in Brazil about teacher education articulated with scientific literacy has been a challenge for researchers, mainly due to the attacks suffered by science in the context of denial and questioning of scientific practices and their products. Considering Brazilian academic production as a form of confrontation, we emphasize that the construction of knowledge about science teaching needs to encompass teachers and their experience, articulating the individual and collective dimensions to implement the issues imposed by society, besides those arising within schools.

The question for empirical research in this study is then about the epistemological foundations that underlie the pre- and in-service science teacher education offered by a public university, the Universidade Federal do Vale do São Francisco, in the interior of the state of Bahia, in the northeast of Brazil. The curricula of the two careers selected for this work did not highlight any explicit concern for organizing science education around the nature of science. Prescriptions currently issued in this regard from didactics of science are not recognizable in the documentation under study.

The previous diagnosis, of a strongly critical nature, assumes that metascientific knowledge should be preponderant in order to *professionalize* the practices of science teachers. Many authors (Duschl, 1985, 1997; Adúriz-Bravo, 1999, 2001, 2007a; Acevedo-Díaz, 2000) claim that the meta-theoretical component in teacher training should come from knowledge of the philosophy and history of science that is selected for its functionality to transform teaching practices.

These authors draw attention to the intrinsic values of meta-scientific content: philosophy of science, for example, reminds us of the inferential and provisional nature of scientific knowledge, and history of science, in turn, confronts *whiggish* (simplified and

triumphalist) interpretations of the advancement of science, which are still prevalent in textbooks.

Science curricula for primary and secondary education in Brazil prescribe addressing the question of *how science arrived at its knowledge*. Teaching what scientific knowledge is implies clearly positioning oneself from a clear meta-scientific perspective (Almeida and Farias, 2011), and this positioning should be explicitly presented during the preparation of those who will teach science. Analysis of the official documents from the two selected careers (Bachelor and Master) highlighted that the concern to incorporate updated, good quality meta-scientific content is not central to them. Both in the degree of prospective science teachers education and in the postgraduate course for physics teaching, curricula relegate the philosophy to a superficial role, of mere accompaniment.

Tables 1 and 2 list the subjects (here divided into elective and compulsory) contained in the in-service teacher education degree analyzed in this study.

Table 1

Compulsory subjects included in the UNIVASF Master's degree.

Subjects	Hours	
	Theoretical	Practical
Thermodynamics and Statistical Mechanics	60	-
Electromagnetism	60	-
Quantum Mechanics	60	-
Contemporary Physics	60	-
The Development of Physics	30	-
Theoretical Foundations of Teaching and Learning	60	-
Assessment of Implementation of Educational Products	30	-

Observation: From MNPEF

Table 2

Elective subjects included in the UNIVASF Master's degree.

Subjects	Hours		
	Theoretical	Practical	
Block A	Computer Activities for Secondary School	60	-
	Experimental Activities for Primary and Secondary School	60	-
Block B	Processes and Sequences of Physics Teaching and Learning in Secondary School	60	-
	A Multi-disciplinary Perspective on Physics in Primary School	60	-

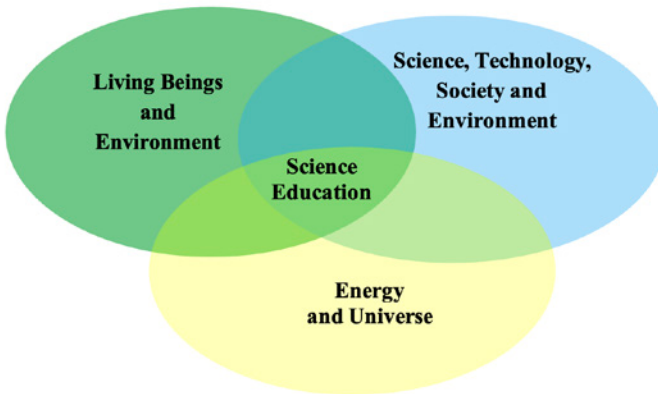
Source: MNPEF

A first look is enough to notice that the proposal for teaching qualification that is discussed here does not contemplate any introductory subject of philosophy of science. In turn, the analysis of the programs and recommended literature of each of the subjects listed in Tables 1 and 2 shows the paucity of content related to meta-theoretical reflection.

In turn, the proposal for pre-service science teacher education (undergraduate degree) studied in this article is organized based on converging thematic axes, as established in Figure 1.

Figure 1

Structuring thematic axes of the UNIVASF Degree.



Observation: Structuring Nucleus of Teaching, Faculty of Natural Sciences, Campus Senhor do Bonfim of UNIVASF.

Through documentary analysis, it is inferred that the philosophy of science somehow impregnates the entire career in a very implicit and indirect way. In some axes, epistemological approaches can be identified with some effort; in others, they are blurred and unrecognizable.

The axis identified as Science, Technology, Society and Environment includes the subjects "Philosophy of Science" and "History of Science"; in their programs, there is a clear intention of approaching logical positivism and its contributions. The first of these subjects list among its content: concept of philosophy of science; the problem of the foundations of science; science at its birth: the Vienna Circle; criteria of scientific demarcation; epistemological implications of the Vienna Circle; scientific realism and anti-realism (UNIVASF, 2017).

In the axis called Science Education, the use of structured debates on philosophical/epistemological issues is explicitly recommended within the program of the subject Psychology of Education and Development (UNIVASF, 2017). Given the orientation of this subject, one would expect that logical positivism would be discussed; however, the suggested literature -strongly situated in the field of learning theories- shows no intention in this sense.

Along the same axis, the subject Didactics of Science includes topics such as the epistemological assumptions on the nature of scientific knowledge in science, and it explicitly mentions the nature of science (UNIVASF, 2017). Bibliographical indications are vague, but it can be considered that this is the privileged space within the entire curriculum to discuss the contributions and legacy of the logical positivistic perspective for science education.

In the complete curricula of the two analyzed careers, the subjects enumerated above are the only curricular spaces where references are made to a study of scientific knowledge from the point of view of its justification and with an analytical perspective that can be related to logical positivism.

Conclusions

The present work sought, through bibliographical research, to answer a question around possible direct and indirect epistemological influences of logical positivism on teacher education in two UNIVASF courses. Results obtained from content analysis of the official documentation of these careers show that there is a very feeble tendency to approach the study of the philosophy of science from its main schools in the 20th century. The curricula of these two careers do not provide teachers with analytical or methodological tools for meta-scientific inspection of the scientific theories to be taught.

In the case of the postgraduate career, it is very unclear where the curriculum suggests establishing among teachers "meta-level" thinking about science. In the case of the undergraduate course, it is prescribed to address elements of the logical positivistic movement in four distinct subjects; but, as it can be inferred from their respective bibliographical lists, the approach is markedly superficial. The fundamental theses of empirio-inductivism are not rescued, nor are they contrasted with more recent deductivist or ampliative reconstructions.

This negative diagnosis that emerges from the analyses that have been carried out to answer the research question formulated above leads to the urgent need to include in science teacher education at UNIVASF some *key epistemological ideas* (Adúriz-Bravo, 2002, 2006, 2007a). Such an inclusion would in turn require equipping teacher trainers, university management and educational technicians with this conceptual framework.

It is well known that in theoretical lessons, problem-solving sections and labs in university science education are still today strongly pervaded by the positivistic tradition (cf. Souza, 2020). This is perhaps the most compelling argument for why science teachers should know the theoretical achievements of the Vienna Circle in their context, critically assess when such achievements were imported into science teaching, and understand the main reasons why this importation impacted and continues to impact the quality of science education and of students' representations of the nature of science. In the particular case of the careers analyzed here, the subjects of physics, chemistry and biology contained in them operate following paths traced to a great extent by logical positivism. The absence of a historicized meta-theoretical reflection on the scientific practices offered in those subjects can empower teachers' performance in the classroom. Science teachers should be able to point out to students that scientific research is a complex activity whose theoretical reconstruction has occupied professional philosophers of science for a century.

On the other hand, today there are new purposes and values that emerge, aiming at quality science education for all. Teacher education should be consistent with these new goals, and new epistemological perspectives can help along this line. Tracing a path towards science education for citizenship crucially requires understanding why meta-scientific tools are substantial. It is not just about proposing new “methods” of science teaching, science teachers’ professionalization requires deeply changing the images of science and of scientists that are socially established and “sneak” into the classroom.

Since the 1990s, attempts have been made to highlight the relevance of *knowing about science*: adequately understanding how the scientific activity is carried out, what the validity of its products is, who the people who conduct it are, what influences it receives and exerts on the sociocultural environment, etc. In addition to this, there emerges yet another, more recent “ingredient”: it is now understood that school science has to enable students *for effective action* -science should empower them to actively transform the world. In this new scenario, it is crucial to have some knowledge of the philosophy of science (complemented with content from the history and sociology of science). Recognition of this new curriculum mandate leads to the need to qualify all those involved in the science education process, such as teacher educators, curriculum designers, policy makers or textbook writers.

As pointed out earlier, this review is part of a wider study in progress within a Doctoral program. This entails some limitations: the results that have been here presented are partial and have been only briefly displayed. Discussions contained in this article should necessarily be complemented by other inquiries that are already underway. Those other pieces of research investigate possible conceptual contributions from schools in the philosophy of science that were developed after logical positivism, such as critical rationalism and the new philosophy of science. The aim is to recognize their respective impacts on teacher education.

Another way in which the findings presented here could be strengthened and deepened is to through interviewing UNIVASF teacher educators in an attempt to characterize their understandings of the epistemological foundations of teacher professionalization and their views on how to implement the inclusion of the analytical perspective to study the nature of science.

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