

TEACHING KNOWLEDGE IN THE AREA OF SCIENCE EDUCATION: A SYSTEMATIC REVIEW¹

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ABSTRACT: In this work, we carried out a systematic review of literature aiming to understand how teaching knowledge has been investigated in the area of Science Teaching in Brazil and to discuss the main contributions and limitations of these investigations. We've done our research on the Bank of Thesis and Dissertations of CAPES and on the Portal for Periodicals of CAPES, using a thematic, but not temporal, approach. Based on the defined criteria of inclusion and exclusion we've obtained a total of 64 works (theses, dissertations, and articles). Through these works we've identified and characterized five axes of investigation: knowledge mobilized by teachers of Science; teaching knowledge and the professional identity; processes of construction and development of the teaching knowledge; contributions of courses and formation programs on the constitution of teaching knowledge; other focuses. We've observed that the researches that seek only to identify the teaching knowledge under an individual analysis perspective are the ones which prevail, especially methods of categorization and content analysis. Limitations such as that point out the need for an effort to amplify the scope of the investigations on the thematic of form and to include and consider, under an ethnographical perspective, the analysis of these teaching knowledge as a social phenomenon, which is constructed on the interaction between teacher and student, with his peers and the other members of the educational community.

Keywords: teaching knowledge, science education, in-service teachers.

OS SABERES DOCENTES NA ÁREA DE ENSINO DE CIÊNCIAS: UMA REVISÃO SISTEMÁTICA

RESUMO: Neste trabalho realizamos uma revisão sistemática da literatura com os intuitos de compreender como os saberes docentes têm sido investigados na área de Ensino de Ciências no Brasil e de discutir as principais contribuições e limitações dessas investigações. Realizamos nossas buscas no

¹ Article published with funding from the *Conselho Nacional de Desenvolvimento Científico e Tecnológico* - CNPq/Brazil for editing, layout and XML conversion services. The translation of this article into English was funded by Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - CAPES/Brazil.

Banco de Teses e Dissertações da CAPES e no Portal de Periódicos da CAPES, a partir de um recorte temático, mas não temporal. Com base nos critérios de inclusão e exclusão definidos, obtivemos um total de 64 trabalhos (teses, dissertações e artigos). Por meio desses trabalhos, identificamos e caracterizamos cinco eixos de investigação: saberes mobilizados por professores de Ciências; saberes docentes e a identidade profissional; processos de construção e desenvolvimento dos saberes docentes; contribuições de cursos e programas de formação na constituição dos saberes docentes; outros focos. Observamos que prevalecem as pesquisas que buscam apenas identificar os saberes docentes sob uma perspectiva individual de análise ao priorizarem, principalmente, métodos de categorização e análise de conteúdo. Limitações como essa apontam para a necessidade de que um esforço seja realizado no sentido de ampliar o escopo das investigações sobre a temática de forma a incluir e considerar, sob uma perspectiva etnográfica, a análise desses saberes docentes como fenômeno social, que se constrói na interação do professor com seus alunos, com seus pares e demais membros da comunidade educacional.

Palavras-chave: saberes docentes, ensino de Ciências, professores em serviço.

EL SABER DOCENTE EN EL ÁREA DE LA ENSEÑANZA DE LAS CIENCIAS: UNA REVISIÓN SISTEMÁTICA

RESUMEN: En este trabajo realizamos una revisión sistemática de literatura con la intención de comprender cómo los saberes docentes han sido investigados en el área de Enseñanza de Ciencias en Brasil y de discutir las principales contribuciones y limitaciones de estas investigaciones. Realizamos nuestras búsquedas en el Banco de Tesis y Disertaciones de CAPES y en el Portal de Periódico de CAPES, a partir de un recorte temático, pero no temporal. Con base en los criterios de inclusión y exclusión definidos, obtuvimos un total de 64 trabajos (tesis, disertaciones y artículos). Por medio de estos trabajos, identificamos y caracterizamos cinco ejes de investigación: saberes movilizados por profesores de ciencias; saberes docentes y la identidad profesional; procesos de construcción y desarrollo de los saberes docentes; contribuciones de cursos y programas de formación en la constitución de los saberes docentes; otros enfoques. Observamos que prevalecen las investigaciones que buscan apenas identificar los saberes docentes bajo una perspectiva individual de análisis al priorizar, principalmente, métodos de categorización y análisis de contenido. Limitaciones como esa apuntan para la necesidad de que un esfuerzo sea realizado en el sentido de ampliar el alcance de las investigaciones sobre la temática de manera a incluir y considerar, bajo una perspectiva etnográfica, el análisis de estos saberes docentes como fenómeno social, que se construye en la interacción del profesor con sus alumnos, con sus parejas y otros miembros de la comunidad educacional.

Palabras clave: saberes docentes, enseñanza de ciencias, profesores en servicio.

INTRODUCTION

Discussions on teaching knowledge are central to the debate on training and the profession. In this context, different typologies have been used to substantiate and characterize teaching knowledge: reservoir of knowledge (Gauthier et al., 2013); professional knowledge base (Shulman, 1987); and epistemology of professional practice (Tardif, 2002). In the area of Science Teaching, some researchers improved Shulman's (1987) ideas and proposed models that characterize the Pedagogical Content Knowledge (PCK) of Science teachers, such as: Components of pedagogical content knowledge for the Science Teaching (Magnusson; Krajcik; Borko, 1999); Model of Teacher Professional Knowledge and Skills that includes PCK (TPK&S) (Gess-Newsome, 2015); and Refined Consensus Model of PCK in Science Teaching (RCM) (Carlson et al., 2019).

This diversity of typologies shows the fertility of this field of investigation but also creates difficulties in comparing different ideas (Puentes; Aquino; Quillici Neto, 2009). This is the first of the reasons that Tardif (2010) points out as responsible for the stagnation in the international scope of

research on teaching knowledge, a field very divided into disciplines and theories. Added to this, there are two other reasons mentioned by the author: (i) the difficulty of decoupling discussions about knowledge from other dimensions of teaching work; and (ii) the attempt to separate normative from epistemological aspects surrounding this issue. That is, teaching knowledge is not a sum of “knowledge” or “skills” that can be categorized in a catalogue. They are knowledge integrated into teaching practices, which are determined by normative, ethical, and political issues.

To understand how teaching knowledge has been investigated in the area of Science Teaching in Brazil and to identify the main contributions and limitations of these investigations, we seek to answer the following research questions: (i) what are the main axes of investigation of research involving the teaching knowledge of Science teachers in Brazil who make up our sample?; (ii) how can the research that makes up these axes be characterized?; and (iii) what are its main contributions and limitations to the investigation of teaching knowledge?

Initially, we show some of the main concepts and typologies of teaching knowledge identified in studies involving the theme of Science Teaching. We place this knowledge at the interface between social and personal aspects of a socially constructed professional activity. We argue about the importance of this knowledge also being studied based on the social interactions established by teachers with other educational actors (Tardif, 2002), and we situate the ethnographic perspective as a consistent investigation logic to achieve this purpose.

TEACHING KNOWLEDGE: DIFFERENT CONCEPTIONS AND TYPOLOGIES

The potential of characterizing a knowledge base to foster improvements in teacher training programs was defended by Shulman (1987), who described it based on the following: *content knowledge* corresponds to scientific content and understanding of the structures of subject themes; *curricular knowledge* involves understanding the materials and curricular programs that the teacher develops in his work; *general pedagogical knowledge* covers the principles and strategies of classroom management and organization that go beyond the scope of the subject; *knowledge of learners and their characteristics* encompasses understanding the main factors that affect student learning; *knowledge of educational contexts* involves understanding the functioning of school institutions and different communities and cultures; *knowledge of educational objectives* includes understanding educational purposes and values and their philosophical and historical foundations; *pedagogical content knowledge* (PCK) encompasses understanding how certain topics are organized, represented and adapted in teaching.

PCK was recognized as the knowledge that would differentiate the teacher of a subject, content specialists, and pedagogues. Therefore, this construct had wide repercussions in academia. However, some of its limitations were identified in Shulman's (2015) original ideas and recognized by the author such as: (i) not explicitly considering non-cognitive attributes (for example: emotion, affect, and motivation); (ii) emphasizing intellectual aspects to the detriment of those related to pedagogical action; (iii) not considering issues related to culture and the broader social context in which teaching activity takes place; and (iv) not considering relationships with educational objectives and student learning.

In addition to such limitations, in Science Teaching, different ways of defining and characterizing PCK were developed, which led to great divergences regarding how to identify and evaluate it (Gess-Newsome, 2015; Park; Oliver, 2008). Given this scenario, researchers from different countries met to discuss the meaning of PCK and try to establish some consensual aspects about the ways to represent it. As a result, the Model of Teacher Professional Knowledge and Skills that includes PCK (TPK&S) was created, systematized by Gess-Newsome (2015), and, later, the Refined Consensual Model of PCK in Science Teaching (RCM) (Carlson et al., 2019).

Both models sought to resolve the limitations and divergences surrounding PCK. In the TPK&S model, PCK was recognized as a component of the teacher's knowledge base that encompasses the skills involved in teaching a given topic. This model also includes the influence of non-cognitive aspects on teaching and learning processes and the relationships between teaching and student outcomes (Gess-Newsome, 2015). The RCM model proposes three types of PCK: collective PCK (cPCK), personal PCK (pPCK) and enacted PCK (ePCK). It also recognizes that broader bases of professional knowledge are fundamental to teacher PCK, and the teaching context influences teaching and learning processes (Carlson et al., 2019).

These are important advances around the PCK construct. However, issues relating to culture and the broader social context, identified as a limitation by Shulman (2015), still receive little emphasis. Although these models explicitly present the influence of the instructional context on teaching and learning processes, consideration of broader social and cultural contexts could elucidate the political role of education and teaching work. This is because education is a social activity, historically situated and intrinsically political, in which teachers are seen as critical intellectuals who recognize the socially constructed nature of teaching and analyze the transformative possibilities implicit in this context (Contreras, 2012).

Gauthier et al. (2013) also highlight the importance of identifying a repertoire of knowledge for teaching, built from the analysis of teachers' practice. For them, knowledge forms a kind of reservoir from which teachers draw to carry out their practice. This reservoir is made up of the following knowledge: *disciplinary*, referring to the content to be taught; *curricular*, relating to the teaching programs that will be developed by teachers; *Educational Sciences*, corresponds to the set of knowledge in school, which is produced in academic centers; the *pedagogical tradition*, related to the knowledge of teaching arising from the social representation of the profession; *experiential*, referring to private judgments responsible for the elaboration, over time, of a particular jurisprudence that guides the teacher's work; *of pedagogical action*, referring to experiential knowledge made public and tested by research carried out in the classroom and corresponds to the repertoire of knowledge that can be learned by other teachers.

Tardif (2002) also highlights the knowledge that teachers effectively use in their daily professional practice and argues that he considers it more pertinent to propose a model built from them. The approach taken by the author is based on the premise that teachers' knowledge is social and depends on teachers as individual subjects committed to pedagogical practice.

According to Tardif (2002), the social nature of this knowledge comes from its sharing by a group of social actors with a common background and who work in the same organization. Thus, the representations and practices of a specific teacher make sense only when contrasted with this collective work situation. Furthermore, a teacher does not alone define his or her professional knowledge, as the mastery and use of this knowledge occurs through a system that guarantees its legitimacy, which includes universities, schools, unions, scientific groups, etc. It is also worth highlighting the fact that, from the author's perspective, knowledge is not content closed in itself; it manifests from the social practices that are established in the complex relationships between the teacher and his/her students and develop in the context of professional socialization, in which the teacher learns to teach by doing his work.

Concerning the construct of teaching knowledge, Tardif (2002, p. 36) defines it as “[...] plural, formed by the amalgam, more or less coherent, of knowledge originating from professional training and disciplinary, curricular and experiential”, which he describes as follows: *professional training knowledge*, transmitted by teacher training institutions and based on Educational Sciences and pedagogical ideology; *disciplinary knowledge*, corresponding to different fields of knowledge (for example Chemistry, Physics, History); *curricular knowledge* presented concretely in the form of school programs that the teacher must learn to apply; *experiential knowledge* arose from experience and validated by it and does not come from training institutions or curricula.

For Tardif (2002), experiential knowledge is of great relevance for teachers. Such knowledge develops in a context of multiple interactions, and characteristics of teaching work, which are conditions for the teacher's performance. From these situations, the teacher develops the habitus that manifests through know-how. He also highlights that experiential knowledge is integrated into practice, constitutes it, and, thus, makes up the teaching culture in action.

It is possible to notice certain similarities in the ideas presented by Gauthier et al. (2013) and Tardif (2002), as both defend a broad conception of teaching knowledge (*saberes docentes*), which includes knowledge (*conhecimentos*²), skills, abilities, and attitudes mobilized by teachers. Furthermore, they consider as knowledge those speeches and actions whose subjects can answer the questions: “why do you say

² In the Portuguese language, some authors establish a distinction between the terms *saberes docentes* and *conhecimentos docentes* which, in the English language, are translated as teaching knowledge. In these cases in which the authors establish this distinction, the term *saberes docentes* is often considered broader than *conhecimentos docentes*.

that?” and “why do you do that?” This conception avoids defining the teacher solely by the “possession” of scientific knowledge and, at the same time, recognizes that not all social practices can be considered knowledge.

However, there is a crucial distinction between the ideas of these authors in the role played by knowledge from experience: while Gauthier et al. (2013) consider that experiential knowledge is private and gains objectivity only when it is tested by research and transformed into knowledge for pedagogical action, Tardif (2002) argues that experiential knowledge has a certain degree of objectivity, a perspective that we share and which is supported by the reasons highlighted below.

The objectivity of experiential knowledge arises from two main factors: (i) they originate in the teacher's pedagogical practice in comparison with the conditions of the profession. Through relationships established with peers and confrontation with knowledge produced by collective experience, subjective certainties are systematized and transformed into a discourse capable of training other teachers; (ii) they establish a critical relationship with other knowledge. Through experience, teachers revisit the knowledge developed before or outside of professional practice, judging and reevaluating them. Therefore, experiential knowledge is formed by all knowledge retranslated and subjected to the validation process through everyday teaching practice (Tardif, 2002).

In addition to being plural, teaching knowledge is temporal, personalized, and situated. They are temporal because teachers' beliefs about teaching come from their life history and are taken up by them in the first years of their careers to solve their problems. Furthermore, the first years of teaching experience are crucial for structuring pedagogical practice. They are personalized and situated because it is in teaching action that they assume their meaning and usefulness. Therefore, they cannot be dissociated from people or working conditions. Furthermore, teaching knowledge always includes ethical and emotional components, because, when making a decision, the teacher is often based on moral values or social norms relating to the differences between what is permitted and what is prohibited (Tardif, 2002).

This complexity of teaching knowledge justifies the wide variety of conceptions and typologies that sometimes compare epistemological principles, sometimes “ideal” models of teaching knowledge, which, as we discussed, makes systematization and comparison between different ideas difficult and generates a certain stagnation in the field (Tardif, 2002; 2010). In the area of Science Teaching, the situation is no different and, therefore, we consider that the review of the literature around this topic will help us to draw an overview, albeit preliminary, of the main trends in this area of investigation, their potential and limitations.

METHODOLOGY

In this work, we carried out a systematic review of the literature on teaching knowledge in Science Teaching, in which we explain the paths taken for the search, selection, and analysis of research. We try to pay attention to the following aspects: objectives; research equations; scope; inclusion criteria; exclusion criteria; methodological validity criteria; results; and data processing (Ramos; Faria; Faria, 2014).

Our central objective was to understand how teaching knowledge has been investigated in Science Teaching in Brazil and to identify the main contributions and limitations of research in this area. To achieve this, we established the research equations through the combination of keywords and the use of the logical operator AND: “teaching knowledge” AND “science teachers”; “professional knowledge” AND “science teachers”; “professional knowledge” AND “science teachers”; “professional knowledge” AND “science teacher”; “teaching knowledge” AND “science teachers”; “professional knowledge” AND “science teachers”; and “knowledge” AND “science teacher” (“*conhecimentos docentes*” AND “*professores de ciências*”; “*conhecimentos profissionais*” AND “*professores de ciências*”; “*conhecimento profissional*” AND “*professores de ciências*”; “*conhecimento profissional*” AND “*professor de ciências*”; “*saberes docentes*” AND “*professores de ciências*”; “*saberes profissionais*” AND “*professores de ciências*”; e “*saberes*” AND “*professor de ciências*”). These different terminologies were used because, as we discussed throughout this work, there is a diversity of terms to refer to teaching knowledge (Puentes; Aquino; Quillici Neto, 2009; Tardif, 2010).

Our choice of these research equations, over others, may have restricted the results obtained in our survey. For example, if our searches included terms related to specific knowledge of different typologies (such as experiential knowledge, content knowledge, pedagogical content knowledge), we

could have accessed additional works. However, as we intended to obtain a general overview of research involving teaching knowledge, and not to focus on specific knowledge, we chose to maintain the general terms described previously.

In the third stage, we defined the scope of the research and determined the databases to carry out our searches: Catalogue of Theses and Dissertations of the Coordination for the Improvement of Higher Education Personnel (CAPES-*Coordenação de Aperfeiçoamento de Pessoal de Nível Superior*) and CAPES Journal Portal. Our choice for these databases was due to their great representation in terms of research carried out in Brazil. All theses and dissertations produced in postgraduate programs accredited by CAPES are published in this catalogue. Furthermore, this journal portal is one of the largest digital scientific collections in the country.

The next step consisted of determining the criteria for including works in our survey: addressing the teaching knowledge of Science teachers in service or continuing education; presenting a summary or full version of the work available online; and in the case of articles, we selected only those published in peer-reviewed journals. Regarding the exclusion criteria, we excluded works that did not address teaching knowledge and Science Teaching, simultaneously; did not involve in-service or continuing education teachers; and did not have a summary or full version available online.

As for the methodological validity criteria, we carried out careful and explicit mapping and selection of the bibliographic sources consulted. In this process, we paid attention to the defined inclusion and exclusion criteria. Furthermore, following the recommendations of Ramos, Faria, and Faria (2014) about the results, we recorded all the steps carried out in our survey and, to process the data, we sought to organize and interpret them in descriptive tables, as explained below.

We began our searches in the CAPES Theses and Dissertations Catalogue on August 12th and 13th, 2020. We did not perform temporal cuts, as our interest was to obtain a broader overview of research involving teaching knowledge in Science Teaching. The searches were carried out using the keyword combinations described previously. In this first stage, our searches provided 163 results, and, after preliminary analysis, we excluded works that were duplicates. After this procedure, 146 different works remained.

The theses and dissertations were accessed in full through the Theses and Dissertations Catalogue and saved in a folder on the computer of the first author of this work. Some of these theses and dissertations predated the Sucupira platform or were not authorized for publication and, as a result, were not available for access in the database. In these cases, simple searches were carried out on Google and on the website of the production's depository library, to find the complete work and/or summary. Despite these attempts, 11 productions were excluded because their summaries and/or full versions were not available online.

After reading the remaining works, we excluded 38 of them because they did not focus on teaching knowledge. Subsequently, we excluded another 18 works that were not focused on the area of Science Teaching – for example, that involved the knowledge of Mathematics and Accounting teachers. After applying these criteria, 79 works remained for analysis, in which we selected those that addressed the teaching knowledge of Basic Education Science teachers in service and/or in continuing education. A total of 44 works were selected: 36 dissertations and eight theses.

To analyze these productions, we organized a table with five columns: author/year of defense; objectives/research questions/topic; theoretical reference; methodology; results/conclusions. The columns were filled in with the information available in the papers.

After filling in the table with information from theses and dissertations, we carried out a new survey on the CAPES Journal Portal, searching for scientific articles on the topic. At this stage, we log in to the Federated Academic Community (CAFe-*Comunidade Acadêmica Federada*) to gain access to the largest possible number of articles available on the CAPES Journal Portal. The survey was carried out between October 13, 2021, and December 9, 2021.

In our search, we used the same keyword combinations highlighted previously. Furthermore, in the filters available for the advanced search, we selected the options: (i) “any field”, to obtain results that had the keywords anywhere in the document; (ii) “it is exact” to obtain results with the exact combination of keywords.

Finally, when performing the search, we filtered our results to obtain only articles from peer-reviewed journals, which totaled 439 results. Following the same procedures used to collect theses and dissertations, initially, we excluded duplicate works and obtained 337 different works. We then analyzed these articles to identify those that focused on teaching knowledge. At this stage, we excluded 291 works that did not meet this criterion. Among the remaining works, we excluded three because they were not in Science Teaching.

After excluding the works mentioned, 43 articles remained that dealt with the teaching knowledge of Science teachers. In a similar way to the procedures carried out to collect theses and dissertations, we selected 20 articles that dealt with the teaching knowledge of Basic Education Science teachers in service and/or in continuing education.

Following the example of what was done to collect theses and dissertations, we organized a table with five columns. From the tables created, we identified the objectives of the 64 selected works and grouped them into five axes that reflect the main aspects investigated in teaching knowledge: knowledge mobilized by Science teachers (Axis A); teaching knowledge, and professional identity (Axis B); processes of construction and development of teaching knowledge (Axis C); contributions of courses and training programs in the constitution of teaching knowledge (Axis D); other focuses (Axis E). For each of the axes, we created categories that specify some characteristics of the investigations. In this process, we read the research on each axis and looked for similarities in their purposes and methodological aspects that would allow us to group them. For example, in Axis A, research sought to identify the knowledge of science teachers in processes of different natures (training, instructional, descriptive). This made us, for example, create category A.1 – Teaching knowledge mobilized in training courses and projects; category A.2 – Teaching knowledge mobilized in teaching action; and category A.3 – Teaching knowledge mobilized in teachers' reports.

Research within Axis B focused on the relationships between teaching knowledge and professional identity, understood as a process under construction (B.1). In Axis C, we grouped the works that sought to study the processes of construction and development of teaching knowledge in training courses and projects (C.1) and throughout the teacher's career (C.2).

Axis D research focused on identifying the *contributions* of training courses and projects to the constitution of teaching knowledge emphasizing teachers' perception of the initial training experienced (D.1); the contributions of continuing education and postgraduate courses to the constitution of teaching knowledge; (D.2) and the role of PIBID in the constitution of teaching knowledge (D.3). Some of the research classified in Axes C and D have aspects in common as they were developed in training contexts. However, Axis C research (category C.1) emphasized the *process* of developing teaching knowledge in a context, and Axis D research focused on the *contributions* of training contexts to the development of that knowledge.

In Axis E, we included two studies that had other focuses: structuring the work of the Science teacher and its impacts on knowledge and political-pedagogical practices (E.1); and teachers' perception of the role of subjectivity in teaching and learning processes (E.2).

Based on these axes, which emerged from central aspects investigated in research on teaching knowledge that makes up this study, we sought important elements to discuss our research questions.

RESULTS AND DISCUSSIONS

In line with other researchers who study teaching knowledge (such as Puentes Aquino; Quillici Neto, 2009; Tardif, 2010), we identified a diversity of terms about the knowledge of science teachers. The works that adopt the terminology teaching knowledge (*saberes docentes*) (33) prevail, followed by those that adopt the terminologies knowledge/teaching knowledge (*saberes/conhecimentos docentes*) as synonyms and/or that intersperse the terms throughout the texts (15). In these works, the authors most cited to support the adopted conception are Maurice Tardif, Clermont Gauthier, and Lee Shulman.

We consider that there are some significant differences between these conceptions and typologies for the study of teaching knowledge. First, Shulman's original proposal is based on *normative principles* and was built based on theoretical criteria that allowed the elaboration of a knowledge base for teaching that could support teacher training courses.

On the other hand, Tardif's proposal was developed based on epistemological principles, considering the importance of identifying the knowledge mobilized by teachers in carrying out their daily work and in reflecting on it. Finally, regarding the proposal by Gauthier and collaborators, we consider that it has characteristics of the two previous approaches. Although, like Maurice Tardif, these authors use a broad perspective of teaching knowledge, they seek to identify a repertoire of knowledge for teaching that should make up the teacher's "reservoir" of knowledge, the same concern as Shulman.

Thus, opting for one of these conceptions can result in different ways of understanding and studying teaching knowledge, which justifies the wide variety of objectives that permeate research in the area. In Box 1, we present the research axes of production in teaching knowledge and associated categories.

Box 1 - Characterization of the research axes of productions about teaching knowledge.

Axes	Categories	Works	Quantity of works
A. Knowledge mobilized by science teachers	A.1 Teaching knowledge mobilized in training courses and projects	Aguiar (2011); Azevedo (2007); Souza (2013); Lozano, Denari e Cavalheiro (2017); Souza e Leão (2015); Pacca (2015)	6
	A.2 Teaching knowledge mobilized in teaching action	Boa (2008); Carvalho (2010); Cravo (2019); Diório (2017); Flór (2018); Freitas (2012); Souza-Junior (2017); Lopes (2012); Moura (2006); Cavalcanti-Neto (2015); Alves (2016); Rodrigues (2007); Rosa (2002); Souza (2010); Borges, Broietti e Arruda (2021); Correia e Freire (2009; 2014); Dantas e Massoni (2019)	18
	A.3 Teaching knowledge mobilized through teachers' reports	Anjos (2012); Binsfeld (2017); Guarany (2013); Leite (2004); Silva, D. (2014); Teodoro (2017); Untar (2008); Vidal (2010); Barros e Queiroz (2020); Lima, Silva, Silva e Malheiro (2011); Monroe, Leite, Santos e Sá-Silva (2013); Silva, Lopes e Takahashi (2020)	12
B. Teaching knowledge and professional identity	B.1 Teaching knowledge and the construction of professional identity	Ambrosini (2012); Villani, Barolli e Nascimento (2020); Ogo e Laburú (2011)	3
C. Processes of construction and development of teaching knowledge	C.1 Knowledge construction and development processes in training courses and projects	Silveira (2017); Dias (2014); Krüger (2001); Labarce (2014); Morita (2012)	5
	C.2 Processes of construction and development of knowledge throughout the teacher's career	Fabian (2012); Melo (2007); Santos (2017); Silva, A. (2015); Soares (2010); Xavier (2014); Barolli e Guridi (2021)	7
D. Contributions of courses and training programs in the constitution of teaching knowledge	D.1 Teachers' perception of the initial training experienced	Carneiro (2017)	1
	D.2 Contributions of continuing education and postgraduate courses to the constitution of teaching knowledge	Silva, A. (2014); Silva, G. (2015); Abreu, Bejarano e Hohenfeld (2013); Azevedo e Abib (2013); Rezende, Egg e Brown (2006); Rodrigues, Krüger e Soares (2010); Schäfer e Ostermann (2013)	7
	D.3 The role of PIBID in the constitution of teaching knowledge	Mesquita (2015); Paredes (2012); Corrêa (2014)	3
E. Other Focuses	E.1 Structuring the work of the Science teacher and its impacts on knowledge and political-pedagogical practices	Rezende (2016)	1

	E.2 Teachers' perception of the role of subjectivity in teaching and learning processes	Carminatti e Del Pino (2019)	1
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Source: Created by the authors.

The analysis of Box 1 shows that most works aimed at identifying teaching knowledge – Axis A (36), followed by those that seek to study the processes of construction and development of this knowledge – Axis C (12). A significant number of works are dedicated to investigating the contributions of specific training processes in the constitution of teaching knowledge – Axis D (11). Fewer are those who seek to study the relationships between teaching knowledge and the composition of professional identity – Axis B (3), and other focuses – Axis E (2).

Due to the extension limits of this article, in the following sections, we discuss our results considering some representative works from each axis.

Axis A - Knowledge mobilized by science teachers

Six Axis A surveys seek to identify knowledge mobilized by science teachers participating in training courses and projects [A.1] (Box 1). Some of them focus on the knowledge mobilized for the use of specific teaching approaches and strategies, such as Information and Communication Technologies (Aguiar, 2011); Teleological explanations (Azevedo, 2007); and FlexQuest (Souza, 2013).

In general, such research shows that teachers in continuing education do not always have an informed view of the teaching strategies covered in the courses and how to use them in Science Teaching. To overcome the difficulties related to the use of these strategies, teachers generally resort to knowledge from experience (Aguiar, 2011; Azevedo, 2007; Souza, 2013), which is mobilized in a way linked to other knowledge from different sources: initial training; the continuing training course; previous school experiences (Azevedo, 2007; Souza, 2013).

Some research also identified the knowledge mobilized by teachers in training courses, when they prepared and developed teaching proposals involving specific topics in Science, such as optics (Pacca, 2015); evolution (Azevedo, 2007); puberty/adolescence (Souza, 2013). In these studies, there is evidence of limited knowledge about the scientific content to be taught and the need for the teacher to know how to formulate this content to make it understandable to students.

For example, Pacca (2015) analyzed the performance of three teachers participating in a continuing education course that aimed to promote the construction of professional competence within constructivist parameters. Throughout the course, the teachers planned classes on the topic of optics, developed this plan with their students, and discussed the results obtained weekly. The teachers answered a questionnaire about the development of classes with their students, which was analyzed using the focus of discursive textual analysis. According to Pacca (2015), the teachers were aware of their performance but also showed some limitations in their knowledge of the content.

An important aspect to be considered about research in category A.1 is that, although they were carried out with teachers participating in training courses and projects, in general, they used category analysis or content analysis (Aguiar, 2011; Azevedo, 2007; Souza, 2013) and the discursive textual analysis of documents (Pacca, 2015), without emphasizing how this knowledge is mobilized and articulated in these training contexts, something that was better considered in the research in category C.1, discussed later.

Axis A also included research that focused on identifying knowledge mobilized in teaching situations by the teacher [A.2] (Table 1) which also highlights a wide variety of knowledge mobilized by teachers in teaching situations and their reflections.

Among these studies, Carvalho (2010) investigated how and when three teachers who taught from the 6th to the 8th year of middle school addressed environmental issues in their classes. The construction of data occurred through observation of these teachers' classes and interviews. The results indicate that most of the time, environmental issues were used by teachers to exemplify content. Furthermore, Carvalho (2010) identified that, at times when Environmental Education was included in classes, the mobilization of experiential and curricular knowledge by teachers predominated, an aspect

that was also identified by Souza-Júnior (2017) when analyzing the knowledge mobilized by science teachers during work with the Environment as a transversal theme.

Cavalcanti-Neto (2015) analyzed how teachers expressed their teaching practice and the mobilization of knowledge in their actions in the classroom, seeking to identify and systematize aspects that constitute this practice. Data were constructed through questionnaires, interviews, and observation of teachers' practices. The author relied on interactional ethnography to conduct the research. Initially, we sought a macro view of the sequence of classes analyzed that would enable the choice of episodes for discourse analysis.

The results of this research show that teaching practice is made up of a multiplicity of aspects that go beyond the cognitive and involve values, feelings, and identities that influence the teacher's actions. These aspects seem to be built on previous school and training experiences by the teacher, in teaching activities based on relationships with students and other subjects in the school community, and participation in projects, among others. All teachers recognized that their current teaching actions had changed over time, based on their experiences as teachers and in initial training.

The study by Cavalcanti-Neto (2015) highlights the potential of investigating teaching knowledge from an ethnographic perspective, based on the analysis of discursive interactions established between subjects. The potential of this logic of investigation lies in considering the situated and nature of the social events in which knowledge was mobilized, its difference to other types of methodological approaches in the field of Education, and, more specifically, those that investigate teaching knowledge based on categories previously defined by the literature in the area. From an ethnographic perspective, the focus on teaching knowledge shifts from what teachers *should* know to what they *do* in their practices, which highlights the social and contextual character of teaching knowledge. In other words, the emphasis of this type of investigation is not on identifying knowledge originating from a specific typology, but on analyzing it as it is mobilized by teachers throughout the interactions they establish with other educational actors (Bloome et al., 2022).

There seems to be a consensus among the research classified in category A.2 around the centrality of experiential knowledge in teaching (Alves, 2016; Boa, 2008; Carvalho, 2010; Cavalcanti-Neto, 2015; Cravo, 2019; Diório, 2017; Freitas, 2012; Moura, 2006; Rodrigues, 2007; Souza-Júnior, 2017; Souza, 2010). However, even though most of them resorted to observing pedagogical practices, the analyses of teaching knowledge were conducted from an individual perspective, focusing on the teacher. Except for the study developed by Cavalcanti-Neto (2015) and discussed previously, in general, the research did not prioritize the description and analysis of teaching knowledge in its social dimension, which is constructed in the teacher's interaction with students and other social actors, like their peers; or they did not combine this dimension with the personal dimension, whose interface delineates teaching knowledge (Tardif, 2002).

In category A.3, works that focus on the knowledge mobilized in teachers' reports to address themes or the use of specific teaching resources predominate. Some examples are audiovisual resources (Vidal, 2010); environmental education (Lima et al., 2011); ecology (Silva, D., 2014); and gender relations (Barros; Queiroz, 2020).

As in research classified in categories A.1 and A.2, research in category A.3 also highlights the plural nature of teaching knowledge, when they identified knowledge originating from different sources that precede initial training and are continually developed through training processes and personal and professional experiences. From an individual perspective, teachers offer reports that when dealing with specific teaching themes or strategies, knowledge from professional experience is of great relevance (Lima et al., 2011; Silva, D., 2014; Vidal, 2010).

In general, Axis A research gives us evidence regarding this plurality of teaching knowledge. However, this research leaves gaps in the processes of construction and development of this knowledge. We believe that such gaps are due to the investigation logic of these studies, which tends to privilege an individual perspective of analyzing teaching knowledge by prioritizing methods of categorization and content analysis (Silva, 2017). Even though this type of analysis has the potential to achieve the objectives of some of this research, we consider that one of its main limitations is that it does not consider the social and contextual dimensions of teaching knowledge that is manifested and transformed through and in

social practices that are established in complex relationships between the teacher and other members of the educational community (Tardif, 2002).

To solve these limitations, it is important to consider methodological approaches that presuppose not only the identification of teaching knowledge but also the understanding of the processes of development of this knowledge on a social level. From an ethnographic perspective, for example, it is considered that, even if certain knowledge originated in the experience of a specific teacher when this experience is public, the knowledge is no longer located only in that teacher and begins to be seen as a public or joint property (Bloome et al., 2022).

Axis B - Teaching knowledge and professional identity

The three studies classified in Axis B focus on the relationships between knowledge and the construction of teaching identity. Ambrosini (2012) studied the composition of teaching identity to verify the presence of characteristic features of the epistemological status of Biological Sciences in teachers trained in this course, based on Gaston Bachelard's epistemological theory.

Ambrosini (2012) developed a case study involving seven teachers from state schools, trained in Biological Sciences, who teach primary or secondary education. Through their answers to a questionnaire, these teachers showed that they value disciplinary and experiential knowledge more, compared to others. As a result, these two pieces of knowledge are considered fundamental elements in the teaching identity of these teachers.

We observed that disciplinary knowledge seems to constitute the reasons for working in the profession and enables the development of specific characteristics among teachers, arising from the empirical-positivist epistemological status of some areas of Biological Sciences. The author highlights that characteristics of this same profile can be perceived in teachers who graduated in other disciplinary areas belonging to another epistemological status. In this sense, she concludes that the conformation of the Degree Course in Biological Sciences investigated prepares the student to act both as a teacher and as a researcher. Given this, professional identity is constituted concerning the researcher, which has greater status in the eyes of others; which, for the author, makes it difficult for the teacher's identity to be assumed as one's identity because it is weakened as an identity for others.

Ogo and Laburú (2011) and Villani, Barolli, and Nascimento (2020) address the knowledge built throughout the teacher's career and its impacts on staying in the career and improving teaching work. Ogo and Laburú (2011) sought to explain how the construction of a science teacher's professional identity occurs throughout their professional activity. Through an adaptation of Charlot's proposal, they defend the idea that the teacher's permanence in the career is related to professional knowledge, which is inseparable from the subject's relationship with the World, the Self, and the Other.

For these authors, the subject's relationship with the World presents an epistemic dimension which, in the case of teaching work, corresponds to the teacher's relationship with the knowledge required by the profession. The relationship with the Self refers to the teacher's perspectives and expectations, the image he has and wants to convey of himself/herself, as well as the professional's life story. Finally, the relationship with professional knowledge maintains a relationship with the Other: the teacher's coexistence with other members of the school community.

Data collection for the research by Ogo and Laburú (2011) was based on semi-structured interviews with two science teachers from public schools, between 10 and 20 years of teaching career. The authors observed that one of the teachers had a relationship with the Self restricted to the economic and sustenance needs of his family, while the other teacher had a strong relationship of professional desire, characterized by the bonds maintained with the Self, with the Other, and with the world. In both cases, these relationships justify remaining in teaching.

Villani, Barolli, and Nascimento (2020) aimed to understand the institutional conditions, subjective characteristics, and social contexts that influence the teaching trajectory to favor a continuous search for educational innovations. This was done through the investigation of how the articulation between the production of teaching knowledge and the implementation of innovative projects occurs, based on a case study involving the trajectories of two physics teachers.

The authors were based on Bernard Lahire's theoretical-methodological perspective, which seeks, through a set of information obtained from in-depth interviews, to monitor the socialization process experienced by subjects in different contexts. Based on the collection of information from interviews, Lattes curriculum, and publications, the authors reconstructed the trajectories of the physics teachers, in the form of sociological portraits – the methodological locus of the detailed analysis of the teachers' trajectories that condense empirical data, theoretical reference and an analysis of the plurality of dispositions and contexts of practices. The authors concluded that the teachers' careers were regulated by a set of individual characteristics, institutional policies, and occasional events that contributed to their stability and satisfaction in their careers as physics teachers.

In the three studies described, the teaching professional identity was investigated based on teachers' reports about their representations and their professional trajectory. If we consider professional identity as a contrastive and relational process, which develops from the moment one assumes the role of teacher in the relationship with educational actors and is recognized by them as a teacher (Diniz-Pereira, 2011), the importance of research also seeking to understand the processes of social construction of this identity, the meanings and social consequences involved in this process becomes evident (Bloome et al., 2022).

Therefore, it seems important to us that research that deals with professional identity and teaching knowledge seeks to understand how participation in social events affects the identities assumed/constructed by the actors involved in educational contexts. The analysis of the social identities assumed/constructed by the interacting actors, as has been done in some research guided by an ethnographic perspective, allows us to elucidate the interpersonal and language processes used by them to create themselves and each other. From this perspective, professional teaching identity cannot be understood as a fixed and stable construct, but as conditioned by social events constructed by people interacting in different contexts (Bloome et al., 2022; Pimenta, 1999).

Axis C - Processes of construction and development of teaching knowledge

Some research that investigates the process of construction and development of teaching knowledge throughout continuing education courses (category C.1) found a certain difficulty and resistance to the redefinition of knowledge by teachers (Dias, 2014; Silveira, 2017). For example, Dias (2014) analyzed the construction of knowledge related to models and modeling in the continuing education of four science teachers from two public schools. The training process prioritized the development of lesson plans considering the concepts of models, modeling, and teaching knowledge and, according to the author, contributed to teachers recognizing some of the potential of these resources.

Dias (2014) also used Shulman's typology of knowledge to understand the factors that hinder the construction of knowledge related to models and modeling. Regarding this aspect, we observed that some teachers have old convictions rooted in their pedagogical practices and wrong conceptions of the subject. Results like this point to the need to plan courses that consider the knowledge that teachers bring with them, as well as a real articulation with the pedagogical practice of these teachers to enable the reframing and construction of knowledge (Tardif, 2002).

Some strategies used in continuing education courses have been identified as favoring the development and redefinition of teaching knowledge. Among them, the following stand out articulation with pedagogical practice; collective discussions between peers; creation of communities of teacher-researchers; written record of the activities and reflections carried out in the course (Krüger, 2001; Labarce, 2014; Morita, 2012; Silveira, 2017).

Research that focuses on the process of building teaching knowledge throughout the teacher's career [C.2] (Table 1) shows that this knowledge is constructed and developed through different sources and in different contexts: in the family (or in other non-school institutions), in the school trajectory before initial training, throughout initial and continuing training courses, and through teaching experience (Fabian, 2012; Silva, A., 2015; Soares, 2010; Xavier, 2014). The process of building teaching knowledge is, therefore, crossed by personal and collective dimensions and involves non-school, school, and professional paths (Santos, 2017; Silva, A., 2015; Soares, 2010).

Fabian (2012), for example, identified elements that constitute the construction of practical knowledge of Middle School Science teachers who work from the 6th to the 9th year. Interviews were carried out with teachers with at least five years of experience in the classroom. Through reflections on action, carried out throughout the interviews, teachers revealed some elements that constitute their practices, such as content knowledge, pedagogical knowledge, awareness of the roles of the Science teacher, the relationship between teacher and student, and didactic content knowledge. These teachers are concerned with aspects related to what to teach, how to teach, and who to teach. The results also suggest that former teachers had a decisive impact on the lives and construction of practical knowledge of some teachers participating in the work. Furthermore, the relationship with peers and the influence of the students in the construction of practical knowledge were aspects highlighted by the teachers.

Fabian (2012) found that the practical knowledge of the teachers investigated is in constant reconstruction and/or adaptation between the personal and social dimensions, depending on their training needs. Therefore, it is knowledge validated by practice, through reflections on the results achieved with students. Therefore, it is tacit professional knowledge, activated in the face of unforeseen situations that manifests through reflection.

Research like this, which seeks to investigate the process of building this practical knowledge, indicates that, in the act of teaching, teachers mobilize various types of knowledge, but, in this process, they produce new, contextualized knowledge that allows them to face the teaching situations they come across (Fabian, 2012; Santos, 2017; Soares, 2010). It is also worth highlighting the fact that some research identifies certain gaps in the initial training of teachers in the knowledge constructed in this training stage (Silva, A., 2015; Soares, 2010; Xavier, 2014). Silva, A. (2015), for example, sought to understand how physical knowledge is constructed in the training of science teachers, who graduated in Biological Sciences, from the municipal public-school network. The interpretation of the data showed that the construction of the physical knowledge of the research subjects occurred especially during their school career in high school and not in the undergraduate course.

Many of the surveys in category C.2 used individual interviews as a data collection instrument. Sometimes, interviews also appeared associated with other instruments, such as questionnaires and documents. Even though the data obtained through this type of instrument facilitates access to personal elements of teaching knowledge, it reinforces our criticism that these studies prioritize an individual perspective of investigating this knowledge.

Axis D - Contributions of courses and training programs in the constitution of teaching knowledge

As we noted, Axis D research aimed to highlight the possible contributions of courses and training programs to the constitution of teaching knowledge. Unlike those classified in category C.1, there is no explicit purpose in these studies to analyze the process of knowledge development throughout these courses. For example, Carneiro (2017) focused on investigating teachers' perception of the initial training experienced [D.1] and used a qualitative approach, with a descriptive focus, with the participation of 35 teachers who graduated from the Natural Sciences course. As data construction instruments, he used a questionnaire and a group interview. This interview revealed the conceptions related to the experience on the course, as well as its impacts on the careers of these teachers. Despite having a research question linked to understanding the impacts of the course on teaching knowledge, the analysis does not focus on this aspect in depth through the lens of theoretical references in the area. The emphasis was on the conceptions presented by the teachers in the training they had.

Regarding research that emphasizes the contributions of continuing education and postgraduate courses to the constitution of teaching knowledge [D.2], in general, they highlight the role of these courses in the development and redefinition of teaching knowledge. Some of these training processes seem to lead to changes in the practice of these professionals (Silva, A., 2014; Silva, G., 2015).

Silva, G. (2015) investigated how continued training based on experimental workshops in science can contribute to the pedagogical practices of nine teachers who taught in the initial years of Elementary School. After the eight meetings in which the workshops took place, the teachers created lesson plans and developed them with their students, discussed this process with the entire group, and

underwent individual interviews that aimed to understand their perceptions regarding this experience. It was concluded that the experience of experiments and the reflections proposed throughout the course triggered changes in the practice of some teachers by favoring the redefinition of knowledge about the topics covered, as well as pedagogical and curricular knowledge.

Some research in this area focuses on science teachers in the early years of elementary school. Such research indicates limitations in the knowledge related to science content by the teachers investigated, which negatively influence the use of certain teaching strategies and methodologies (Abreu; Bejarano; Hohenfeld, 2013; Silva, A., 2014; Silva, G., 2015).

Distancing from this deficit perspective, Almeida (2017) studied the discursive interactions developed in the classroom by an educational teacher and her students, by articulating the assumptions related to teaching knowledge and the micro-ethnographic analysis of discourse. From this perspective, discourse is understood as language in use, in close relationship with culture, social contexts, and the different meanings and expectations that are shared by people in interaction.

The teacher investigated had extensive experience in teaching children's literacy, while she was beginning her work with Science Teaching at this level of education. The observation and analysis of the teacher's classes in these two contexts (Literacy and Science Teaching) revealed that she mobilized the knowledge of a literacy teacher for Science Teaching. Based on these results, Almeida (2017) argues that this teacher's teaching repertoire enabled her to carry out some actions that make her Science Teaching viable.

We believe that this new perspective on working with Science Teaching in the early years was possible in the work of Almeida (2017), mainly because he is concerned with the knowledge that is mobilized by the teacher in her work, in place of focusing on the knowledge that the teacher should have. As indicated, this seems to us to be an important contribution of research carried out from an ethnographic perspective to the study of teaching knowledge.

Regarding research classified in category D.3, they show that PIBID³ is a program that contributes not only to the initial training of undergraduate students involved in the project but also to the continued training of supervising teachers in Basic Education, especially by encouraging reflection and resignification of their knowledge. The study by Mesquita (2015), for example, investigated the role of PIBID in initial and continuing training actions for Science/Chemistry teachers in the basic education network.

The author prepared a case study involving teacher trainers from the Biology and Chemistry Degree Courses, Basic Education teachers, and undergraduate students from the Biology and Chemistry Degree Courses who are part of PIBID/Interdisciplinary. The following instruments were used to construct the data: participant observation, questionnaires, and interviews. The seven training meetings were recorded using videos.

Mesquita (2015) concluded that: (i) PIBID favors the establishment of partnerships between peers from the same school and professionals from other levels; (ii) there is a certain deficiency in initial training courses, which tend to assume a configuration based on technical rationality. PIBID acts as a way of strengthening links between schools and universities to contribute to the training of undergraduate students.

If, on the one hand, PIBID has the potential to contribute to the initial and continued training of the subjects involved, on the other hand, some limitations of this program have been identified. Paredes (2012) investigated the understanding of PIBID and its implications for the construction of teaching knowledge of science teachers. The research was carried out using a qualitative approach and its sources of information were public documents about PIBID and interviews with three supervising Basic Education teachers from each of the subprojects.

Paredes (2012) observed that the subproject graduates recognized the importance of having mastery of the subject to be taught, but also of pedagogical knowledge of the content. Furthermore, the interviews showed that the Biology, Physics, and Chemistry subprojects contributed to the construction

³ The Institutional Teaching Initiation Scholarship Program (PIBID-*Programa Institucional de Bolsas de Iniciação à Docência*) is an action of the Ministry of Education (MEC), which provides undergraduate students with an approach to public Basic Education schools, under the supervision of Basic Education teachers and professors coordinating the project at universities.

of disciplinary and curricular knowledge and favored the understanding of the role of the researcher teacher. However, according to the author, the strategies used in the Biology and Chemistry subprojects in the period analyzed reproduced a training model based on technical rationality and disregarded the experiential knowledge of the Basic Education teachers participating in the program.

Therefore, Axis D research discussed the potentialities and limitations of training processes in the development of teaching knowledge. We consider that the identification of strategies that enhance the development of this knowledge throughout training courses/projects is an important aspect to favor the implementation of training processes that can effectively contribute to teaching professional development. However, we also highlight that it is important to consider the overvaluation that some authors attribute to the teaching strategies used in these courses to the detriment of the role assumed and negotiated by teachers in the training processes and the broader contexts in which these actors are inserted.

We use the ideas of Ricketts (2019) to argue that interactions about practice that are built in groups in which teachers strive to support each other's learning and development mediate what, to what degree, and how teachers learn. These interactions include both previously planned factors and spontaneous factors that can generate or restrict teachers' learning opportunities, but few studies have investigated them.

This overvaluation of training strategies also results in a tendency for some research in the area to consider that short courses have the potential to bring about major changes in teachers' pedagogical practices. On the contrary, the process of teaching professional development involves continuous learning about teaching, throughout a career (Imbernón, 2016).

We believe that analyzes informed by an ethnographic perspective, such as the one from Ricketts (2019), have the potential to overcome the tendency to overvalue training strategies, in a cause-effect relationship, by focusing on teachers as active subjects, who they act and react to each other in the construction of the worlds in which they live. In this sense, broader contexts – such as political, institutional, training, etc. – influence (but do not determine!) and are influenced by what teachers do in the social events in which they participate (Bloome et al., 2022).

Axis E - Other focuses

The two Axis E surveys have different research focuses. Carminatti and Del Pino (2019) discuss teachers' perceptions of the influence of affection and the teacher-student relationship on teaching and learning processes in Natural Sciences in High School. Data were obtained from questionnaires and interviews carried out with Chemistry, Physics, and Biology teachers. The teachers interviewed recognize that they build relationships with their students from certain spaces and times, and it is through coexistence that these relationships are built. Thus, it is highlighted that disciplinary contents are important, but they are not the only factors that impact the teaching and learning processes.

Rezende (2016) described and analyzed the structuring of the science teacher's work and its impacts on knowledge and political-pedagogical practices in the context of a municipal school organized from the perspective of democratic curriculum management and the collective construction of knowledge. To develop this research, participant observation techniques, bibliographical research, and structured interviews with two science teachers in the institution were used. The analysis was based on the dialectical-hermeneutic method that considers that data cannot be dissociated from the historical, social, economic, and political reality in which they are inserted. In this way, the researcher is responsible for attributing meaning to them.

The data reveal that the work of science teachers at this school is not limited to specific subjects, in a fragmented schedule, and relies on the collaboration of colleagues from other areas in collective study spaces. It was also observed that the teacher's work is marked by a character of mediation and collaboration with students, unlike conventional public schools, which tend to prioritize expository classes.

Rezende (2016) concluded that the redefinition of the work of teachers and, specifically, those of science, occurred due to the profound changes in the organization of school space-time, the possibilities for collective construction of the political-pedagogical project, and the effective participation

of the community of the school institution. The use of ethnographic methods (such as participant observation) and the valorization of everyday actions contributed to the author's focusing on this social dimension of the construction of teachers' knowledge and practices. However, this was done from an ethical perspective (that of the researcher) and not from an emic perspective (that of social actors). The latter has the potential to provide a more accurate understanding of teaching knowledge at the interface between the personal and the social since its mobilization and negotiation are investigated based on the analysis of how teachers act and react discursively with other educational actors at social events (Bloome et al., 2022).

FINAL CONSIDERATIONS

In this work, we seek to understand how teaching knowledge has been investigated in Science Teaching in Brazil and identify the main contributions and limitations of these investigations. First, this survey allowed us to demonstrate that, as what occurs in other areas, research on teaching knowledge in Science Teaching uses a variety of terminologies and theoretical bases to address the topic. Although many authors present similar ideas, certain differences have important impacts in terms of how to identify and study such knowledge. This is evident when we observe the great diversity of objectives of the research analyzed in the survey.

In our first research question – what are the main axes of investigation in the research section involving the teaching knowledge of science teachers in Brazil that make up our sample? –, we identified the following: knowledge mobilized by science teachers (Axis A); teaching knowledge and professional identity (Axis B); processes of construction and development of teaching knowledge (Axis C); contributions of courses and training programs in the constitution of teaching knowledge (Axis D); other focuses (Axis E).

To answer our second research question – how can the research that makes up these axes be characterized? –, we discuss general characteristics of research in each of these axes. We observed that research that seeks only to identify teaching knowledge in different contexts prevails (Axis A). Such research provides additional evidence regarding the plurality of teaching knowledge, an aspect that seems to be well consolidated in this field and which is evidenced by the numerous characterizations and typologies present in the literature (for example Gauthier et al., 2013; Shulman, 1987; Tardif, 2010). Also in Axis A, we identified some limitations in the investigation logic adopted in these studies. Most of them tend to favor an individual perspective of studying teaching knowledge, based on analysis by categories. This type of analysis, although it makes it possible to combine information from different sources into the same category, does not consider the social and contextual dimensions of teaching knowledge.

We observed a small number of studies that investigate the relationships between teaching knowledge and the professional identity of science teachers (Axis B). The few research that does so also focuses attention on the identity of specific teachers as individual subjects. In this sense, little attention has been given to the fact that teaching knowledge develops at the interface between social and personal aspects of the profession and its relationships with the construction of a collective identity among teachers.

Furthermore, such research does not prioritize understanding how participation in social events affects the identities assumed/constructed by the actors involved in educational contexts, something that requires attention to the use of language as a constructor of social identities. As we discussed, through language and discursive interactions, social actors, such as teachers and students, create themselves and each other in these events (Bloome et al., 2022). Taking such a perspective requires understanding teaching identity as dynamic and highly dependent on the contexts and interactions established within them, especially those around what counts as valid knowledge and practices.

Axis C research presented significant considerations for understanding that teaching knowledge is expanded and improved in a continuous process of professional development, throughout the teachers' career. However, in these studies, little attention has been given to how this knowledge is constructed by teachers at the interface between social and personal aspects. Therefore, they do not focus on investigating the processes of knowledge development based on the discursive interactions established

among teachers throughout these courses, but they are based on an individual perspective of developing this knowledge.

Regarding research that studies the contributions of training courses to the development of teaching knowledge (Axis D), they tend to point to limitations in teachers' conceptions and the course's contributions to the development of that knowledge. We observed that there is a tendency in research to consider that the strategies used in training courses/programs were decisive for the development of teaching knowledge without, however, this being accompanied by an in-depth discussion about how and why the activities developed in these courses contributed to the advancement of teaching knowledge. Based on the investigation by Ricketts (2019), we consider that the interactions that teachers actively establish around teaching practice in these training processes mediate *what, to what degree, and how* they learn, and, therefore, their analysis has great potential to substantiate this type of discussion.

Regarding our third research question – what are the main contributions and limitations of this research? –, we evidenced that research has contributed to consolidating aspects highlighted by Tardif (2010) that teachers' knowledge is not exclusively theoretical knowledge, and that this knowledge is characterized by the interactional contexts in which teachers participate. This aspect was well portrayed, mainly in the research that constitutes Axes B, C, and E. Although these three axes focus on different aspects related to teaching knowledge, the research that constitutes them gave strong indications that the personal and professional trajectories of teachers are decisive in elucidating aspects related to teaching identity and the processes of developing teaching knowledge, for example.

Furthermore, like Tardif (2010), we also observe the relevance of knowledge from experience among teachers as those that open possibilities for other knowledge to be adapted depending on the specific demands of their work. This centrality of experiential knowledge was evident both in research that sought to identify the knowledge mobilized by teachers (Axis A), and in those that sought to investigate the processes of development of teaching knowledge (Axis C). Finally, Axis D research contributed to elucidating the potential of strategies and limitations of training processes in the development of teaching knowledge, which is important for thinking about the implementation of educational policies aimed at improving professional practice.

Regarding the main limitations that we identified in the research analyzed, we highlight that: (i) there is an emphasis on the identification/categorization of knowledge mobilized by teachers; (ii) although teaching knowledge is developed in social interactions established between teachers and other educational actors, there is a lack of research in the area of Science Teaching that seeks to study how the mobilization and development of this knowledge occur through such interactions; and, consequently, (iii) although teachers' knowledge is influenced by socio-educational and institutional contexts, the contextualized study of this knowledge has not received the necessary attention.

Thus, regardless of the research axis, the limitations identified in research on teaching knowledge point to the need for an effort to describe teaching knowledge as a social phenomenon, which is constructed in the teacher's interaction with his/her students, with their peers and other members of the educational community (Tardif, 2002).

The study of teaching knowledge as a social phenomenon presupposes the analysis of discursive interactions, since through language and other semiotic systems related to it, people act and react among themselves and with the world. This premise is based on a conception of discourse as a type of action that people perform with each other (Bloome et al., 2008). Thus, we understand that teaching knowledge is mobilized and constructed in discourse when teachers engage in interactions with educational actors and, therefore, its study requires the analysis of discursive interactions between participants, shifting the focus from the individual as the basic unit of analysis (Putnam; Borko, 2000).

Based on these assumptions, the central purpose of studies of this nature is not to identify knowledge expressed by a specific teacher but to understand how this knowledge is mobilized as different actors act and react to each other and construct cultural meanings through everyday practices (which includes teaching practice) of a group. Cultural meanings become propositional, socially significant, and culturally relevant through discursive interactions and, therefore, are inseparable from these interactions. In this sense, it is necessary to consider how the cultural processes and practices of a group are particular and situated, that is, to give due importance to the specific aspects of that situation studied. This does not mean that macro-level contexts are disregarded. On the contrary, “situated” refers not only to the

local situation but also to the relationships between it and other events and social contexts at multiple levels (Bloome et al., 2022).

Considering an ethnographic perspective for the study of teaching knowledge allows us to capture this uniqueness and the specificities of the events in which teachers are involved, by focusing on the use of language for the construction of cultural practices, at the same time allows us to establish relationships with broader social contexts. This requires a certain distance from pre-existing typologies and an attempt to understand this knowledge as it is mobilized and used by teachers throughout these interactions. This is an aspect that we have explored in our ongoing research, based on the micro-ethnographic approach to discourse. This approach values the processes through which people use language and other communication systems in their interactions, considering social, cultural, and political processes, such as those that permeate the development of teaching knowledge (Bloome et al., 2022).

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Submitted: 04/17/2023

Preprint: 04/12/2023

Approved: 10/22/2023

AUTHORS' CONTRIBUTIONS

Author 1 – Data collection, data analysis, and text writing.

Author 2 – Project coordinator, active participation in data analysis and writing review.

DECLARATION OF CONFLICT OF INTEREST

The authors declare that there is no conflict of interest with this article.

ACKNOWLEDGMENT

This work was carried out with the support of the *Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brasil* (CAPES) – Financing Code 001; FAPEMIG; CNPq. We would also like to thank the Federal University of Ouro Preto for its support in developing the research.