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SHULMAN'S THEORETICAL CATEGORIES: AN INTEGRATIVE REVIEW IN THE FIELD OF TEACHER EDUCATION

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Abstract

This study presents an integrative literature review. It aim was to identify the trends and characteristics of Brazilian academic researches that used the theoretical categories of teaching knowledge, formulated by Shulman and collaborators: pedagogical content knowledge (PCK), pedagogical action and reasoning processes. We found 114 studies, most of which published since 2010. The studies focus mainly on the initial education of teachers who teach in the final years of fundamental (from 11 to 14 years old) and high school, to understand how PCK is developed and mobilized. The analysis presented here can stimulate the development of further research.

TEACHER TRAINING • KNOWLEDGE • REASONING • PEDAGOGY

CATEGORIAS TEÓRICAS DE SHULMAN: REVISÃO INTEGRATIVA NO CAMPO DA FORMAÇÃO DOCENTE

Resumo

Este estudo apresenta uma revisão integrativa da literatura que buscou identificar as tendências e características das produções acadêmicas brasileiras que fizeram uso do conhecimento pedagógico do conteúdo [pedagogical content knowledge] (PCK) e dos processos de ação e raciocínio pedagógicos, categorias teóricas de conhecimento docente formuladas por Shulman e colaboradores. Foram localizadas 114 produções, a maioria publicada a partir de 2010. O interesse das pesquisas incide principalmente na formação inicial de professores e nos docentes que atuam nos anos finais do ensino fundamental e/ou no ensino médio, de modo a apreender como se dá o desenvolvimento e a mobilização do PCK. A análise aqui apresentada pode estimular o desenvolvimento de novas pesquisas.

FORMAÇÃO DE PROFESSORES • CONHECIMENTO • RACIOCÍNIO • PEDAGOGIA

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CATÉGORIES THÉORIQUES DE SHULMAN: RÉVISION INTÉGRATIVE DE LA FORMATION DES ENSEIGNANTS

Résumé

Cette étude présente une révision intégrative de la littérature dont le but est d'identifier les tendances et les caractéristiques de la production académique brésilienne qui utilise la connaissance du contenu pédagogique [pedagogical content knowledge] (PCK) et les processus d'action et de raisonnement. Ces catégories théoriques concernant les connaissances pédagogiques ont été formulées par Shulman et ses collaborateurs. 114 textes ont été pris en compte, dont la plupart ont été publiés à partir de 2010. Les recherches concernent surtout la formation initiale des enseignants et les enseignants des dernières années de l'école primaire et/ou du secondaire et visent à mieux comprendre le développement et la mobilisation de la PCK. Cette analyse entend contribuer à la realisation de nouvelles recherches.

FORMATION DES ENSEIGNANTS • CONNAISSANCES • RAISONNEMENT • PÉDAGOGIE

CATEGORÍAS TEÓRICAS DE SHULMAN: REVISIÓN INTEGRATIVA EN EL ÁMBITO DE LA FORMACIÓN DOCENTE

Resumen

Este estudio presenta una revisión integrativa de la literatura que buscaba identificar las tendencias y características de las producciones académicas brasileñas que utilizaban el conocimiento pedagógico del contenido [pedagogical content knowledge] (PCK) y de los procesos de acción y razonamiento pedagógico, categorías teóricas de conocimiento docente formuladas por Shulman y colaboradores. Se encontraron un total de 114 producciones, la mayoría de ellas publicadas en 2010. El interés de las investigaciones se centra en la formación inicial de maestros y en los docentes que trabajan en los últimos años de la escuela primaria y/o secundaria, para comprender cómo se da el desarrollo y la movilización del PCK. El análisis presentado aquí puede estimular el desarrollo de nuevas investigaciones.

FORMACIÓN DE PROFESORES • CONOCIMIENTO • RAZONAMIENTO • PEDAGOGÍA

STUDIES ON THEORIZATION ABOUT THE NATURE OF PROFESSIONAL TEACHING KNOWLEDGE have been abundant since the 1980s in various countries, playing a prominent role in teacher education. This can be mostly attributed to its possibilities to drive the development of training actions in licensure programs and continuing education programs and practices. Thus, Roldão (2007) explains that in theorization about professional knowledge, two dominant streams can be found: one is related to the studies of Shulman (1986, 1987) and collaborators. They intended to develop an explanatory and descriptive model of the components at the base of teaching, particularly how the teacher change representations about educational contents into teaching practices. The other theoretical trend was developed under the influence of Donald Schön and his epistemology of practice (1987). His main objective was to deal with "the teacher's thinking," which "focuses on the construction of professional knowledge as a process of reflexive elaboration based on the professional's practice in action " (ROLDÃO, 2007, p. 98).

Also, according to Roldão (2007), although theorists choose different approaches, there are several points on which they converge. The author cites two: (a) the closeness of Shulman's approach to the teacher-researcher (STENHOUSE, 1991) and the reflective practitioner (SCHÖN, 1987) models, since "knowledge resulting from practice does not refer to the legitimation of any practice, but to the knowledge that results from the analytical reflection of competent teachers

– reflection and competence which implicitly"[1] (ROLDÃO, 2007, p. 99, own translation) mobilize, in a unified manner, the categories of knowledge at the base of teaching; (b) the fact that both propositions are "supported by case studies that underlie and illuminate their respective theorizations, i.e., they actually build on the knowledge expressed by teachers in real situations"[2] (ROLDÃO, 2007, p. 99).

In this study, the focus is on the approaches developed by Shulman and collaborators in the research program called "Knowledge Growth in a Profession: Development of Knowledge in Teaching" in the 1980s, at Stanford University. This program was proposed and implemented by Shulman, based on the critique of teacher education preparations. According to the author, it consisted of assembling subject and pedagogical knowledge, as well as the skills necessary to perform teaching actions in a given teaching context. For Shulman (1987), it was necessary to focus on the knowledge basis required for teaching, its sources, and on the complexity of the pedagogical process, since there was a lack of studies aimed at elucidating the character of this knowledge, which implied questioning what teachers know (or do not know) about what allow them to teach in a given way.

Believing that research was trivializing pedagogical practice, Shulman and his collaborators dedicated to developing a theoretical framework that explained and described the knowledge that underpins teaching. They also included the possibility for teachers to transform content knowledge into forms that are pedagogically effective and adaptable to variations both to context and to the skills already achieved by students (ALMEIDA; BIAJONE, 2007). Seeking to legitimize the knowledge that underpins teaching, Shulman and collaborators have made essential contributions to teacher education. In these studies as a whole, 'Pedagogical Content Knowledge' (PCK) and 'pedagogical action and reasoning processes' are theoretical categories of teaching the knowledge of great interest to the field of didactics and teacher education in all knowledge areas.

The studies developed by Shulman and collaborators, particularly those regarding PCK, became, according to Bolívar (2005), a privileged epistemological framework in the research of specific didactics, especially in the areas of sciences and Mathematics. Their goal was to discuss Shulman's original model, trying to enlarge it in light of the specific features of each discipline. Due to the diversity of models and concepts regarding PCK and teachers' knowledge, a project called the "PCK Summit" was created, aiming to build a definition and a unified model for this construct. In 2012, thirty groups of researchers studying PCK in Science teaching (Physics, Chemistry, and Biology) gathered at a conference in Colorado Springs. Their purpose: to reach a consensus on the definition of the basic knowledge to be taught in schools and to give precision to the PCK concept.

1 In the original: "conhecimento resultante da prática não se reporta à legitimação de qualquer prática, mas ao conhecimento que resulta da reflexão analítica de professores competentes".

2 In the original: "sustentadas por estudos de caso que fundamentam e iluminam suas respectivas teorizações, ou seja, alimentam-se, de facto, do conhecimento expresso pelos professores em situação real".

Thus, considering the various possibilities of appropriation and use of PCK and pedagogical action and reasoning processes, we surveyed the studies published in Brazil, which used these theoretical categories within the scope of teacher education. The aim was to identify the trends and characteristics of Brazilian research on the knowledge that sustain teaching. Particular attention was given to the ways of accessing teachers' PCK. The study is organized into four parts: in the first one, we briefly present PCK and pedagogical action and reasoning processes as theoretical categories. In the second, the method employed, as well as the analysis of the studies, are explained. Subsequently, we present and discuss the main findings and, finally, we present our final considerations.

PEDAGOGICAL CONTENT KNOWLEDGE AS A THEORETICAL CATEGORY

Based on studies with beginning and experienced teachers, Shulman proposed, in 1986, three theoretical categories of knowledge that are present in the teacher's cognitive development: content, pedagogical content knowledge, and the curricular one. Then, in 1987, he reviewed these categories and divide them into seven others, namely: (i) knowledge of the content to be taught; (ii) general pedagogical knowledge, particularly concerning the broader principles and strategies of classroom management and organization; (iii) knowledge of the curriculum, particularly regarding programs aimed at teaching specific subjects and topics at a particular level, as well as the range of teaching material available; (iv) pedagogical knowledge of content related to the specific amalgam of content and pedagogy, which is the exclusive domain of teachers; (v) knowledge of learners and their characteristics; (vi) knowledge of educational contexts, from group or classroom functioning to the management and funding of educational systems, to the characteristics of communities and their cultures (vii); and, finally, knowledge of the aims, purposes and values of education, as well as its historical and philosophical foundation.

Of all these categories, pedagogical content knowledge is, according to Shulman (1987), the most interesting one. This is so because this concept allows the identification of distinct parts of knowledge for teaching and, also, involves the intersection of content and pedagogy in understanding, for example, how particular topics, problems, or subjects are organized, represented, and adapted to learners' various interests and skills in teaching contexts. Therefore, PCK consists of ways of formulating and presenting content that is understandable to students, including the use of analogies, illustrations, examples, explanations, and demonstrations. Also, PCK concerns the teacher's comprehension of what facilitates or hinders the learning of specific content, including students' misconceptions and their implications for learning (SHULMAN, 1987). As he argues that to teach is, above all, to understand, Shulman (1987) considers that PCK is a set of alternative forms of representation which originate both in research and in knowledge derived from teaching practice. Thus, because PCK refers to something that is the domain of teachers alone – their unique form of

professional comprehension – Shulman (1987) considers this to be the category that most likely differentiates an expert's comprehension from that of a teacher.

In 1990, Pamela Grossman, a member of Shulman's research team, redefined the categories he proposed in 1987, reducing them to four: (i) general pedagogical knowledge, which combines knowledge of students and their learning, as well as classroom management skills and curriculum knowledge, both horizontally and vertically; (ii) specific content knowledge, which is constituted by what is taught and, therefore, has a direct influence on curricular decisions; (iii) context knowledge, which includes the teacher's comprehension of where he will teach, i.e., knowing the students individually and as a group, the school's administrative and pedagogical organization, the social and cultural particularities of the community the school and its students are in, all of which imply that the teacher's knowledge be adjusted to these features; and, (iv) pedagogical content knowledge, considered as nuclear knowledge, since it interacts with all the other forms.

According to Grossman (1990), PCK encompasses conceiving the purposes for teaching an individual content, i.e., it concerns how precisely the teacher can know the need and the objective of working on a given topic in the classroom. This comprehension requires, in turn, knowing students' understanding of the content to be taught: their experiences and conceptions, their ways of thinking, their possibilities and difficulties, as well as other variables that may influence students' knowledge about the contents presented by the teacher in teaching contexts. Such comprehension is essential for the teacher to conduct learning experiences, as it implies devising ways to represent and explain content. PCK also includes knowledge of the curriculum, i.e., of the curricular materials available for teaching a particular topic, as well as the relationships it has with other topics. Such knowledge allows the teacher to prepare and organize the content to be taught in light of the particularities of the teaching and learning context. Finally, PCK also involves knowledge of instructional strategies: the ways in which the teacher represents contents for students (e.g., the types of examples, demonstrations, analogies, metaphors, experiments, and activities to make them accessible to students).

Thus, PCK is not simply formed by knowledge of each of these categories, but rather by their integration, combination and transformation, something that is influenced by and influences the other domains of knowledge (GROSSMAN, 1990). Therefore, it is a complex construct that encompasses a set of knowledge forms that are implicit and dynamic, thus involving a cohesive and articulated mobilization. PCK is something that can be learned, and its development, according to Grossman (1990), begins with the observation of classes, during one's schooling process; it then continues in initial teacher education, in specific programs and in the teacher's actual practice. Therefore, PCK develops in a continuum, driven by transformation. Personal knowledge of PCK is constituted and transformed in classroom practice, in contexts where the teacher reflects on his own actions, in view of students' learning. Understanding how PCK is formed

in teachers necessarily encompasses the intrinsic relationship of this category with the pedagogical action and reasoning processes proposed by Shulman.

PEDAGOGICAL ACTION AND REASONING PROCESSES

In an article published in 1987, Shulman discusses the theoretical categories of knowledge that are present in the teacher's cognitive development and presents the model of pedagogical action and reasoning processes as he argues that teaching requires both reasoning and knowledge. He therefore proposes an interactive cycle that includes comprehension, transformation, instruction, assessment, reflection and the attainment of a new comprehension, as shown in Figure 1. The pedagogical action and reasoning processes elucidate how knowledge is activated, articulated and built by the teacher during the teaching and learning process. The model he proposed was the result of several studies with teachers, involving interviews, observations, structured tasks and material analysis conducted in order to understand how apprentices turn into teachers, which, in Shulman's view, means mastering subject content and presenting it in new ways and by employing different activities, including the use of metaphors, exercises, examples, and demonstrations in an attempt to lead students to learn the content taught. In these studies, Shulman (1987) emphasizes that teaching involves comprehension and reasoning, transformation and reflection. The author explains that training practices should not make teachers mere followers of textbooks, but rather prepare them to reason deeply about how they teach. Therefore, teacher education should operate with concepts and premises that guide the actions of future teachers, who must appropriate and employ their knowledge base in their choices and actions. Thus, the teacher's comprehension implies a vigorous interaction of ideas and premises to be analyzed from different perspectives (SHULMAN, 1987).

Comprehension, as shown in Figure 1, is the first stage in the cycle proposed by Shulman (1987), and it concerns how the teacher understands the subject he teaches, i.e., understanding a group of ideas that needs to be critically taught. To that end, the teacher must master what he teaches and, if possible, master it in many ways, which presupposes knowing how a particular idea relates to other ideas, whether they belong to the same subject or to others. However, Shulman (1987) believes that such understanding does not distinguish a beginning teacher from an expert in a given subject. On the contrary, he postulates that understanding ideas requires their transformation so that they become accessible to students.

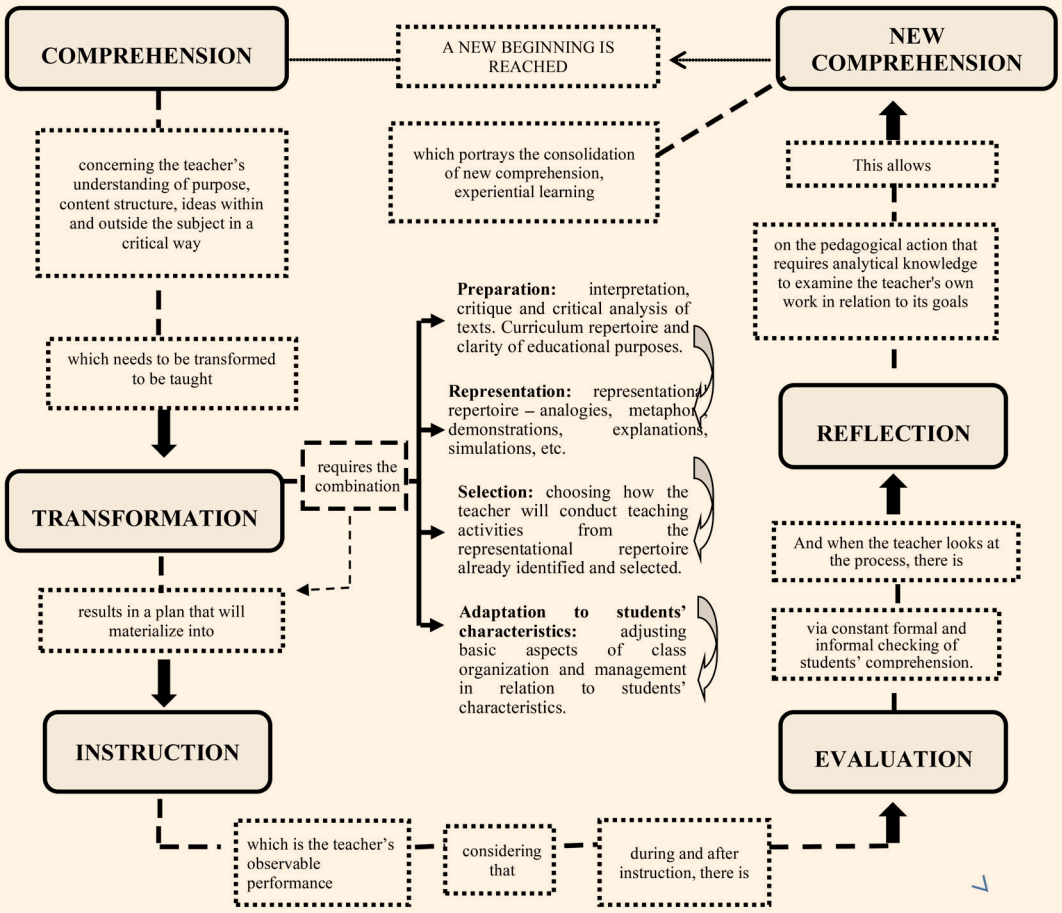
Hence the **transformation**, which requires combining and ordering five subprocesses, which actually represent an intervention proposition. These are: (a) 'preparation', which involves a critical and specialized interpretation of texts and materials, with a view to creating the necessary conditions for students to learn; (b) 'representation', which involves identifying alternative ways of presenting content to students by using analogies, metaphors, examples, explanations, dramatizations, songs, films, teaching cases, demonstrations, different types

of media, etc., thus building bridges between the teacher's many forms of understanding and those that students are expected to constitute; (c) 'selection', relating to the teacher's choices about how to conduct teaching activities, based on representational repertoire that has been previously identified and chosen; (d) 'adaptation' refers to the process of adapting basic classroom organization and management aspects to the characteristics of students, classes and specific contexts (SHULMAN, 1987).

These transformation processes result in a plan that may concern one lesson, a set of lessons, the whole semester, or the school year. So far, according to Shulman (1987), it is all a rehearsal for the performance of teaching that has not yet occurred and will not become real until instruction: the teacher's observable performance, which involves classroom and learning organization and management, explanations, questions, humor, discussions, discipline, as well as all observable characteristics of classroom teaching.

The next stage in the cycle is **evaluation**, which takes place during and after instruction in a constant way: informally, during interactions; formally, through systematic assessment tools. When the teacher looks at the process that has occurred and rebuilds it, reenacts and/or recaptures the events, emotions and results obtained, there is **reflection**. Reviewing and critically analyzing pedagogical action also require using specific knowledge to examine one's own work in relation to its established ends (SHULMAN, 1987). This process, according to Shulman (1987), can be done by the teacher alone or with his peers, using records or just memory. Finally, the last stage in the cycle (Figure 1) concerns **new comprehension**, when the teacher comes to a new beginning, an enriched comprehension of teaching goals, the content to be taught, the strategies employed and also the students, thus establishing the consolidation of new comprehension and learning based on experience. According to Shulman (1987), this new comprehension does not occur automatically, even after evaluation or reflection. To him, specific documentation, analysis and discussion strategies are necessary.

FIGURE 1
MODEL OF PEDAGOGICAL ACTION AND REASONING PROCESSES



Source: Prepared by the authors based on Shulman (1987).

Shulman (1987) clarifies that although pedagogical action and reasoning processes are presented in sequence, that does not mean that they represent a set of fixed stages, steps or phases. Some of them may not occur at all or be truncated, others are ignored or, on the contrary, elaborated, thus receiving more time in this model. In any case, this process can help build knowledge on how to teach different subjects to different students and in different contexts. It is noteworthy that comprehension, transformation, evaluation and reflection activities continue to occur during teaching (instruction). Therefore, it is through pedagogical action and reasoning that the knowledge underlying teaching is transformed over the teacher's professional development. There is, therefore, a close relationship and even interdependence between the pedagogical action and reasoning processes and PCK, since "both combine efforts in the common direction of turning future teachers' knowledge into knowledge that is teachable, understandable and useful to students" (MARCON; GRAÇA; NASCIMENTO, 2011, p. 283).

METHOD

This study aimed to identify the trends and characteristics of research that uses pedagogical content knowledge and/or pedagogical action and reasoning processes as theoretical constructs. We conducted a literature review in the modality defined as integrative review because its purpose is to answer specific questions in a planned way. In this type of review, explicit methodological procedures are employed to identify, select and critically evaluate studies already carried out and knowledge already constructed so as to reach a synthesis of the studies already published and consequently attain a broader understanding of a particular phenomenon (BOTELHO; CUNHA; MACEDO, 2011). To that end, we followed the suggestions of Botelho, Cunha and Macedo (2001), which involve a succession of defined stages.

The first stage consisted of 'identifying the subject and selecting the research problem', which included studying theoretical definitions. It was here that the research question was clearly and specifically defined, which, in turn, guided the selection of the search strategy descriptors and the databases that would be consulted. As a corpus of analysis, we considered the studies in the three most used bases, namely the Capes dissertation and thesis database and the SciELO[3] and educ@[4] websites for the period from 1986, when the PCK concept was first released, to January 2019. The search terms used in the title, abstract and keywords fields were: pedagogical content knowledge, PCK, pedagogical action and reasoning and pedagogical action and reasoning processes.

In the second stage, we sought to 'establish data inclusion and exclusion criteria'. Thus, the main selection criterion was the use of PCK and pedagogical action and reasoning processes as theoretical categories. The process of 'identifying pre-selected and selected studies' – the third stage – required carefully reading titles, abstracts and keywords in order to check whether the criterion adopted was appropriate, and organizing a table with pre-selected studies for the integrative review. In the fourth stage – 'categorizing the selected studies' –, we established the analysis descriptors, i.e., "the aspects to be analyzed in the classification, description and analysis of the targeted material in order to perceive common characteristics and trends among them" (MEGID NETO, 1999 *apud* GOES; FERNANDEZ, 2018, p. 101). For each descriptor, we defined two or more indicators, a term used to refer to the sub-descriptors.

In the fifth and last stage, which consists of 'analyzing and interpreting results', the following descriptors were discussed and interpreted: a) the form of dissemination of the study; b) the research type; c) the participants of interest in the studies, concerning their phase of professional teaching development and their field of work; d) the knowledge area; e) data collection methods and strategies; and f) the main aspects observed in the studies when describing their

3 *Scielo* – The *Scientific Electronic Library Online*. *Website* http://www.scielo.br is an electronic library that contains a selected collection of Brazilian scientific journals.

4 Educ@ – It is a virtual library that aims to provide vast access to collections of well-rated journals in the educational field.

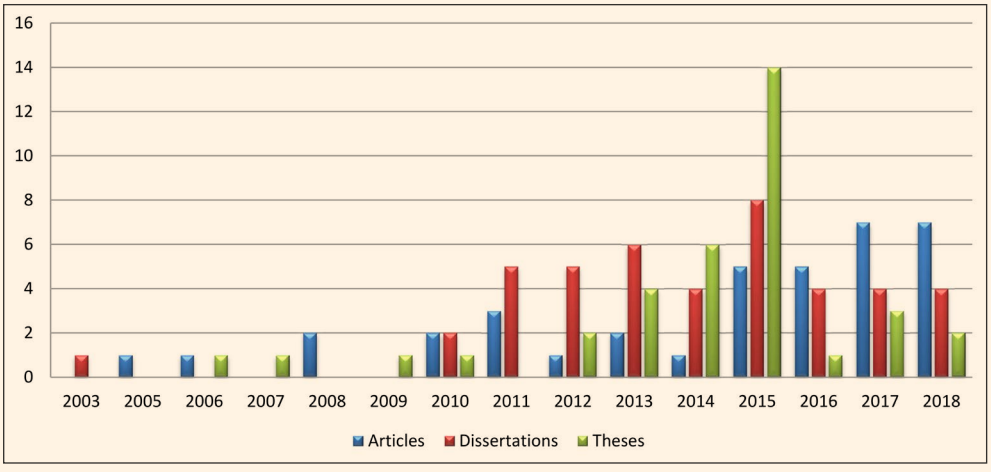
results. Thus, we were able to highlight the aspects that allowed identifying the trends and characteristics of the Brazilian studies consulted about PCK and pedagogical action and reasoning processes. It is worth adding that the analysis resulted from reading both the abstracts and, where necessary, the full papers.

MAIN FINDINGS

We found 114 texts, of which 39 were scientific articles, 49 were dissertations and 35 were theses. These *forms of dissemination* increased in number, mainly from 2011 (Graph 1), with the highest concentration in 2015, with 24 publications, and also in 2017 and 2018, with 15 and 14 publications, respectively. This indicates that the dissemination of authors' ideas in Brazil is recent.

GRAPH 1

NUMBER OF ARTICLES, DISSERTATIONS AND THESES ABOUT PCK AND PEDAGOGICAL ACTION AND REASONING PROCESSES, FROM 2003 TO 2018



Source: Prepared by the authors.

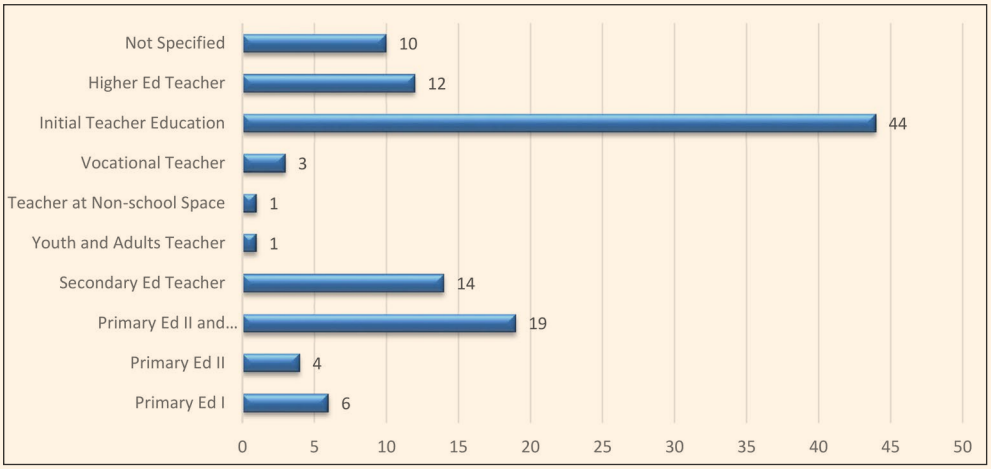
For the *research type* descriptor, we adopted three indicators: empirical research, theoretical research and literature review studies. Empirical research was considered as the studies that obtained data from direct sources, i.e., people who know, experienced or have knowledge about the subject, fact or situation by using field data collection instruments. Theoretical research was considered to be "dedicated to reconstructing theory, concepts, ideas, ideologies, polemics in order to immediately improve practices" (DEMO, 2000, p. 20). Literature review studies are those that involve searching, analyzing and describing a certain body of knowledge in order to answer specific questions. Literature is understood as any relevant material written on a subject: books, journal articles, newspaper articles, historical records, government reports, theses and dissertations and other types. Vosgerau and Romanowski (2014, p. 183) highlight that there are several types of literature review procedures, which can be grouped according to their characteristics: "literature review; bibliometric studies; state of the art research;

narrative review; systematic review, integrative review; qualitative evidence synthesis; meta-analysis; qualitative meta-synthesis or meta-summarization".

Among the research found, empirical studies were the majority, with 92 texts comprising mainly dissertations and theses. Next were 16 theoretical studies, six literature review studies, four of which in the area of Science education and two about technological pedagogical content knowledge (TPACK). This acronym indicates the intersection of three knowledge forms, i.e., content, pedagogy and technology, and refers to the ability to select the most appropriate technological resources to teach a particular curriculum content, which in turn implies knowing how to use these resources in the teaching and learning process.

Considering the studies as a whole, we found that research interest in terms of teaching level, as illustrated in Graph 2, focuses mainly on basic education teachers, who teach for the final years of primary education and/or secondary education (N = 37), as well as initial teacher education (N = 44). It is worth noting that there are few studies on teachers for the initial years of primary education, and none related to early childhood education. With regard to higher education teachers, we found 12 texts. There were few studies on teachers for Youth and Adult Education, vocational programs and teachers in non-school spaces.

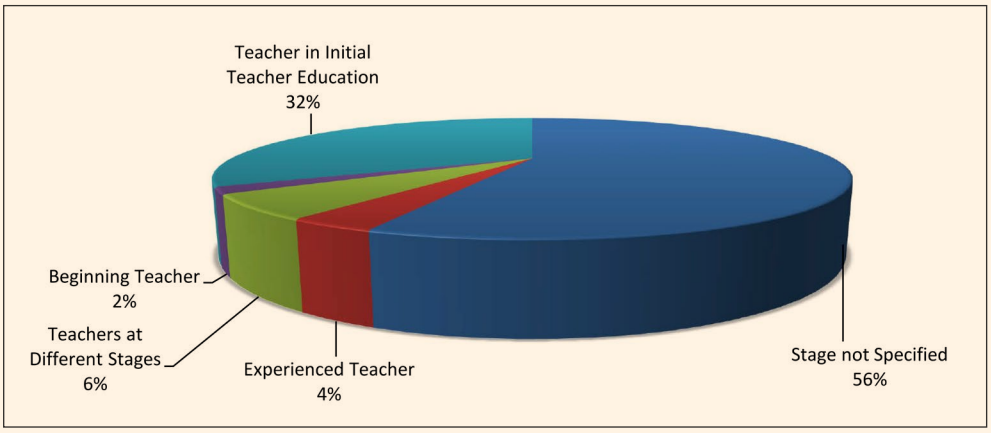
GRAPH 2
THE OBJECT OF RESEARCH INTEREST IN TERMS OF TEACHING LEVEL



Source: Prepared by the authors.

We also sought to identify the focus of studies with regard to the stage of teachers' professional development, as shown in Graph 3. Over half of the studies (N = 64) do not mention what that stage is. In the texts as a whole, 37 studies investigated teachers in initial education; two focused on beginning teachers with less than five years of experience; four investigated experienced teachers; and seven established comparative analyzes between teachers with different experience times.

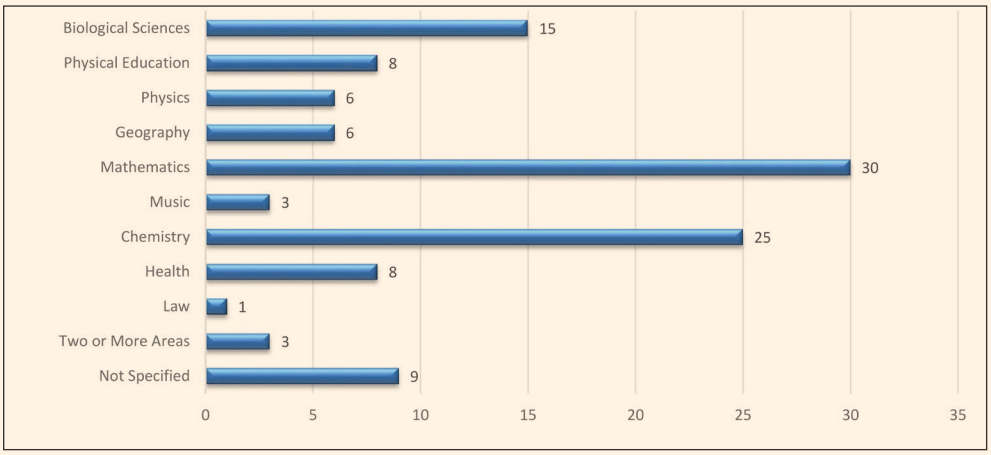
GRAPH 3
THE OBJECT OF RESEARCH INTEREST IN TERMS OF THE STAGE OF TEACHER PROFESSIONAL DEVELOPMENT



Source: Prepared by the authors.

Considering that teacher education in Brazil is basically subject-oriented, we organized the texts based on knowledge areas. In the set of dissertations, theses and articles, more studies were found for the areas of Mathematics (N = 30) and Chemistry (N = 25), as shown in Graph 4. There were also studies focusing on Biological Sciences (N = 15) and Physical Education (N = 8). A smaller number of studies were found on Geography (N = 6), Physics (N = 6) and Music (N = 3). There were also three studies involving two or more knowledge areas. Of the 12 studies focusing on higher education teachers (Graph 2), eight dealt with the Health area, one with the Law area and three investigated teachers who taught pedagogical subjects in licensure programs. No studies were found on History, Portuguese, Languages, Philosophy or Sociology teachers. Most likely, the greater number of studies on Chemistry, Mathematics and Science is due to the fact that the studies developed by Shulman and collaborators have influenced, as said earlier, the research of specific didactics.

GRAPH 4
DISTRIBUTION OF STUDIES BY KNOWLEDGE AREA



Source: Prepared by the authors.

In the studies as a whole, we found interest in examining the development and mobilization of PCK by teachers by focusing on different issues. The most recurrent ones were: (i) PCK in specific subjects, especially in Mathematics, Biological Sciences and Physics. The studies focus mainly on how teachers teach subject-specific topics such as 'combinatorial problems' in Mathematics or 'solutions' in Chemistry in order to gain access to the knowledge and skills developed to teach a particular topic in order to lead the student to understand/increase knowledge of the subject; (ii) PCK development and mobilization considering different stages of professional development, especially by experienced teachers; (iii) PCK development by teachers participating in reflective processes in the context of collaborative groups; (iv) knowledge base categories such as the influence of contextual knowledge (teacher, student and educational institution) on teaching (PCK); (v) development and mobilization of technological and pedagogical content knowledge (TPACK); (vi) role of teacher education practices and teacher trainer in developing PCK in licensure students.

Only four studies were found which investigate the relationship between PCK and pedagogical action and reasoning processes in training contexts. These studies discussed the possibility of building the knowledge base for teaching since initial teacher education by highlighting the pedagogical reasoning processes involved in supervised internship contexts and in activities requiring shared reflection processes. Considering that investigating the knowledge that underlies teaching is a complex process, we sought to identify, in the analyzed studies, the methodological procedures employed to access teachers' professional knowledge. As Fernandez (2015, p. 517) points out, "studying a teacher's PCK is quite complex, due to, among other things, the fact that it is implicit knowledge which must somehow be made explicit". Thus, we sought to identify the

methodological procedures[5] that are most used to investigate teachers' PCK and pedagogical action and reasoning processes.

Of the 92 empirical studies, 18 used a single data collection instrument; the others combined two to four instruments as a means of accessing PCK. The most used ones were: interview (N = 39), observation (N = 28), audiovisual records of classes and/or discussions (N = 20), questionnaire (N = 22), narratives (N = 15), diaries or written records (N = 27) and analyzing and/or designing didactic lesson sequences and/or teaching plans (N = 16). In smaller numbers, reports and portfolios were used, as well as digital tools such as forums, chats, moodle and software.

Content Representation (CoRe) and Professional and Pedagogical Experience Repertoires (PaP-eR) were employed in 13 studies, always in combination with others, by researchers in the Science area in order to access and document teachers' PCK (LOUGHRAN *et al.*, 2001; LOUGHRAN; MULHALL; BERRY, 2004). While doing so, CoRe is also intended to analyze particular PCK aspects. It is, therefore, a research instrument and also a way of encouraging teacher reflection and analyzing how the teacher can reverse possible negative aspects of his class by reflecting on his own practice. This instrument is used to gain insight into the contents of the central ideas associated with the topic to be taught and it can be used both individually and in groups (LOUGHRAN; MULHALL; BERRY, 2004; FERNANDEZ, 2015).

In turn, the PaP-eR instrument emerges from real situations of teaching practice and does not necessarily apply to a particular teacher. It is a narrative of practice, made by the researcher based on class records and on teachers' reflection, from detailed descriptions about the teaching of a particular content, extracted from interviews, ideas expressed in discussions and interactions during practice, among others (LOUGHRAN; BERRY; MULHALL, 2004; FERNANDEZ, 2015). It is worth noting that both procedures promote the development of teachers' PCK, since they encourage reflection on their own teaching practice and thus contribute to improving PCK (GOES, 2014).

Case study was the option of 12 studies to understand how teachers and/or licensure students build and practice PCK. Considering the multiple aspects that characterize a case, researchers can use a wide range of data collection and recording instruments, namely: interviews, teaching plan analysis, non-participant observation, audiovisual class records, field notes and others.

Most of the research developed in the context of initial teacher education in licensure programs explored internship situations; the activities developed therein, in basic education schools; and supervision meetings. In these cases, the most used research instruments were diaries or written records, making and/or analyzing didactic sequences of lessons and/or teaching plans, reports and

5 It is worth noting that some studies do not clearly explain the methodological procedures employed.

portfolios. In eight studies, we found the use of reflections individually conducted or in collaborative contexts as part of the methodological procedures.

Recording and accessing PCK does require combining multiple research tools and data cross-referencing in order to generate reliable results and avoid, for example, the risk of merely recognizing the teacher's beliefs, since researching PCK and/or pedagogical action and reasoning processes requires, as said earlier, making explicit knowledge that is implicit, i.e., of a subjective nature. In their study of science teachers' PCK, Loughran, Mulhall and Berry (2004) underscore the efforts to illustrate what PCK can involve, considering that it is an idiosyncratic, abstract construction influenced by teaching context, content and experience. Thus, the knowledge of how to teach a particular content so as to make it better understood by students may be the same (or quite similar) for some teachers and different for others.

Although the present study did not consider analyzing in detail the results of the analyzed texts, it was inevitable to draw an overview of the main aspects observed by the studies in describing their findings. Thus, we found that, in the analyzed texts as a whole, more than one third explored, in their results, the training actions that promote the development of PCK, both in initial and continuing teacher education. The most recurrent aspects found were: relating theoretical and practical knowledge in order to build PCK; promoting activities that explore knowledge at the base of teaching in different contexts and stages of training practices; provoking systematic reflection processes in the actions of teachers or licensure students; investing in the pedagogical use of ICTs in training processes. Some of the studies conducted in the context of initial teacher education drew attention to the role of trainers, reflective practices and training strategies that promote the development of PCK by coming closer to professional reality and practical experiences.

In their results, about a third of the texts described the researched teachers' knowledge, especially the studies that focused on PCK in a specific subject, PCK of teachers in certain knowledge areas, and PCK of teachers in training processes. Some studies have described the knowledge mobilized to teach a particular content; others focused on how to integrate, e.g., content, general pedagogical, curriculum and context knowledge. Others studies also described and analyzed: (a) situations where the teacher finds it more difficult to teach a particular topic; (b) difficulties experienced in context situations; (c) aspects that positively or negatively interfere with the construction and/or mobilization of PCK and pedagogical action and reasoning processes.

Another aspect that stood out among the findings that describe the teacher's knowledge concerns precarious training in specific contents. Undeniably, these contents are the ones the teacher should know in order to teach and which consequently affect other domains of knowledge. Some studies reported situations of intervention in initial and continuing education practices, which helped teachers expand their knowledge base for teaching and mobilize their pedagogical action and reasoning process. Reflection processes in collaborative

environments have shown great potential in the development of PCK, both in initial and continuing education and/or in collaborative work situations at school. The studies addressing this issue converged to the same point: the importance of teacher participation in collaborative groups which promote discussion, reflection and experience exchange. Indeed, they contribute to developing and improving PCK in a similar way to that proposed by Shulman's pedagogical action and reasoning process.

IN SUM

This integrative review provided important elements for insight into the trends and characteristics of Brazilian research that resorted to PCK and pedagogical action and reasoning process as theoretical categories. The studies found showed great diversity in relation to knowledge area, research objectives and the methodological procedures. Despite this diversity, the analysis allowed revealing movements that help compose a portrait of research in the area, and it can, in fact, encourage the development of further research on the nature of professional teaching knowledge.

Results showed a significant increase in the studies that, especially since 2012, use the theoretical concepts proposed by Shulman to unveil the knowledge mobilized by teachers in teaching contexts. The attention given to teachers' practices and, more specifically, to the development and mobilization of knowledge that underlies teaching, with the use of a theoretical and methodological approach that goes beyond teachers' perceptions, opinions and representations, can be viewed as a major advancement in the field of teacher education. This should not be taken to mean that research on beliefs, perceptions and representations is less important. On the contrary, our intention is to point out that there is demand for studies that come close to teachers' practices and their daily work in order to investigate the processes of development and mobilization of professional knowledge.

From the perspective of the ways employed to access teachers' PCK, we found in part of the analyzed studies a rich detailing of their theoretical and methodological research design. Probably, the complexity of the object, combined with the use of multiple data collection instruments, required greater methodological rigor. However, we also found research that left many doubts regarding data collection and analysis procedures, thus corroborating what has been pointed out by several studies: the methodological weakness that exists in studies in the area of education (ANDRÉ, 2000, 2009).

It was also interesting to see how the Chemistry, Biological Sciences and Mathematics areas have been dedicated to studying the PCK of teachers (including teachers in training) who teach final years of primary education and secondary education.

As mentioned earlier, these areas have greatly contributed to improve the theoretical constructs originally proposed by Shulman, and also to the

construction of instruments to access teacher's PCK. On the other hand, we found a small number of studies on teachers of initial years, and no research on the early childhood education teacher.

Another aspect that drew our attention concerns the small number of studies that resorted, in data analysis, to the theoretical model of pedagogical action and reasoning process, especially considering that the development of teachers' PCK involves this process, despite the fact that Shulman himself highlighted how great the challenge inherent in this problem is (MARCON; GRAÇA; NASCIMENTO, 2011). Marcon, Graça and Nascimento (2011, p. 263) wrote an essay in which they establish "a parallel between the tasks performed by pedagogical content knowledge and the stages of pedagogical reasoning and action process", in order to "[...] see how they coexist, interact, or sometimes overlap". The authors, in an interesting analysis of this parallelism, concluded that both propositions of Shulman (1987) "keep a close, reciprocal and almost interdependent relationship with one another" (p. 263). Thus, they complement each other in their "common goal of transforming future teachers' content knowledge into knowledge that is teachable, understandable, and useful for students" (p. 263). Therefore, research that shows the interdependence of these constructs are promising and may contribute to develop training practices that integrate these aspects in the context of both initial and continuing teacher education.

The role of reflecting on real or simulated teaching situations in order to develop PCK in different stages of professional development was also discussed/analyzed in most studies, which shows how Shulman's propositions are close to the teacher-researcher and reflective practitioner model, as highlighted by Roldão (2007). In a study on the different ways in which teachers learn, Shulman and Shulman (2004) emphasize that reflection is the key to teacher learning and development. In some cases, the reflection processes related to PCK were studied in collaborative contexts created to promote collective learning and the exchange of experiences, in training practices that require collaboration and the joint construction of actions, especially in finding a solution to the dilemmas and problem situations detected in specific contexts.

Therefore, we can see that when PCK and pedagogical action and reasoning processes are treated as theoretical categories, they can contribute significantly to the production of knowledge in the field of teacher education and, consequently, to the introduction of initial and continuing education devices that enable teachers to teach better by turning content knowledge into good teaching. In other words, it is important to lead teachers to know what to do so that, through teaching action, knowledge can be learned and apprehended by the student. This requires consolidating a coherent and pertinent "knowledge repertoire" that corresponds to the professional knowledge characteristic of teachers, considering the specific features of each area.

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