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ARTICLE

INQUIRY-BASED APPROACHES IN SCIENCE AND MATHEMATICS TEACHER EDUCATION: AN ANALYSIS OF STUDIES PUBLISHED IN BRAZIL

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ABSTRACT: This paper introduces a bibliographical study that aims to broaden the understanding of inquiry-based approaches published by national magazines about teacher education in Natural Sciences (Chemistry, Physics and Biology) and Mathematics. The study included 13 Brazilian magazines, which are available online and classified as A1 and A2 by Qualis Capes. We found 35 papers and analyzed them in the light of the principles of the Discursive Analysis of Texts. Data analysis led to three categories: I) Investigation in school as a space of teacher education; II) Conceptions of teaching permeating teachers' investigation practices; and III) Professional practice in teacher-researcher education. Results showed the emergence of a coalescent argument regarding to the fact that insertion of investigation practices in class is associated with teachers' different conceptions of teaching. **Keywords:** Teacher education; Inquiry-based approaches; Bibliographical study; Discursive Analysis of Texts.

ABORDAGENS INVESTIGATIVAS NA FORMAÇÃO DE PROFESSORES DE CIÊNCIAS E MATEMÁTICA: INTERLOCUÇÕES COM ESTUDOS PUBLICADOS NO BRASIL

RESUMO: O artigo apresenta um estudo bibliográfico com o objetivo de ampliar as compreensões acerca das abordagens investigativas comunicadas em periódicos nacionais sobre/na formação de professores de Ciências da Natureza (Química, Física e Biologia) e Matemática. O estudo contemplou 13 periódicos brasileiros, disponíveis *on-line* e de classificação A1 e A2 em termos de *Qualis* Capes. Registra 35 artigos, que foram analisados seguindo os princípios da Análise Textual Discursiva (ATD). Na análise das informações emergiram três categorias finais: I) Investigação na escola como espaço da formação de professores; II) As concepções de ensino perpassam as práticas de investigação dos professores; III) A Prática

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profissional na formação do professor pesquisador. Compreendemos com a análise, a emergência de um argumento aglutinador de que a inserção de práticas investigativas em sala de aula perpassa pelas distintas concepções de ensino dos professores.

Palavras-chave: Formação de professores; Abordagens investigativas; Estudo bibliográfico; Análise textual discursiva.

LOS ENFOQUES DE INVESTIGACIÓN EN LA EDUCACIÓN DE MAESTROS DE LAS CIENCIAS Y MATEMÁTICAS: DIÁLOGOS CON LOS ESTUDIOS PUBLICADOS EN BRASIL

RESUMEN: Este artículo presenta un estudio bibliográfico, con la meta de agrandar la comprensión de los enfoques de investigación publicados en revistas nacionales con respecto a la formación de profesores de las Ciencias Naturales (Física, Química y Biología) y Matemáticas. El estudio incluye 13 revistas brasileñas disponibles en línea con clasificación A1 o A2 segundo Qualis Capes. Se registraron 35 artículos, que fueron analizados a través de los principios del Análisis Textual Discursivo (ATD). En el análisis de la información ha surgido tres categorías: I) La investigación en la escuela como un espacio para la formación del profesorado; II) La enseñanza de las ideas impregnan las prácticas de investigación de los profesores; III) La práctica profesional en la formación de profesor de investigación. Comprendemos con el análisis la aparición de un argumento unificador de que la inclusión de prácticas de investigación en el aula atraviesa diferentes concepciones de enseñanza de los profesores.

Palabras clave: Formación de profesores; Enfoques de investigación; Estudio bibliográfico; Análisis Textual Discursivo.

1. INTRODUCTION

This paper introduces reflections constructed on inquiry-based approaches in Natural Sciences and Mathematics teacher education which have been publicized by the Brazilian scientific community. Therefore, we kept an interlocution with studies of different inquiry perspectives carried out in the field of Natural Sciences and Mathematics teacher education in Brazil.

The methodological structure of the study considered the main question: Which perspectives of inquiry-based approaches in teacher education processes emerge from the analysis of papers published by journals classified as A1 and A2 by Qualis Capes? In order to understand the main issue, we investigated 13 national journals in the area of Science and Mathematics teaching. We found 35 papers that problematize inquiry processes in Natural Sciences and Mathematics teacher education. Papers were analyzed in two steps. The first one was descriptive and enabled us to identify the number of papers per journal and the public they aimed at, regarding teacher education (either initial teacher education or continuing education). The second step consisted in the development of an interpretative analysis in the light of Moraes and Galiazzi's Discourse Textual Analysis (DTA) (2011).

Three categories emerged in this bibliographical study after the corpus was selected: I) Inquiry into school as a space of teacher education; II) Conceptions of teaching permeating teachers' inquiry practices; and III) Professional practice in teacher-researcher education. We have described the methodological path we have followed to reach the categories and our understanding of this bibliographical study in the metatext entitled "Inquiry into school, its conceptions and professional practice: teacher-researcher education".

2. SELECTION OF DATA FOUND IN PAPERS PUBLISHED BY NATIONAL JOURNALS

The journals chosen to carry out the bibliographical study aim at the field of Science and Mathematics teaching in the area of Teaching in the database Journal Qualis¹ and in the *Coordenação de Aperfeiçoamento de Pessoal de Nível Superior* (Capes), updated in 2014. The analysis of the papers included 13 national online journals classified as A1 and A2 (Table 1).

Table 1. List of journals under Inquiry and their descriptions

Journal	Qualis	Description
Centro de Estudos Educação e Sociedade (CEDES)	A1	Published by the Centro de Estudos Educação e Sociedade (CEDES) every four months; it aims at professionals and researchers in Education and addresses current and significant issues in this area.
Ciência & Educação	A1	Published by UNESP (Bauru, SP) every three months; it disseminates original scientific studies in the areas of Science and Mathematics Education and related areas.
Boletim de Educação Matemática (BOLEMA)	A1	Published by UNESP (Rio Claro, SP) every three months; it disseminates scientific studies in Mathematics Education and related areas.
Revista Brasileira de Ensino de Física (RBEF)	A1	Published by the Sociedade Brasileira de Física (SBF) every three months; it focuses on cultural issues and themes in the area of Physics, in a broad pedagogical approach.
Educação e Realidade	A2	Published by UFRGS, every three months; it aims at publicizing scientific studies in the area of Education and stimulates academic debate to yield new knowledge.
Educação em Revista	A2	Published by UFMG every three months; it aims at disseminating scientific knowledge yielded in the area of Education.
Investigação em Ensino de Ciências (IENCI)	A2	Published by UFRGS, every four months; it is indexed and aims exclusively at research in the area of teaching/learning Sciences (Physics, Chemistry, Biology and Natural Sciences, in an integrated approach).
Ensaio: Pesquisa em Educação em Ciências	A2	Published by UFMG every three months; it aims at disseminating researches in the field of Science Education.
Educar em Revista	A2	Published by UFPR every three months; it aims at publishing original scientific papers which deal with themes related to the area of Education.
Avaliação: Revista de Avaliação da Educação Superior	A2	Publication which results from a partnership among the Rede de Avaliação Institucional da Educação Superior (RAIES), Unicamp and Uniso; its main theme is the institutional evaluation of higher education.

Revista Brasileira de Estudos Pedagógicos (RBEP)	A2	Published by the Instituto Nacional de Estudos e Pesquisas Anísio Teixeira every four months; it aims at contributing to the development of educational knowledge.
Revista Brasileira de Pesquisa em Educação em Ciências (RBPEC)	A2	Published by the Associação Brasileira de Pesquisa em Educação em Ciências (ABRAPEC) every four months; it aims at disseminating results and reflections on inquiry carried out in the area of Science Education.
Caderno de Pesquisa	A2	Published by the Fundação Carlos Chagas every four months; it aims at publicizing innovative researches, essays and other texts which are either directly or indirectly related to Education.

Source: Guidotti and Heckler (2017)

Based on the question that asks which inquiry-based approaches of teacher education processes emerge from the analysis of papers published by journals classified as A1 and A2 by Qualis Capes, we searched for papers which dealt exclusively with teacher education. Firstly, we used predefined descriptors in the search system which is available in the site of each journal or in the database in which they have been indexed (such as Scielo). In this process, we used the following terms: teacher education; teaching degree; PIBID (Programa Institucional de Bolsas de Iniciação Científica), a program for young researchers; fair (referring to Science fair); PET (Programa de Educação Tutorial), a tutoring program; new talents; and apprenticeship. The search included all papers published from the year they were created to September 2016. In this step of the study, we found 2,720 papers. Table 2 shows the number of papers found for each descriptor.

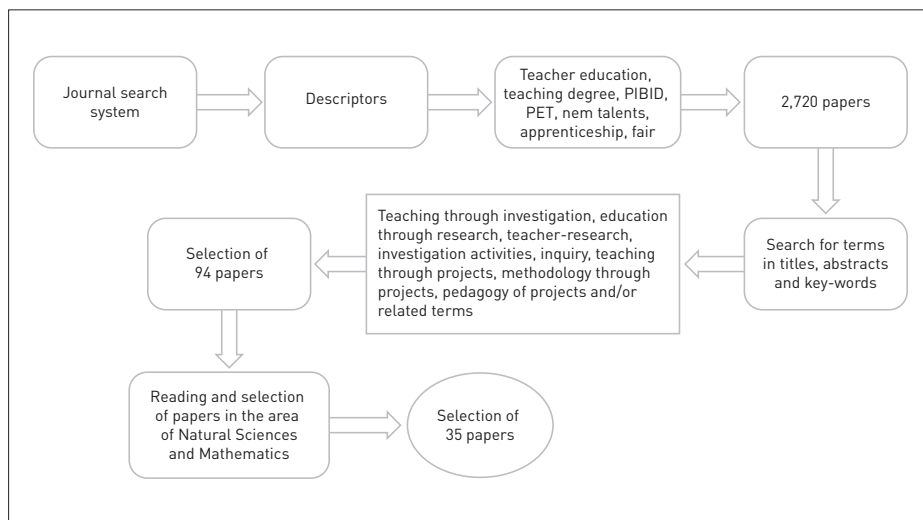
Table 2. Descriptors and number of papers found after the search

Descriptors	Number of papers
Teacher Education	1,780
Teaching Degree	598
PIBID	21
Fair	82
PET	8
New talents	4
Apprenticeship	227
Total	2,720

Source: Guidotti and Heckler (2017)

After having found the papers, we selected those that explicitly introduced in their titles, abstracts or key words, at least one of the following terms: teaching through inquiry, education through research, teacher-researcher, inquiry activities, teaching through projects, methodology through projects, pedagogy of projects and/or related terms. After this process, the number of papers decreased and we got 94. Figure 1 shows the diagram of the search for the papers that composed the analysis set.

Figure 1. Diagram of the steps of the process of search for papers



Source: Guidotti and Heckler (2017)

In some cases, just reading the abstract did not enable us to identify the field of knowledge of the paper. Therefore, we read the whole text in order to identify researches that addressed teacher education in Natural Sciences (Chemistry, Physics, Biology and Sciences) and Mathematics. As a result, we ended up selecting 35 papers.

In this step, we found papers in 6 journals: 14 papers in **Ciência & Educação**, 6 in **Investigação em Ensino de Ciências (IENCI)**, 5 in **Ensaio: Pesquisa em Educação em Ciências**, 4 in **Boletim de Educação Matemática (BOLEMA)**, 4 in **Revista Brasileira de Pesquisa em Educação em Ciências (RBPEC)** and 2 in **Educar em Revista**. We did not find studies of interest in the following journals: **Centro de Estudos Educação e Sociedade (CEDES)**, **Revista Brasileira de Ensino de Física (RBEF)**, **Educação e Realidade**, **Educação em Revista**, **Avaliação: Revista de Avaliação da Educação Superior**, **Revista Brasileira de Estudos Pedagógicos (RBEP)** and **Caderno de Pesquisa**.

Table 3 shows the total numbers of papers selected in each journal and the references of the papers under analysis.

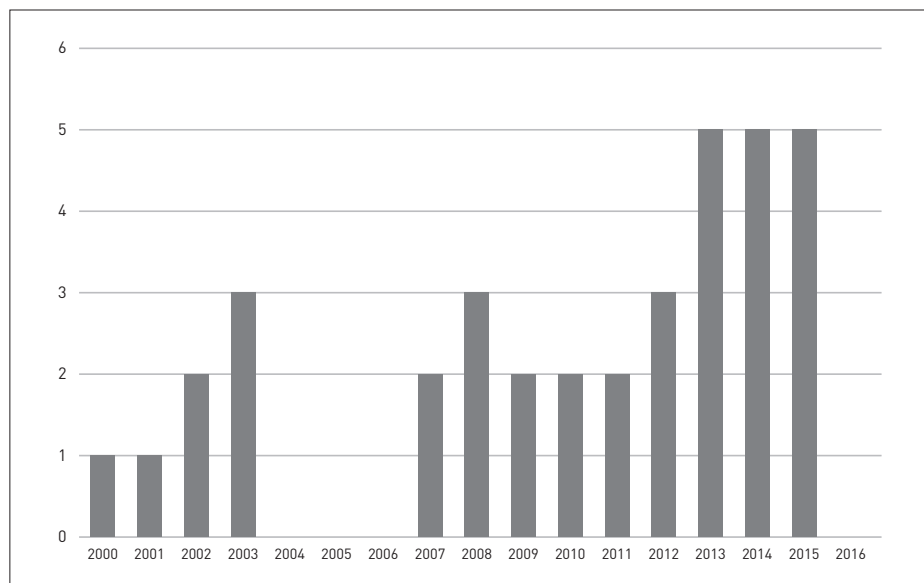
Table 3. Number of papers selected in each journal and references of the papers under analysis

Journal	Number of studies per journal	References
Ciência & Educação	14	Teixeira et al. (2015); Souza (2014); Pires and Igliori (2013); Silva and Cunha (2012); Oliveira and Gonzaga (2012); Sangiogo et al. (2011); Barcelos et al. (2010); Cattai and Penteado (2009); Galvão and Praia (2009); Rosa and Schnetzler (2003); Rodrigues and Carvalho (2002); Galiazzi and Moraes (2002); Galizzi et al. (2001); Vianna and Carvalho (2000).
Boletim de Educação Matemática (BOLEMA)	4	Bertini (2015); Carneiro (2008); Bem-Chaim et al. (2008); Souza and Campos (2008).
Investigação em Ensino de Ciências (IENCI)	6	Coswosk and Giusta (2015); Goi and Santos (2014); Silva et al. (2014); Abreu et al. (2013); Azevedo and Abib (2013); Sá et al.(2011);
Ensaio: Pesquisa em Educação em Ciências	5	Paniago et al. (2014); Massi and Giordan (2014); Teixeira (2013); Rosa and Lorencini (2007); Munford and Lima (2007).
Educar em Revista	2	Catani (2010); Galiazzi et al. (2003).
Revista Brasileira de Pesquisa em Educação em Ciências (RBPEC)	4	Lima and Pagan (2015); Machado and Queiroz (2012); Lima and Amaral (2013); Rosa et al. (2003);

Source: Guidotti and Heckler (2017)

The graph of Figure 2 shows the total number of papers published per year.

Figure 2. Number of papers published per year



Source: Guidotti and Heckler (2017)

Figure 2 shows that, in the journals under analysis, there are studies of inquiry-based approaches in teacher education in Natural Sciences and Mathematics just from 2000 on. It is worth mentioning that after 2002 – except in 2004, 2005 and 2006 – there was increase in the number of studies of the theme.

We also observed that only 1.28% of papers, i. e., 35 out of 2,720 studies under analysis in 13 journals, problematize inquiry-based approaches in teacher education in Sciences and Mathematics. Thus, 14 out of 35 papers report studies of initial teacher education, whereas 18 describe in-service teacher education. Besides, 2 papers involve both and only 1 paper addresses general teacher education and teaching through inquiry theoretically.

All 35 papers selected in September 2016 compose the data used in the analysis carried out in this bibliographical study. They challenged us to structure an analysis that could make us reflect on the theme under study. The next section describes the development of the qualitative analysis guided by the principles of the Discourse Textual Analysis (DTA).

3. CONSTITUTION OF ANALYSIS OF PAPERS BY DTA

This study, which comprises reading and analyzing data found in 35 selected texts, follows the principles of the Discourse Textual Analysis (DTA). It includes a metanalysis from the hermeneutical phenomenological perspective that enables researchers to reflect on different types of inquiry-based approaches in teacher education processes as the result of the analysis of papers published by journals classified as A1 and A2 by Qualis Capes. Based on Moraes and Galiazzi (2011), we understand this analysis process as the self-organizing construction of new perceptions of different inquiry-based approaches in teacher education.

In the analysis, we used a recursive sequence with three components, as proposed by Moraes and Galiazzi (2011): deconstruction of the texts that compose the corpus (unitarization); establishment of relations among unitary elements (categorization); and capture of new perceptions which are publicized and validated in the interlocution with the construction of arguments in a metatext.

In this study, data analysis starts with the unitarization of the objectives, activities and final remarks depicted in the papers under Inquiry. According to Moraes and Galiazzi (2011), in this step, the researcher examines the texts minutely and fragments them so as to get meaning units related to the phenomena under study. Table 4 is an excerpt from the table of data which was analyzed by this study.

Table 4. Excerpt from 155 meaning units and their codification on the electronic spreadsheet

Code	Meaning unit	Key words	Title
A10. 1	In this paper, we show the results of a collective Inquiry into the objectives of experimental activities in high school, highlighting the possibilities of research in class as teachers' and students' development by using it as a didactic principle.	Collective Inquiry, research in class, professional development, didactic principle	Research in class as a didactic principle enables collective Inquiry and professional development
A26. C.H.3	Partnership between schools and universities cannot be punctual; there must be time and space so that teachers-to-be, teachers and professors can problematize Inquiry in teaching.	School-university partnership, time and space, teaching through Inquiry	Teacher education focused on Inquiry takes place in the partnership between schools and universities with adequate time and space
A31.2	The methodology of teaching through projects which structures the Science fair is a special opportunity in teachers' continuing education.	Teaching through projects, Science fair, continuing education	Science fairs based on teaching through projects potentialize teachers' continuing education
A31.3	[...] since it involves participants' sensitization, planning the proposal, work implementation and evaluation; in all steps, teachers face challenges that must be discussed collectively.	Teaching through projects, Science fairs, [...]	The Science fair structured by teaching through projects in the school challenges teachers to work collectively
A31. C.H.1	The Science fair structured by teaching through projects in the school is a great opportunity for teachers and students to develop interdisciplinary studies.	Science fair, teaching through projects, interdisciplinarity	Teaching through projects and Science fairs enable interdisciplinarity

Source: Guidotti and Heckler (2017)

The excerpt from 155 meaning units in Table 4 exemplifies how we systematized the analysis. Meaning units, which are shown in the second column in Table 4, result from the deconstruction of the texts under analysis. Every unit got a code, such as A10.1, to identify that this meaning unit was found in paper no. 10 and that it is the first unit from this text. Besides, the analysis process carried out by the DTA enables researchers to create their own meaning units. In order to identify the units whose author is the researcher, we used a letter, such as A26.C.H.3. This code means that this unit cannot be found directly in the text, but that it expresses implicit meanings, near unit A26.3, for instance. This movement of unit codification enabled us to find the origin of any unit, in any text, whenever necessary, throughout the study.

The third column lists key words that help us create the title of the meaning unit, which is shown in the fourth column in Table 4. Interpretation and understanding of the units depend on the researcher's theoretical knowledge. Therefore, according to Moraes and Galiuzzi (2011), a set of elements may lead to the construction of several meanings which originate from every researcher's theoretical presuppositions.

After the unitarization process, categorization starts. This movement compares the titles that were attributed to every meaning unit and leads to the grouping of units that express similar elements. As a result, it originated 13 initial categories. Table 5 shows an excerpt of this organization.

Table 5. Excerpt of 13 initial categories

Code	Initial Category	Argument	Code of the Final Category
2	Teaching through Inquiry in school challenges teacher education	Implementation of teaching through Inquiry in school encompasses the need for teachers' professional development.	A
3	Inquiry projects in school include spaces for teacher education	Inquiry projects in school must include reflective spaces as a teacher education process.	A
6	The scientific method as a teaching methodology	The scientific method based on a problem is adopted in some cases as the teaching methodology in the school.	B
9	Educational research as a syllabus activity in teacher education	Insertion of research activities in teacher education enables teacher-researchers to develop their professional practice.	B

5	Teacher-researcher education through Inquiry into professional practices	The syllabus that questions professional practices contributes to teacher-researcher education	C
8	Education through research as teachers' educational principle	Education through research as an educational principle enables the academic-professional transformation of teachers and their classes	C

Source: Guidotti and Heckler (2017)

Every category corresponds to a set of meaning units which express similar ideas. The DTA challenges researchers to construct coalescent arguments throughout the whole analysis process. The arguments help to develop a quality and clear self-organized analysis. In this step of the study, the arguments coalesce into the ideas exposed by the meaning units which originated the category they belong to.

The 13 initial categories made us resume the processes of comparison and coalescence so as to construct three final categories: I) Inquiry into school as a space of teacher education; II) Conceptions of teaching permeating teachers' inquiry practices; and III) Professional practice in teacher-researcher education.

Table 6. Codification and final categories Source: Guidotti and Heckler (2017)

Code of the Final Category	Final Category
A	Inquiry into school as a space of teacher education
B	Conceptions of teaching permeating teachers' inquiry practices
C	Professional practice in teacher-researcher education

We should point out that the final categories result from the researchers' intense movement of immersion in the corpus of the analysis. In this process, we let phenomena take place so that categories can emerge from the array of data found in the papers under Inquiry. Tables 4, 5 and 6 show that we started from 155 meaning units which represent specific and restricted categories that get increasingly broader and whose number decreases.

Based on the three final categories, we started to structure the metatext in which we describe the reflections that emerged about the theme under study. In the following section, the metatext entitled "Inquiry into school, its conceptions and professional practice: teacher-researcher education" is introduced. It develops interlocation with the texts we have selected so as to enable us to express different views.

4. METATEXT: INQUIRY INTO SCHOOL, ITS CONCEPTIONS AND PROFESSIONAL PRACTICE: TEACHER-RESEARCHER EDUCATION

4.1. INQUIRY INTO SCHOOL AS A SPACE OF TEACHER EDUCATION

In the first category, whose construction was based on the analysis of set of papers which composed the corpus of this study, we stated that inquiry practices in school encompass the need for teachers' professional development. We believe that working with projects and teaching through inquiry implies collaborative activities and the need to include reflective spaces in school. This education process may be provided by a partnership between schools and higher education institutions.

Teaching which aims at inquiry may be the mediator in teacher education processes. Therefore, in the field of initial teacher education, studies carried out by Galiazzi *et al.* (2001) and Silva *et al.* (2014) introduce research as an educational principle which enables teachers-to-be to reflect on conceptions of being a student and teacher. These authors take on inquiry as a means of teacher education and address college students' commitment to research by analyzing data on teachers' work in class, their roles and their methodological strategies. This movement in teaching degree courses encompass inquiry practices in the professional field that will be faced by teachers-to-be.

We believe that teacher-researchers' education process is improved when inquiry practices are included in their initial professional education. Coswosk and Giusta (2015) proposed a pedagogical project called "Inquiry practices in Microbiology teaching in a teaching degree course in Biological Sciences". When the authors proposed it, they noticed the increase in students' interest in research and in connections among conceptual, procedural and attitudinal contents. We acknowledge that these inquiry practices in teacher education not only gather multiple fields of knowledge but also stimulate autonomy, creativity and the development of the ability to introduce arguments and record students' discussions (BERTIN, 2015).

In the field of continuing teacher education, similar understanding has been observed regarding the importance of investigating professional practices in order to develop students' and teachers' autonomy, creativity and argumentation. Gonçalves (2004) also found evidence of knowledge about the importance of collective work when he investigated professional senses and meanings which were developed when inquiry was the principle of teaching practices. The author highlights the importance of an investigative attitude when problem-situations have to be faced, the social role the school plays in the community, the education of critical citizens and senses of autonomy and authorship that emerge from this process.

Investigative attitudes in a Sciences class may be carried out by both teachers and students. Azevedo and Abib (2013) analyzed the education process of a group of teachers who teach Sciences to children that attend the first grades by using inquiry practices. Their study emphasizes that teaching which is planned this way enables teachers and students to learn how to solve problems related to teaching and learning, respectively.

Studies carried out by Silva and Cunha (2002), Gonçalves (2004), Machado (2012), Paniago *et al.* (2014) and Bertini (2015) show some factors that limit the use of inquiry practices in school. We point out some of them: the theme is not included in initial teacher education; students' lack of experience and resistance against new teaching proposals; and lack of time and infrastructure in school. We see them as challenges that must be overcome by teachers and students in order to develop inquiry practices in Science teaching.

Rodrigues and Carvalho (2002) show that these difficulties are overcome when teacher-researchers constitute work teams that have objectives in common. When the authors analyzed a team with six elementary school teachers who aimed at implementing inquiry activities to teach Thermodynamics, they observed that difficulties found in inquiry practices in a teacher's class were always discussed by the whole group so as to find the solution for that problem. Therefore, we understand that the solution for problems that arise in the implementation of teaching through inquiry in a school may be solved by teachers' collaborative and reflective activities.

Collective reflective activities related to inquiry practices in school potentialize teachers' professional development. Rosa *et al.* (2003) state that teachers' professional development as the result of inquiry practices only takes place when it is considered a collective process in which different kinds of knowledge intertwine to enable intervention in their professional practice connected to their classes.

However, in order to start collective work, the papers show that long-term continuing education is needed. Some authors point out that teachers must discuss their professional practices collectively, besides undergoing inquiry practices as learners (MUNFORD; LIMA, 2007 and ABREU; BEJARANO; HOHENFELD, 2013). According to Azevedo and Abib (2013), it is a collective educational movement, since it enables collaborative situations to be developed, i. e., teachers chose problems related to teaching and search for solutions through planned activities of debate and reflection. Collective discussions may be carried out by research groups, for instance, so as to enable teachers to deepen their theoretical knowledge of methodological issues and to learn how to publicize results of researches in different communities (TEIXEIRA; PASSOS; ARRUDA, 2015).

In this context, the paper published by Barcelos, Jacobucci and Jacobucci (2010) reports the analysis of the collective construction of a Science fair in a school, based on teaching through projects. The authors highlight that this kind of activity has the potential to be

[...] a great opportunity for teachers' continuing education, since it involves participants' sensitization, the proposal planning, work implementation and evaluation; in all steps, teachers face challenges that must be collectively discussed. (BARCELOS; JACOBUCCI; JACOBUCCI, 2010, p.19).

Discussions about planning, implementation and evaluation of inquiry activities in teacher education processes may take place in concerted actions taken by schools and higher education institutions. Based on Machado and Queiroz (2006), we understand that the culture of projects constructed in the partnership

between both institutions may contribute to teachers' initial and continuing education. However, school teachers' involvement and commitment processes complicated the partnership with the researchers from the university, for instance: "[...] there was an initial feeling of mistrust regarding the partnership with the university, besides difficulties in using the pedagogy of projects and hesitation in carrying out critical reflection on their classes" (MACHADO; QUEIROZ, 2006, p. 113). It is worth highlighting that the difficulties faced by the authors result from the little use of inquiry practices in the Brazilian teaching system. They have been used by schools and universities in an isolated and circumstantial way, since they have not been considered a long-term teacher education process yet.

An emergent synthesis of activities, which were identified in the papers that compose this study and constitute inquiry processes as teacher education processes, is shown below:

- Development of collective studies, i. e., readings, discussions about theoretical references, data collection and analysis, among college students, school teachers and professors;
- Planning of inquiry practices in schools and in college;
- Development of didactic material which focuses on teaching through inquiry for teachers' initial education;
- Implementation of Science fairs as an opportunity for teachers' initial and continuing education;
- Development of collective activities whose aim is reflection on teachers' professional practice;
- Development of teaching projects in schools;
- Recording, writing and critical analysis of teaching activities;
- Dissemination of inquiry activities in different research communities;
- Establishment of research groups in partnership between schools and higher education institutions.

Ideas that emerged from this category show that the implementation of inquiry-based approaches, both in schools and in higher education institutions, challenges teachers' professional development in the light of collective activities of planning, reflection and theoretical studies of the theme. This educational process may take place in concerted actions taken by schools and higher education institutions, since inquiry practices may contribute to teachers' initial and continuing education. The uneasiness that arises in this category and leads us to the second category refers to the relations among teachers' conceptions of teaching and inquiry-based approaches in Science teaching.

4.2. CONCEPTIONS OF TEACHING PERMEATING TEACHERS' INQUIRY PRACTICES

In this category, the argument under development encompasses teachers' conceptions of teaching methodologies and their influence on inquiry practices, both in schools and in the field of teacher education. The analysis of the texts made us identify different inquiry perspectives, such as scientific method, research activity and problem solving, used by teachers. These conceptions instigate the education of teacher-researchers by means of reflection on their professional practices, regarding teaching and the specific content they teach.

Throughout the analysis process, we noticed that research is an important pedagogical tool for the problematization, intervention, transformation and re-signification of teaching practices. However, teachers' traditional inertia, dialogue restriction and lack of interest in the search for knowledge of theoretical issues of teaching, learning and evaluating processes have been pointed out by Galiazzi, Moraes and Ramos (2003) as factors of resistance against inquiry practices in Science teaching.

Thus, teaching methodologies which focus on the principles of inquiry face obstacles in teachers' conceptions of teaching. As a result, research is considered a teaching methodology in Sciences in class and an educational principle in teacher education. Therefore, the following different methodologies used in teacher education have emerged in the text: inquiry connected to the scientific method, problem solving, introduction to research as a syllabus activity, teaching through projects and inquiry based on writing and reading through dialogues and collaboration in virtual learning environments.

It is worth mentioning that inquiry practices, as a teaching methodology in class, also take into account perspectives of the scientific method (SM). With regard to it, Silva and Cunha (2012) studied Science teachers' social representations of the scientific method as a teaching approach. They observed that inquiry practices are tightly connected to the use of laboratories, the need to define steps, emphasis on observation and validation of scientific theories. The main representations that were identified by these authors are:

Experience of the "SM" takes place in the lab. The "SM" is constituted by steps. Practical classes certify what the theory says. The "SM" is related to research. The "SM" involves observation. Working with the "SM" is an attempt to solve a problem. The "SM" leads to knowledge in the end. The "SM" "proves" theories. The "SM" is a train of thought. The "SM" is a kind of organized work. Through the "SM", students learn how to think, criticize, create hypotheses. The "SM" associates with norms and rules. The "SM" would be a manual. The "SM" may or may not include experimentation. The "SM" supposes practical activities (SILVA; CUNHA, 2012, p. 51).

Likewise, Munford and Lima (2007) address different teaching approaches which focus on inquiry and show three mistaken conceptions that are usually used for referring to inquiry practices in Science teaching:

- To believe that teaching through inquiry always involves practical and experimental activities or is restricted to them;
- Science teaching through inquiry always involves “open” activities in which students have total autonomy to choose issues, determine procedures of inquiry and decide how to analyze its results;
- To believe that all content may be taught by means of an inquiry- based approach (MUNFORD; LIMA, 2007, p.7).

These different conceptions enable us to think about inquiry processes in distinct ways. Therefore, Sá, Lima and Aguiar (2011) believe that teaching through inquiry may encompass any activity (either experimental or non-experimental). The authors point out that these activities must be student-centered, i. e., they must develop students’ autonomy, decision-making capacity, problem evaluation and problem solving with the appropriation of Natural Sciences concepts. Activities may be organized to provide teaching based on debate, argumentation, writing and dissemination of results and constructed knowledge.

We understand that, if these conceptions of teaching are not culturally constructed by and with teachers, they become mere insertion of inquiry practices in educational processes. Thus, the challenge in teacher education is the principle of research based on reflection on the teacher’s work. Studies carried out by Teixeira (2003), Galiazzi, Moraes and Ramos (2003), Souza and Campos (2011), Sangiogo *et al.* (2011), Machado and Queiroz (2012), Massi and Giordan (2014) and Lima and Amaral (2013) show possibilities of breaking away from traditional teaching models by including inquiry moments in teacher education.

Sangiogo *et al.* (2011) states that inquiry moments in teacher education processes may be included when research is introduced as a syllabus activity in teaching degree courses. In this study, the authors highlight that the focus of research made students identify “[...] the chemical understanding that college and high school students have about everyday phenomena which involve transformations in matter and energetic phenomena” (SANGIOGO *et al.*; 2011, p. 524). According to the authors, this inquiry activity enabled teachers-to-be to learn about the reality of school learning, cultural tools and re-signification of specific knowledge of the education area.

Focus on studies of academic-professional education is also mentioned in the study carried out by Souza and Campos (2011) who investigate how the experience with work through projects may contribute to Mathematics teacher education. They highlight that:

[...] students started to develop knowledge about teaching with research, collaborative work, use of computational resources, methodology of projects and inquiry in statistical methods (SOUZA; CAMPOS, 2011, p. 428).

From this perspective, insertion of inquiry practices in teacher education enabled teachers’ professional development, besides the improvement

of their knowledge of specific contents and methodologies of teaching with research. Likewise, studies carried out by Bejarano and Hohenfeld (2013) and Goi and Santos (2014) show the importance of the fact that teacher education must be based on problem-solving strategies. The texts under analysis lead to the understanding that this methodological approach, which involves problematization, intervention and reflection on teaching, enables teachers-to-be to re-signify different kinds of knowledge.

Regarding teacher education, Galiuzzi, Moraes and Ramos (2003) emphasize that inquiry processes demand data collection, synthesis elaboration and meaning re-elaboration, while teachers construct their professional knowledge. The same journey is described by Machado and Queiroz (2012); they show that, when teachers-to-be are stimulated to define their research problems in search for pedagogical solutions, they are more willing to exercise critical reflection. Thus, they get closer to research activities. Such movement has been acknowledged as a possibility of professional and personal growth.

The movement which encompasses inquiry processes in teacher education may also be achieved through reading, analysis and dissemination of papers and presentations in congresses whose focus is research that originates in teachers' professional practice. Massi and Giordan (2014) report results of a proposal of teacher education for research which encompasses construction, application and analysis of didactic sequences in a specialization course in online education (OLE). Based on the analysis of the interaction that occurred in virtual learning environments (VLE) during reading sessions, diary writing and dialogues between teachers and their tutors, the authors found evidence of the fact that they created a space that intertwined teaching and inquiry into one's own activity.

Therefore, we understand that creation, discussion and reflection processes of teaching approaches may be offered in VLE. Lima and Amaral (2013) believe that experiences undergone by teachers-to-be in activities which aim at developing dialogical interaction in VLE may contribute to break models that follow traditional conceptions of teaching. We think that this environment in the internet potentializes the education of teachers who research and reflect on their professional practice, since it enables them to share and record new knowledge they yield in teaching. Thus, this context makes an inquiry perspective emerge from writing and reading in a dialogical and collaborative way.

In this category, papers refer to conceptions of teaching in which the main discussion is the insertion of teaching practices that trigger inquiry. As a result, we compiled different practices in teacher education which aim at overcoming conceptions of teaching that have been traditionally experienced over the years. The following category shows the constitution of a syllabus that questions professional practices in teacher education

4.3. PROFESSIONAL PRACTICE IN TEACHER-RESEARCHER EDUCATION

The third category shows that the development of teacher-researchers takes place in a syllabus that questions their professional practice. We observe that this process can take place when teachers commit to post-graduate programs

and school projects, such as Science fairs. Teachers' academic and professional transformation – and their classes – may result from the educational principle of education through research.

Education through research enables the education of teacher-researchers. It is a process that has been emphasized in the literature as an educational principle that enables teachers-to-be and teachers to experience different teaching and learning processes which go beyond traditional models characterized by knowledge reproduction. Galiazzi and Moraes (2002) introduce theoretical and practical arguments in favor of education through research as a way, time and space of qualification in initial teacher education. In short, the authors defend that teacher education through research establishes:

[...] very productive relations between inquiry and teacher education. Technical rationality is overcome by transforming all persons involved in the activity into participants in the research process. Teachers-to-be become subjects, rather than objects, of their own educational process and deepen their pedagogical views. Theory gets closer to practice and academic knowledge gets closer to practical knowledge; integration of knowledge that was fragmented throughout different disciplines occurs (GALIAZZI; MORAES, 2002, p.251).

Therefore, we highlight the importance of promoting research as a resource of professional development in teacher education courses. Silva *et al.* (2014) state that the insertion of research in initial teacher education enables teacher-to-be to acquire knowledge about their professional practice in class. In this process, due to the contact with the school environment, the debate/study of teachers' roles and their methodological strategies takes place. According to Galiazzi and Moraes (2002), research in teaching practices in initial teacher education makes professional learning more significant, since it enables teachers-to-be to get data and be able to record, analyze, reflect and transform their class.

In this context, teaching through research is defined as:

[...] a dialectical and recursive cycle which begins with a question and follows with attempts to re-construct knowledge and practices by organizing and defending new arguments. They are publicized and submitted to a critical community, so as to be gradually evaluated and improved (GALIAZZI; MORAES, 2002, p. 242).

We understand that this concept of research in initial teacher education may be differently organized, provided that it enables teachers-to-be to reflect on teaching. Studies carried out by Machado and Queiroz (2002) and Barcelos *et al.* (2010) show that this movement may take place when teachers get involved in projects related to the planning of Science fairs in schools. We see it as collective work among school teachers, professors and teachers-to-be with planning, recording, systematization and dissemination of results.

However, collective activities are not common in teacher education processes. Lima *et al.* (2015) point out factors that limit the development of a syllabus which focus on the inquiry into teaching practices: the gap between higher institutions and elementary education, as well as the education process

experienced by some professors. This scenario may be changed by the insertion of permanent processes in teacher education intertwined with experiences with the methodology of projects in schools.

Cattai and Penteado (2009) investigated how in-service teacher education takes place in the case of Mathematics teachers who work with projects in their schools. The authors point out that development occurs when teachers take part in continuing teacher education courses which promote experiences with projects in their professional practice.

We acknowledge that teaching strategies based on research benefit continuing teacher education. In regard to it, Galvão and Praia (2009) worked with Science teachers in the first grades and found positive impact on their education, since they used research as a teaching strategy in their classes. Their results show that insertion of research as a teaching methodology enables teachers to overcome their learning difficulties in professional education processes. Thus, teaching practices that include inquiry strategies may lead teachers to promote educational activities in teaching, based on problems found in their classes (AZEVEDO; ABIB, 2013).

Educational activities in teaching are important to trigger partnerships between schools and higher education institutions. These partnerships should aim at contributing to the professional development of teachers-to-be, teachers and professors. The movement that aims at approximating schools and higher education institutions also takes place in activities proposed by post-graduate programs. Souza (2014) states that knowledge yielded in Master's programs may be considered intentional, since teachers study and plan activities that aim at interfering in their teaching practices. We acknowledge it as research that teachers carry out in/on their classes.

From this perspective, the term teacher's research is defined as "[...] research which is different from 'scientific research', another kind of research, in which the author's professional life has its place, research that originates from practice and proposes something to practice" (CARNEIRO, 2008, p. 2017). Based on this study, we understand the important roles of higher education institutions and professors in the qualification of inquiry carried out by school teachers in order to construct their theoretical and methodological ways.

Professional post-graduate programs, mainly professional Master's programs, have been the quality space-time for inquiry conducted by school teachers. They aim at developing products and analyzing their implementation in class to enable teachers to re-think their own professional practices. Pires and Igliori (2013) highlight that teacher education in professional Master's programs is a process that involves different knowledge domains. They believe that teachers themselves should expose their needs regarding their professional activities.

In an attempt to involve school teachers in post-graduate programs, studies carried out by Sá et al. (2011) and Munford and Lima (2007) focus on teaching through inquiry in schools. They show researches conducted by the specialization course in Science Teaching through Inquiry (STI), which was offered by the Centro de Ensino de Ciências e Matemática (CECIMIG) at the Universidade Federal do Minas Gerais (UFMG) from 2005 to 2008. According to Munford and Lima (2007), the course has two presuppositions:

- 1) Scientific explanations arise and develop in guided inquiry spaces;
- 2) There is need for permanent reflection, an inquiry space and exchange of experiences among teachers regarding the implementation of this methodology in their work so as to support and maintain changes in the schools where they teach (MUNFORD; LIMA, 2017. p.3).

These activities, which are announced by the course, enable teachers to analyze, plan and change their classes. Besides, both teachers and professors can evaluate together transformations that derive from teaching strategies based on inquiry in Science students' learning. Thus, we understand that this educational movement encompasses the study of contents of Science, its teaching methodologies and activities that involve professional practices.

This category also encompasses teachers' involvement in research groups, as a space where teacher-researchers can develop. According to Goi and Santos (2014) and Teixeira et al. (2015), research groups enable teachers-to-be to broaden their theoretical and practical knowledge. As a result, they improve their way of investigating and teaching Science.

This category showed different spaces which are potentially significant for teacher-researcher education, both in initial and continuing education. We believe that the insertion of research – based on reflection and knowledge systematization – in teachers' professional practice leads to professional transformations which affect the way a teacher thinks about teaching and learning Science.

5. FINAL REMARKS: A SYNTHESIS OF THE STUDY

In short, Table 11 synthesizes our final remarks. Their construction was based on the analysis of papers that composed the corpus of this study. In agreement with Moraes and Galiazzi (2011), we adopted the coalescent argument of a text as a theoretical statement of ideas that must be publicized since they show what researchers think about their object of study.

Table 7. Final categories and their arguments

Final Category	Argument
Inquiry into school as a space of teacher education	Inquiry practices in school encompass teachers' need for professional development. We believe that work with projects and teaching through inquiry implies collaborative activities and reflective spaces in school. This educational process may be provided by a partnership between schools and higher education institutions.
Conceptions of teaching permeating teachers' inquiry practices	Teachers have different conceptions of teaching methodologies and how they influence inquiry practices, both in schools and in the field of teacher education. The analysis of the texts made us understand different inquiry perspective used by teachers, i. e., the scientific method, research activity and problem solving. These conceptions aim at developing teacher-researchers who reflect on their professional practices related to teaching and the specific content they teach.

Professional practice in teacher-researcher education	Teacher-researcher education takes place when the syllabus questions the professional practice. This process may happen when teachers get involved in post-graduate programs and projects in school, such as Science fairs. Teachers' academic and professional transformation, as well as changes in their classes, may emerge as an educational principle of teaching through research.
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Fonte: Guidotti and Heckler (2017)

Every category constructed with its argument represents one or several aspects collected from the papers under analysis. In a reconstruction movement, from the final categories, initial categories and meaning units, the researchers disseminate different views in the recursive writing of the metatext which is in section 4.0.

Therefore, the set of arguments shown in Table 7 leads to the main argument of this study, which records the researchers' views of inquiry-based approaches in teacher education, based on the analysis of 35 papers published in 6 journals. We believe that the insertion of inquiry practices in class is permeated by teachers' different conceptions of teaching. Thus, it challenges teachers' professional development both in initial and continuing education, since it demands collaborative activities regarding planning and reflection on their professional practices, besides theoretical studies of teaching issues and specific contents. We believe that teacher-researcher education takes place when the syllabus problematizes teaching practices. Thus, this process may take place when schools and higher education institutions establish partnerships in projects that aim at contributing to both initial and continuing teacher education.

The analysis described by this paper enabled us to broaden views of inquiry-based approaches in teacher education. We showed the methodological path which enabled us to analyze the insertion of inquiry-based approaches in teachers' professional practices, based on collective, collaborative and reflective activities that deepen theoretical knowledge and systematization and dissemination of new knowledge. As a result, it helps teachers transform their ways of teaching and learning Science.

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