



AN ANALYSIS OF THE FORMATIVE EMPHASIS OF PROFESSIONAL MASTER'S DEGREES DIRECTED TO MATHEMATICS TEACHERS

ANÁLISE DAS ÊNFASES FORMATIVAS DE MESTRADOS PROFISSIONAIS DESTINADOS A PROFESSORES DE MATEMÁTICA

ANÁLISIS DE LOS ÉNFASIS FORMATIVOS DE MAESTRÍAS PROFESIONALES DESTINADAS A PROFESORES DE MATEMÁTICA

Ana Leticia Losano¹
Dario Fiorentini²

ABSTRACT: Nowadays, professional master's degrees constitute an important and varied formative possibility inside Higher Education for in-service teachers. Since its origins, professional master's degrees have been at the center of several debates. A particularly important point concerning those debates is the discussion about the ways of organizing the curriculum (its structure and dynamics as well as the relations between teaching and research) that better articulate the program with the practice of teaching in the school. In order to contribute to these debates, this article aims at describing and analyzing the ways in which the teacher is conceived and the formative emphases of four professional master's degrees directed to mathematics teachers in the São Paulo state. Using a qualitative methodology, we present a documentary analysis of diverse official documents produced and made available by the four programs. The results show that, although they are directed to mathematics teachers, the four programs conceive the teacher differently and establish different levels of articulation between the formative activities organized by the program and the teaching practice in the school.

KEYWORDS: Professional master's degrees. Teachers education. Qualitative research.

RESUMO: Os mestrados profissionais representam, atualmente, uma importante e variada oportunidade formativa dentro da Educação Superior para os professores em exercício. Desde a sua criação, eles têm sido alvo de diversos debates, muitos deles ainda em vigência. Um ponto particularmente importante desses debates tem sido a discussão sobre as formas de organizar as propostas curriculares (sua estrutura e dinâmica, assim como as vinculações entre ensino e pesquisa) que melhor potencializem a articulação entre o mestrado profissional e a prática docente nas escolas dos professores-mestrandos. Buscando contribuir com estes debates, este artigo tem por objetivo descrever e analisar as maneiras em que é concebido o sujeito da formação e as ênfases formativas de quatro cursos de mestrado profissional destinados a professores de matemática no estado de São Paulo. Utilizando uma metodologia qualitativa, desenvolveu-se uma análise documental de diversos documentos oficiais produzidos e disponibilizados pelos quatro cursos. Os resultados mostram que, embora estejam destinados a professores de matemática, os quatro cursos concebem o professor-mestrando de maneiras diversas e privilegiam diferentes conhecimentos e aprendizagens docentes. Deste modo, os quatro cursos estabelecem diferentes níveis de articulação entre as atividades formativas organizadas dentro do mestrado e a prática docente nas escolas dos professores-mestrandos.

PALAVRAS-CHAVE: Mestrado profissional. Formação docente. Análise documental.

RESUMEN: En la actualidad, las maestrías profesionales representan una importante y variada oportunidad formativa dentro de la Educación Superior para profesores en servicio. Desde su creación estos cursos han sido objeto de diversos debates, muchos de ellos todavía vigentes. Un punto particularmente importante de estos debates ha sido la discusión sobre las maneras de organizar las

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propuestas curriculares (su estructura y dinámica, así como también las vinculaciones entre enseñanza e investigación) que mejor potencialicen la articulación entre las Maestrías Profesionales y la práctica docente en las escuelas de los profesores-maestrandos. Buscando contribuir con estos debates, este artículo tiene por objetivo describir y analizar las maneras en que es concebido el sujeto de la formación y los énfasis formativos de cuatro maestrías profesionales destinadas a profesores de matemática en el estado de San Paulo. Utilizando una metodología cualitativa, desarrollamos un análisis documental de diversos documentos oficiales producidos y disponibilizados por los cuatro cursos. Los resultados muestran que, aunque todos estén destinadas a profesores de matemática, las cuatro maestrías conciben al profesor-maestrando de maneras diversas y privilegian diferentes conocimientos y aprendizajes docentes. De este modo, los cuatro cursos establecen diferentes niveles de articulación entre las actividades formativas organizadas dentro de la maestría y la práctica docente en las escuelas de los profesores-maestrandos.

PALABRAS CLAVE: Maestrías profesionales. Formación docente. Investigación cualitativa.

INTRODUCTION

This article reports results from a wider research project focused on a specific formative initiative: Professional Master's Degrees (PMDs) directed to mathematics teachers.

The commitment of Higher Education institutions with teachers' education has been a discussed issue in different historical moment in Brazil. Particularly, PMDs bring a new element to such debates, since they reinforce the commitment of postgraduate programs with teachers' qualification (CAMPOS; GUÉRIOS, 2017). In the Brazilian context, PMDs directed to teachers have a short existence, and their implementation has been characterized by resistance and mistrust (ANDRÉ; PRINCEPE, 2017). In this way, their role in teachers' education is still in process of consolidation.

PMDs' goals, orientations, and norms have been defined by the federal government agency responsible for quality assessment of postgraduate programs in Brazil (Capes) (BRASIL, 2009). One of the PMDs' goals aims at training qualified professional for advanced professional practice, looking to attend social, organizational, and professional demands as well as demands coming from the labor market (BRASIL, 2009). Therefore, PMDs directed to teachers can be understood as formative spaces focused on the professional qualification of in-service teachers, considering the specificities of teaching practice.

Nine years passed since the formulation of these orientations. Nowadays, PMDs constitute an important and varied formative possibility inside Higher Education for in-service teachers. In this direction, The Capes website informed – on January 2018 – that 82 programs had been approved in the Teaching Area and others 47 in the Education Area. According to Campos and Guérios (2017), this expansion is an important indicator of the legitimacy that PMDs reached over the last years. Besides, PMDs are varied formative initiatives, being offered by different Higher Education institutions –

such as public and private universities and research centers – throughout the country, looking to attend diverse goals, and having different curricular organizations. In this context, several authors highlighted the importance of developing studies that analyze the impacts of these formative initiatives and the experiences that in-service teachers are living inside them (CAMPOS; GUÉRIOS, 2017; NERES; NOGUEIRA; BRITO, 2014).

In this respect, the words of Cochran-Smith and Lytle (1999, 249) seem particularly pertinent:

there are radically different conceptions of teacher learning, including varying images of knowledge; of professional practice; of the necessary and/or potential relationships that exist between the two; of the intellectual, social, and organizational contexts that support teacher learning; and of the ways teacher learning is linked to educational change and the purposes of schooling. Different conceptions of teacher learning – although not always made explicit – lead to very different ideas about how to improve teacher education and professional development.

From this perspective, we understand that the different PMDs directed to teachers currently offered in Brazil are conceived and sustained by different conceptions of teachers' learning, knowledge, and practice. In this direction, we cannot ignore that inside our community of teachers' educators – in the sphere of Higher Education – there are still many polemics issues regarding the formative emphases of these specific programs. Some of these questions – emerged from our own experience and from the contribution of other authors (CARNEIRO, 2008; PIRES; INGLIORI, 2013; SOUSA, 2013) – are: How to characterize a PMD directed to mathematics teachers? How do these programs understand teacher education? To whom are they directed? What are the demands they try to address? How do they organize the curriculum? What are the contributions of these formative initiatives to the teaching practices at school? What are the contributions of the research carried out in the context of a PMD? What should be the nature and focus of the master's thesis? What should be the links between the master's thesis and the teaching practice at schools? Although our research is intended to respond to several of these questions, in this article we will focus on some of them. Concretely, we will describe and analyze the formative emphases and the ways in which the teacher is conceived in four PMDs directed to mathematics teachers in the São Paulo state. Our analysis is based on official documents made available by the four courses: Regulations, documents regulating the selection process, syllabi, courses' descriptions, etc. In the next section, we delineate our theoretical perspective concerning teachers' education. Then, we focus on the methodological perspective of our study, describing the documents considered in our research and the methodological procedures we carried out. Next, we present the description and analysis of each PMDs. In the last section of the article, we discuss our results and indicate some challenges regarding mathematics teachers' education in the context of PMDs.

IN-SERVICE TEACHERS' EDUCATION

Over the last decades, teachers' education gained momentum on the Mathematics Education field, originating several research projects (BEDNARZ; FIORENTINI; HUANG, 2011; JAWORSKI, 2006, 2008; KIERAN; KRAINER; SHAUGHNESSY, 2013; MATOS; POWELL; SZTAJN, 2009). Those studies understand in diverse ways in-service teachers as educational subjects and discuss what knowledge and educational practices should be at the center of teachers' education. For example, Kieran, Krainer, and Shaughnessy (2013) underline the importance of formative initiatives in line with the teachers' interests, beliefs, emotions, knowledge, and practice. Furthermore, several researchers (COCHRAN-SMITH; LYTLE, 1999; CRECCI, 2016; KIERAN; KRANIER; SHAUGHNESSY, 2013; WHITE et al., 2013) highlight the relevance of organizing formative opportunities in which teachers theorize about their teaching practice through critical reflection. On the same token, André and Princepe (2017), Campos and Guérios (2017), and Pires and Ingliori (2013), among others, affirm that PMDs organized around the analysis of teachers' daily practice have the potential for reducing the distance between schools and universities, between theory and practice.

In our view, in-service teachers enrolled in a PMDs have knowledge acquired through their daily experience of working inside the classroom. Drawing on the work of Cochran-Smith and Lytle (1999), we consider that a teacher enrolled in a PMD has **knowledge-for-practice**, developed during pre-service education. This knowledge is centered on subject-matter knowledge as well as on the strategies for selecting, using, and assessing different representations of such contents for teaching. But the teacher has also **knowledge-in-practice**, that is, an experiential knowledge developed through the experience of teaching. This is a situated knowledge (LAVE, 1996), crafted in response to the particularities of everyday schools and classrooms. This is a knowledge manifested on teachers' actions, decisions, and judgments.

Assuming this perspective involves considering that teachers do not only learn knowledge, they also produce knowledge. Such knowledge – charged of values and beliefs – is fundamental for developing their teaching practices. However, it may become naturalized and fossilized concealing ideologies, power relationships, and shortcuts (FIORENTINI, 2013; FIORENTINI; CARVALHO, 2015). Formative initiatives that problematize the teachers' knowledge **for** and **in** practice – dialoguing with the academic knowledge developed by research – have the potential of developing the **knowledge-of-practice**. In this way, **knowledge-of-practice** is crafted when “teachers treat their own classrooms and schools as sites for intentional investigation at the same time that they treat the knowledge and theory produced by others as generative

material for interrogation and interpretation” (COCHRAN-SMITH; LYTLE, 1999, p. 250).

Using this perspective, we analyze the four PMDs using two analytical focal points. In the first place, how the **educational subjects** are understood, that is, how the teachers are conceived in each program. In the second place, the program’s **formative emphases**, that is, what is the knowledge valued by each PMD and what are the opportunities offered for developing such knowledge inside each program.

RESEARCH METHODOLOGY

This article reports results from a large ongoing research project framed within the interpretative paradigm (ROCKWELL, 2009). The research focuses on four PMDs directed to mathematics teachers offered in the São Paulo State (Brazil). It aims at describing the four programs as well as developing case studies focused on mathematics teachers who graduated from such programs in the period 2014-2016. We choose such period of time due to our capacity for analyzing the official documents produced by each program (mainly the defended master’s theses). This period does not allow us to delineate the historical development of the PMDs. However, considering that our main research focus is the identity development from participation in a PMD and the possible impacts of these formative initiatives in the teaching practices at schools, the period is suitable for constructing a thick description of the programs.

We selected four programs considering the different areas of the CAPES in which there are PMDs directed to mathematics teachers (Teaching, Education, and Mathematics). We also prioritized oldest programs with many graduates. In this way, we selected two PMDs belonging to the Teaching area, here called PMD 1² and PMD 2. Both are the oldest PMDs in the São Paulo State. Thus, they have many graduates. We also selected a program that combines face-to-face and distance learning, here called PMD 3, that belongs to the Mathematics area. This decision was based on the fact that this is the largest PMD directed to mathematics teachers in Brazil. Considering the scope of PMD 3, here we will analyze only one of its centers, located at a public university, here called *Center A*. Finally, we selected a program of the Education area that, although its generalist characteristics, has important relations with the field of mathematics education. Here this program is called PMD 4.

We developed a documentary analysis, understanding this analytical procedure as

² The research is approved by the four programs’ Research Ethics Committees. All the names mentioned in this paper are pseudonyms. Project CAAE N^o: 68159717.1.0000.5404.

A set of procedures aiming at analyzing one or several documents looking for factual information in order to discover the social, economic and ecological circumstances to which they are related (KRIPKA; SCHELLER; BONOTTO, 2015, p. 245).

In this way, we seek to produce new knowledge about the studied phenomenon – the PMDs as educational initiatives with different formative emphases and diverse understandings of teachers as educational subjects – analyzing the perspectives reified in the official documents produced by the four programs. We consider that documents “can be instructive for understanding social realities in institutional contexts” (FLICK, 2007, p. 237) such as the PMDs. Through our analysis, we seek to study the content of the documents but also to reveal the ways in which each of them understands teachers and teacher education. In this way, documents are not only a source of information; they arise from a context and provide information about it (LÜDKE; ANDRÉ, 1986).

Analytical procedures

We first select documents produced by the four PMDs and made available in their web pages (the documents are summarized in Table 1). In this way, we choose official, open, and public documents (FLICK, 2007). We accessed these data between March and May 2017.

Table 1. Set of documents considered in the research.

	Document
PMD 1	Internal regulations; syllabus; courses' descriptions; documents regulating the selection process (2017); 32 master's theses defended between 2014 and 2016 ³ .
PMD 2	Goals, syllabus; courses' descriptions; documents concerning the selection process (2017); master's theses defended between 2014 and 2015 ⁴ .
PMD 3	Internal regulations; syllabus; courses' descriptions; documents concerning the selection process (2012, 2013, 2014); academic norms; 42 master's theses defended between 2014 and 2016 at <i>Center A</i> .
PMD 4	Internal regulations; syllabus; courses' descriptions; documents concerning the selection process (2013, 2014); 6 master's theses defended between 2014 and 2016.

Source: The authors

³ During the period 2014-2016, a total of 33 master's thesis were defended in the area of Mathematics Teaching. However, only 32 were available on the web page at the moment in which the documentary analysis was carried out.

⁴ At the time we developed our analysis the master's theses defended in 2016 were not available at the PMD's web page.

Two reasons justify choosing these documents. Firstly, they constitute the PMDs' prescribed curriculum (SACRISTÁN, 1998). In this way, their analysis reveals what knowledge and practices should be addressed by these formative initiatives. Secondly, these documents provide information about the **educational subjects** and/or the **formative emphases** of the PMDs, our two analytical focal points.

In order to analyze how each PMD understood the **educational subjects**, we selected information concerning the target public and the profile of degrees. Such information was generally expressed in the PMD's goals or in the documents regulating the selection process.

In order to describe the **formative emphases** of the programs, we selected information concerning the PMD's syllabus. We also analyzed each master's thesis. Such analysis was carried out by reading each thesis abstract, keywords, table of contents, and the introductory chapter. Our intention was to expose the formative role assigned to the thesis inside each PMD. Besides, we sought to reveal the relation between the thesis and the teaching practices of its author. In this way, we analyze if the thesis involved the teacher in constructing, implementing and reflecting on classroom tasks.

The analysis of each PMD's syllabus was carried out by reading the courses' descriptions. Our intention was to delineate the knowledge privileged by each course and its relations to the teaching practice at schools. Following diverse models of teachers' knowledge (CARRILLO et al., 2013; SHULMAN, 1986, 1987), we used three general categories for describing the knowledge each course intended to develop. The first one is **mathematical knowledge**, that is, the subject-matter knowledge including mathematical concepts, procedures, and practices. The second category was called **general pedagogical knowledge**. It encompasses general pedagogical principles and strategies of classroom organization and management. The third category is **pedagogical content knowledge**, that is, an amalgam of content and pedagogy, including knowledge of how different topics can be represented and adapted to the diverse interests and abilities of learners. These three categories served as a general framework for our analysis. In this way, the concrete meaning each of them acquired inside a PMD was an emergent result and, therefore, was not previously determined. Besides, we were open to including other categories when needed. We also identified, in a fourth category, the courses focused on the development of the master's thesis.

Since each course could address knowledge related to several categories, we use diagrams to represent our analysis (see figure 1). For example, when evidence indicated that a course seeks to develop mathematical knowledge as well as pedagogical content knowledge it was placed in the intersection between the yellow circle (mathematical

knowledge) and the pink circle (pedagogical content knowledge). On the diagrams, the mandatory courses were highlighted in bold. In this way, the diagrams allowed us to easily visualize how many courses were placed in each category, in which categories were located the mandatory courses, which categories were empty, etc. The next sections are devoted to present our results regarding each PMD.

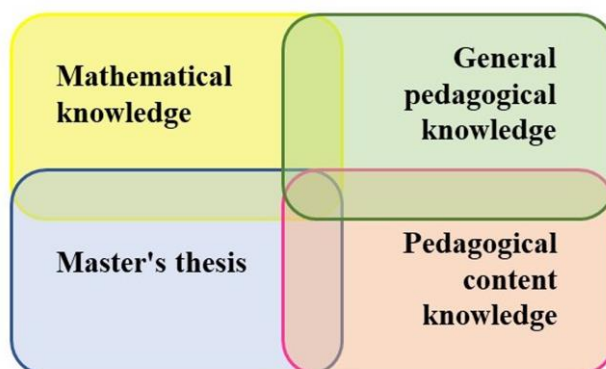


Figure 1. Diagram used for categorizing the PMDs' courses.
Source: The authors

RESULTS

The PMD 1

This program, offered by a public university, was created in 2008. It is divided into two areas: Physics teaching and Mathematics teaching. According to its web page and the documents regulating the selection process, the PMD 1 is directed to in-service mathematics teachers who teach at Secondary Education, preferably at public schools. Such teachers may hold different university degrees such as mathematics teachers, mathematicians, engineers, accountants, etc.

Concerning the teachers' needs that the program is intended to address, the internal regulation establishes that the PMD 1 promotes the development of innovative professional practices by means of the incorporation of the scientific methodology and the application of new techniques and processes (PMD 1, 2008). In this way, the PMD 1 is configured as a formative initiative aiming at transforming teaching practices through a process in which the teacher incorporates methods and applies knowledge produced by other people in other contexts.

The PMD 1 is structured in courses (56 credits) and the master's thesis (44 credits). Thus, courses are considered important opportunities in the PMD 1. They are divided into five mandatory courses and elective courses. The diagram showing the

categorization of the courses is shown in Figure 2. An interesting feature of this program is the existence of mandatory courses for the Physics teaching area that are elective for the Mathematics teaching area, and vice-versa. This fact shows that inside the PMD 1 it is assumed that courses focused on the teaching of Physics could contribute to mathematics teachers' education. Due to this fact, we added a new category in our diagram, encompassing the knowledge of Physics (grey circle at the left of Figure 2.)

The diagram shows that this program privileges the development of mathematical knowledge. The descriptions of the courses included in this category consist, mainly, on a list of mathematical topics. They comprise, in some cases, "applications" directed to understand the relationships between mathematics and other fields of study. The course called "History of Science and Mathematics" was placed at the intersection between mathematical knowledge and physical knowledge, since it is focused on the historical development of these fields and on the practices legitimated by the academic community throughout the centuries. In this way, we concluded that the mathematical knowledge developed by the PMD 1 is strongly related to academic mathematics, encompassing advanced mathematical contents, knowledge of the structure of this field, and legitimated mathematical practices.

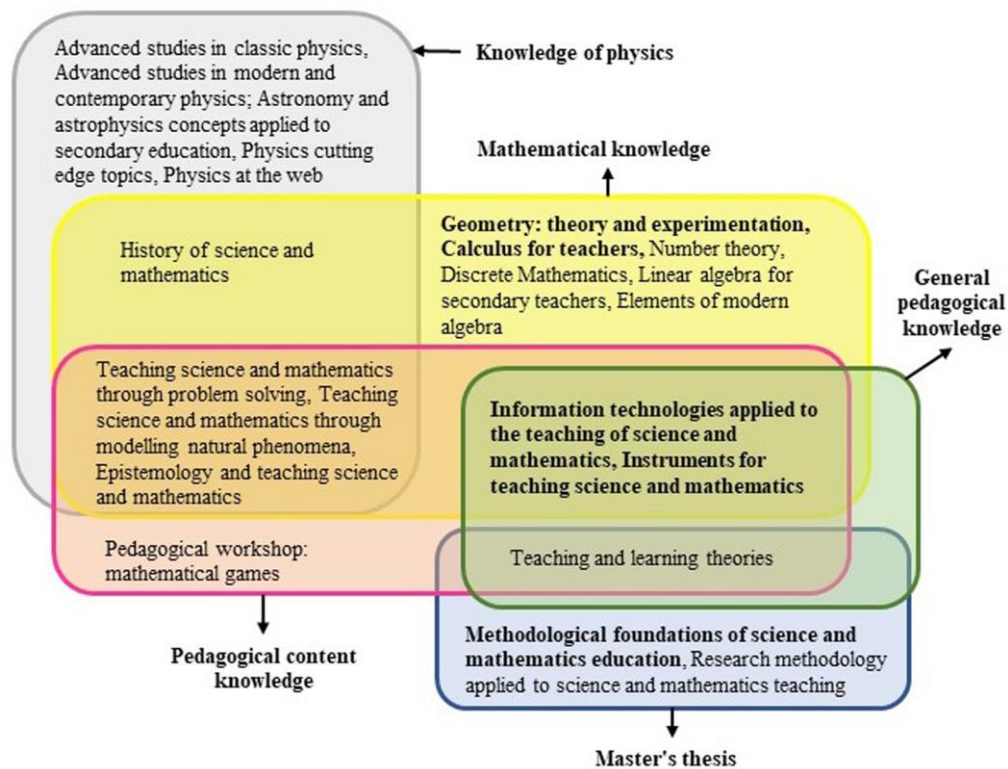


Figure 2. Diagram of the courses offered by the PMD 1
Source: the authors

The courses placed at the intersection between the mathematical knowledge, the physical knowledge, and the pedagogical content knowledge address practices used to produce mathematics – including problem-solving and modeling –. They also propose reflections about the teaching and learning of mathematics teaching through such practices. Thus, the pedagogical content knowledge developed by the PMD 1 is related to studying teaching tools inspired by practices coming from the academic field of mathematics – problem-solving and modeling – as well as from pedagogical practices – such as games.

Two courses were placed at the triple intersection between mathematical knowledge, general pedagogical knowledge, and pedagogical content knowledge. Both involve the elaboration, implementation, and analysis of classroom activities – the first one inside contexts mediated by technologies and the second one during a field experience–. In our view, teaching practice inside classrooms involves mobilizing, at least, these three kinds of knowledge. Both courses are mandatory. This fact provides evidence that, inside the PMD 1, these learning opportunities are valued to the same extent as the learning of geometry and calculus – the other two mandatory courses.

The course called “Teaching and Learning Theories” was located in the intersection between general pedagogical knowledge, pedagogical content knowledge, and the thesis development. This decision is justified because the course presents theoretical perspectives regarding teaching and learning, uses them as didactical tools for teaching science and mathematics, and seeks to contribute to the selection of the theoretical frameworks used in the teachers’ research projects.

33 master’s theses were defended on the period 2014-2016. Approximately 79% involved the elaboration and implementation of classroom tasks. Many of these works begin by describing the historical development of the mathematical topic that is at the core of the thesis and discussing its place on the secondary education curriculum. Next, they present a set of classroom activities and describe its implementation. Almost all of them end with an analysis of the experience. The Didactic Engineering is the theoretical and methodological framework most commonly used. Problem-solving, Guiding Activity of Teaching, and, to a lesser extent, Mathematical Modeling, are also used as theoretical frameworks.

It was possible to verify that in 15 of these 26 theses the activities were carried out in the classrooms where the authors teach regularly. The topic at the core of those 15 works emerged from the authors’ experiences as teachers, being their students’ difficulties for learning the mathematical content the most frequent one. The other 11 theses did not establish clearly if the activities were implemented, or not, in the author’s classroom.

The 7 theses that did not involve the elaboration, implementation, and analysis of classroom activities have diverse focuses: three of them analyze the student learning processes using the notions of memorization, semiotic representation, and software use; one thesis develops an analysis of curricular documents; one constructs manipulative materials, and other focusses on the author's practice as teacher educator.

Based on our analysis, we concluded that the PMD 1 sustains two formative emphases: the first one privileges the learning of academic mathematical knowledge produced by mathematicians. The PMD 1 offers opportunities to link such knowledge to the mathematics mobilized inside the classroom. Those opportunities involve studying teaching practices and strategies based on the development of mathematics as a field of study – problem-solving, mathematical modeling, the use of the history of mathematics to teach mathematics –, as well as mathematical games. Therefore, such emphasis privileges learning **knowledge-for-practice** (COCHRAN-SMITH; LYTLE, 1999); a knowledge that, in this PMD, is strongly mediated and structured by academic mathematics.

The second formative emphasis values the experiential knowledge developed by the teachers **in** practice, looking at problematizing and questioning it through reflection. The master's thesis, as well as the courses involving the development of classroom activities, are the opportunities to develop such learning. The knowledge-for-practice previously mentioned – mainly some pedagogical perspectives such as Didactical Engineering – is used as a tool to assist and structure teachers' reflections. Hence, we conclude that the PMD 1 also privileges opportunities for learning **knowledge-of-practice** (COCHRAN-SMITH; LYTLE, 1999).

The PMD 2

Considering the four PMDs selected for our study, this is the oldest. It was established in 2004 in a private university, in the Teaching Area. The PMD 2 target public is wide. In this direction, the documents that regulated the selection process in 2017 established that candidates could be teachers and other professionals acting in the areas of Science and Mathematics teaching at any educational level. Thus, the PMD 2 audience are teachers who teach Physics, Chemistry, Biology, and/or Mathematics at the elementary or secondary level. It is possible that some of them hold teaching degrees while others not (mathematicians, biologist, architects, etc.).

The program goals emphasize educating teachers-researchers trained to act as teachers' educators at different levels and contexts. From this perspective, the PMD 2 is a formative initiative oriented to the professional development of teachers' educators. But the notion of teacher-researcher is also understood as an "autonomous professional that contributes to the utilization and spreading of research results in the school context"

(PMD 2, n.d., on-line). From this other perspective, the PMD 2 is an initiative that seeks to develop teachers who - considering their own criteria and educational realities - may recover knowledge coming from mathematics education research to put them at the service of their professional practice, contributing to the dissemination of research results in diverse settings. Another goal of the program is that the research developed by the teachers contribute to their professional development, having relationships to their teaching practice.

The PMD 2 offers a variety of learning opportunities. The credits are distributed among courses, workshops, field experiences, participation in research groups, and the master's thesis.

The courses are divided between mandatory and electives. The mandatories are four and focus on the development of scientific knowledge related to teaching practice. The elective courses are split among three groups: the first one is composed of courses centered on specific subject-matters. The teacher must choose three courses related to her area of expertise (Physics, Mathematics, Biology or Chemistry). The second group is composed of courses focused on pedagogical topics, encompassing curriculum, assessment, educational politics, and teachers' education. The teacher must choose two courses belonging to this group. The courses that comprise the third group are centered on teaching methodologies. The teacher must choose one course belonging to this group. The diagram showing the categorization of the courses is shown in Figure 3.

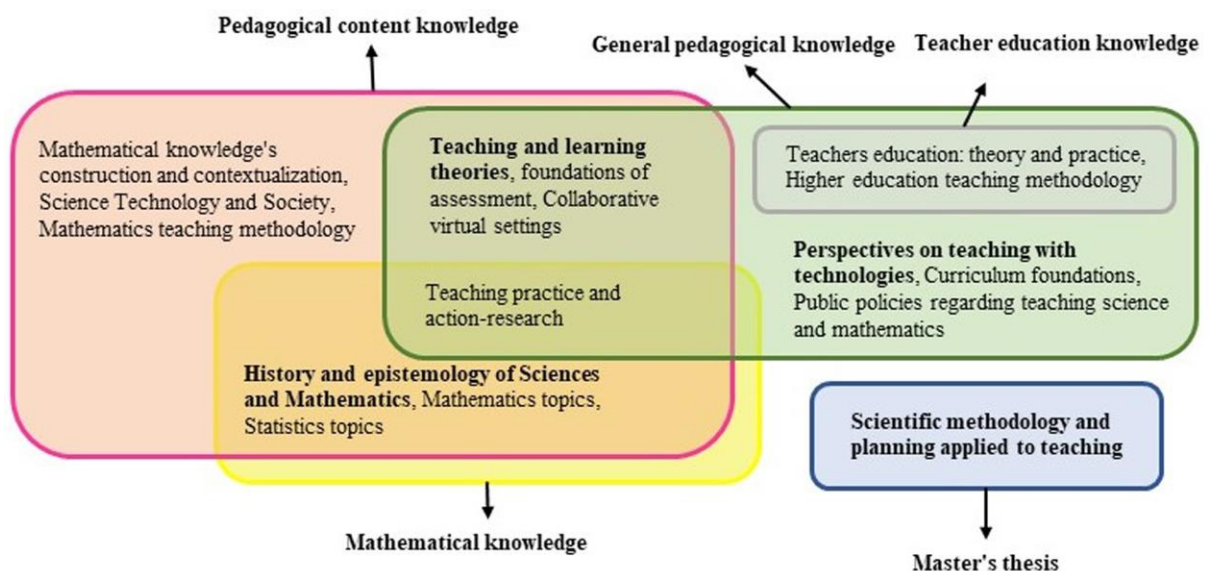


Figure 3. Diagram of the courses offered by the PMD 2
Source: The authors

The diagram shows that, in the PMD 2, the mathematical knowledge is always related to the pedagogical content knowledge. Thus, three courses were placed at the

intersection between these two categories since they address, in an interconnected way, the mathematical content, the students' difficulties in learning such topics, and ways of presenting or exploring them in the classroom. An interesting point is that the mathematics contents included in these courses are similar the ones addressed at Secondary Education. Therefore, we conclude that the mathematics valued and privileged by the PMD 2 is school mathematics.

Three courses were assigned to the category called pedagogical content knowledge since they focus on exploring different mathematics teaching perspectives. The course called "Teaching practice and action-research" was placed at the intersection of the three categories, since it presents action-research as a possibility for the teachers' professional development and proposes planning, implementing, and assessing this kind of project in the school setting. Another three courses were located in the intersection between pedagogical content knowledge and general pedagogical knowledge. They address learning theories, technology use, and assessment, considering their foundations as well as their contributions to mathematics teaching.

Five courses were assigned to the category called general pedagogical knowledge. Three of them address technology use, curriculum, and educational policies. Others two were grouped in a new category associated with the development of the knowledge required by teachers' educators. The last course contributes to the development of the master's thesis, introducing scientific methodology as a tool for analyzing teaching practice.

In the PMD 2 teachers must write a master's thesis and elaborate an educational product. The main content of educational products are the classroom activities specially elaborated for the thesis. The main audience of these educational products is other in-service teachers. 15 theses centered on topics related to mathematics education were defended on the period 2014-2015, nine of which involved the development of classroom activities. Seven out of those nine addressed issues emergent of their authors' teaching practices. In all cases, the activities were effectively carried out. In 8 cases the implementation occurred in the classroom were the author teach regularly. Besides, all the theses developed an analysis of the whole process and a reflection of the students' difficulties and achievements. Another four theses were developed by teachers' educators and their focus emerged from the authors' experiences acting at Higher Education. The last two theses analyzed diverse curricular materials.

Another important point concerning the learning opportunities offered by the PMD 2 is that the teachers must complete a field experience in which they relate the thesis and the knowledge acquired during the courses to their own teaching practice at schools. The

teachers become involved in such field experience after having chosen the topic of their theses.

We conclude that the formative emphasis of this program is the learning of knowledge related to teaching mathematics at schools. On some opportunities, such knowledge seems to be knowledge-for-practice, addressing disciplinary, pedagogical, and didactical contents that may help the teacher to improve their practice. However, the PMD 2 also offers relevant opportunities in which such knowledge is taken as a tool for questioning the teachers own practices and actions. Those opportunities allow the teachers to recover their knowledge-in-practice and to develop knowledge-of-practice. Some of these opportunities are the field experience, the master's thesis, and the course called "Teaching practice and action-research".

The PMD 3

This program, belonging to the Mathematics area, was established in 2011. PMD 3 is a large-scale program that combines face-to-face and distance learning. It is coordinated by a mathematicians' national association and composed by a web of Higher Education institutions that constitute the program's centers.

Concerning its target public, this is the most specific PMD: it is directed at in-service mathematics teachers, especially the ones who teach in public schools. The program's main goal is to provide "a solid mathematics education, relevant for teaching mathematics in Secondary Education" (PMD 3, 2014, Art. 2). In this way, the PMD 3 considers that, in order to teach, teachers require a deep understanding of the subject-matter. However, the program does not explain in what consists such a "deep understanding" nor what is the knowledge "relevant for teaching mathematics" at Secondary Education.

Since this is a program that combines face-to-face and distance learning, some of the learning opportunities are mediated by technologies (videos, virtual settings, etc.). Each center organizes the face-to-face activities. All credits are distributed among courses, eight mandatories, and two electives. In the PMD 3, the master's thesis is considered as a mandatory course. In this way, courses are the privileged formative opportunities. The diagram showing the categorization of the courses is shown in Figure 4.

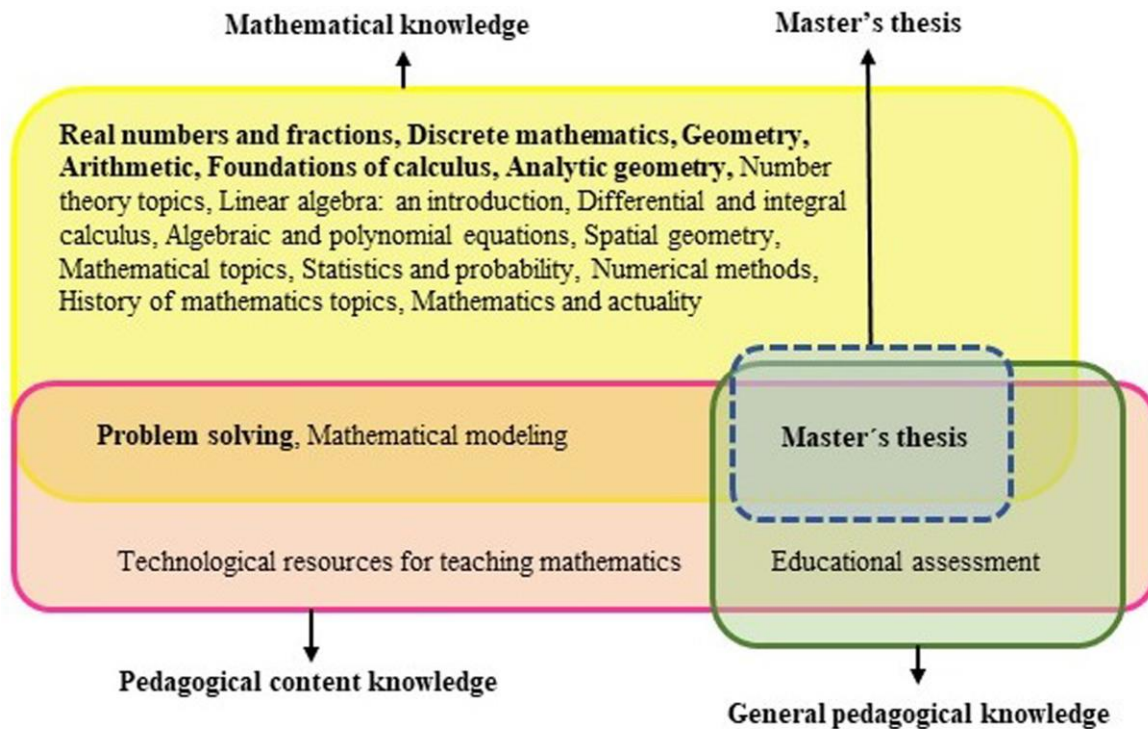


Figure 4. Diagram of the courses offered by the PMD 3
Source: The authors

Figure 4 reveals that the PMD 3 privileges the development of mathematical knowledge. Many of the courses are described through a list of topics, encompassing several areas of mathematics. We consider that this fact is in resonance with the main goal of the program: to train teachers in advanced mathematical contents. Some of the topics addressed in such courses may be related to the contents included in the Secondary Education curriculum. Others seem very similar to those studied during Higher Education. Besides, the links between such mathematical knowledge and the one mobilized in classroom teaching seem poorly discussed during the courses. Thus, we conclude that the mathematical knowledge valued by the PMD 2 is academic mathematics, emphasizing its formal and rigorous character.

Two courses were located in the intersection between mathematical knowledge and pedagogical content knowledge. Concerning mathematical knowledge, they focus on problem-solving and modeling as practices for producing mathematics. Regarding pedagogical content knowledge, they discuss teaching strategies based on these specific mathematical practices. The course called “Technological resources for teaching mathematics” was assigned to the pedagogical content knowledge category. One course was placed at the intersection between pedagogical content knowledge and general pedagogical knowledge because it addresses pedagogical issues concerning

assessment but also proposes the analysis of the mathematical problems included in national assessments. It is important to highlight that no courses were assigned only to the general pedagogical knowledge category.

The course called “master’s thesis” deserves special attention. In the program syllabus, it is described as:

A course oriented to supporting the development of an assignment focused on a mathematical topic included in the Secondary Education curriculum and impacting on classroom teaching practice. Each assignment is presented through an oral exposition and a written text (MP 3, 2016, p. 17).

Drawing from this quotation, we placed the course at the intersection between the three categories because it involves developing classroom activities which, in turn, require mobilizing the three types of knowledge. Nevertheless, the course description does not specify what are the possible “mathematical topics” considered nor what does it mean to have an “impact on classroom teaching practice”. For this reason, the line contouring the blue circle in the diagram is discontinuous.

Some of these issues can be addressed by the analysis of the 42 master’s theses defended at Center A during the period 2014-2016. The reason that justifies the election of the theses’ topics is, mainly, mathematics itself. In this way, the theses seek to apply academic mathematics to school teaching practice. Another motivation is to produce didactical resources for studying mathematical topics included in universities selection processes. The use of the history of mathematics is also a motivating factor of six theses. Six out of the 42 theses were developed choosing as a focus a problem that emerged from the author’s teaching practice.

Considering their structure, the theses can be divided among three groups. The first group gathers theses written using the format of an academic book, focused on the study of a mathematical topic. These works have a similar format to the one used by traditional textbooks employed at Higher Education. The second group gathers 28 theses that devote several chapters to the study of a mathematical topic, generally beginning with its historical development. The theses in this group have a similar structure to the ones included in the first group but they also include, in the last chapter, some classroom activities. Such activities are varied including a list of problems and/or exercises; solved problems; tasks followed by orientations for the teacher, activities involving manipulative materials or software; games or apps; inquiry activities or projects, and scripts focused on presenting a mathematical content. The third group gathers five theses organized around a classroom task. Two present and develop projects and experiments to study certain mathematical topics. The other three present the classroom task, describe its implementation and analyze the whole experience.

About 62% of the theses (26) did not involve the development of tasks effectively implemented at schools. Therefore, we conclude that, although the course description establishes that the thesis should impact on teaching practice, this course is a learning opportunity that privileges the study of a mathematical topic and relegates to second place the construction and implementation of classroom activities.

Based on our analysis, we conclude that the formative emphasis of PMD 3 is oriented to the learning of academic mathematical knowledge, developed by mathematicians at the university. The perspective that sustains such emphasis is related to the idea that “a good teacher is the one that masters advanced mathematical contents”. The analysis of the courses reveals that this program offers few opportunities to link such mathematical knowledge to the classroom teaching practice. Our analysis shows that it is difficult that the PMD 3 develops **knowledge-for-practice** since the reflection about how the knowledge acquired during the program could assist teachers in developing the topics included in the school’s curriculum seems to be disregarded. In the same direction, it seems difficult that teachers have opportunities for analyzing and problematizing the knowledge they developed **in** practice.

The PMD 4

Belonging to the Education Area, the PMD 4 is offered by a public university. The program was established in 2014. The target public of PMD 4 is wide. In this way, the documents that regulated the selection process in 2017 established that candidates could hold any degree related to teaching. Therefore, they arrive at the program with a previous pedagogical and didactical education. Besides, to be an in-service teacher was an admission requirement. Thus, candidates should demonstrate at least two years of teaching experience at schools. We conclude that the PMD 4 is directed to teachers of all the disciplines included in Elementary and Secondary education - being a generalist or specialized teachers -. Such teachers share concerns regarding teaching and learning emerged from educational practice.

According to its web page, the PMD 4 offers an “academic education situated in the professional practices of teachers who teach diverse disciplines” adding that the program “seeks to develop a deep understanding of the epistemological principles that guide and sustain teachers’ actions” (PMD 4, n.d., on-line). In this way, the program strongly connects teachers’ education and professional practice – the formative opportunities offered by the PMD 4 are situated in teaching practice. Based on this situated nature, the program is organized around opportunities in which teachers reflect about the principles underpinning their practices at school. Therefore, the PMD 4 is an

initiative in which teachers consider and problematize the knowledge-in-practice. The program's goals are formulated using a similar perspective. Some of them are:

- 2) To promote a partnership between school and university, considering the school as a space for teachers' education and as a producer of knowledge;
- 3) To contribute to the teachers' professional development, considered as a process developed throughout their careers;
- 4) To promote actions directed at developing an inquiry stance by the teachers, recognizing themselves as teachers-researchers (PMD 4, 2014, Art. 1) .

Considering these goals, the PMD 4 understands teachers' education as a developing an unfinished process. This perspective allows to appreciate the participation in the program as a phase in the teachers' career path; a path that began long ago and that will continue after the teacher graduated. Another important feature of PMD 4 is its interest in building non-hierarchic relationships between the school and the university. The program's goals also mention the notion of teachers-researchers, in this case, associated with the development of reflective perspectives about the teacher's practices.

The credits are distributed between courses and the master's thesis. Considering the four programs selected for our study, this is the one that more credits assigned to the master's thesis. This fact indicates that, in the PMD 4, the thesis is considered as a fundamental learning opportunity for the teachers. Courses are divided between mandatories (two courses) and electives (four courses). The diagram showing the categorization of the courses is shown in Figure 5.

The diagram reveals that the courses privilege the development of general pedagogical knowledge. Three courses were in this category since they focus on foundations of education – a mandatory course –, curriculum theories, and relationships between culture and technology. Mathematical knowledge and pedagogical content knowledge are always linked to general pedagogical knowledge. This fact is not surprising since this is a generalist program, in which teachers of diverse areas, school principals, and educational advisors are enrolled.

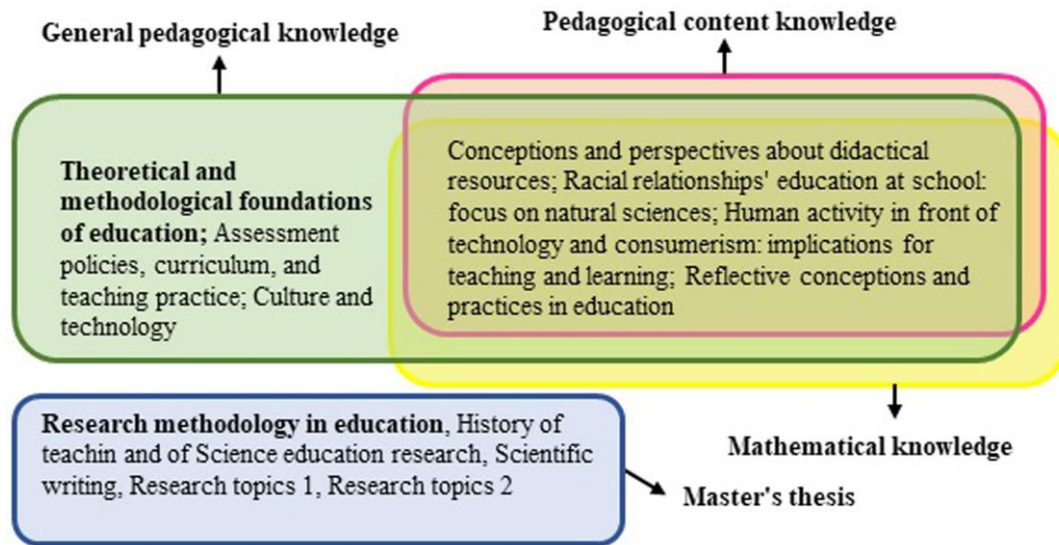


Figure 5. Diagram of the courses offered by the PMD 4
Source: The authors

Four courses were placed at the intersection between mathematical knowledge, pedagogical content knowledge, and general pedagogical knowledge. On the one side, they discuss, at a general level, racial relations, citizens' education, and the transformations in schools caused by the consumerist society. On the other side, they propose the construction and implementation of classroom tasks or encourage teachers' reflection about their own educational practice. Such activities contribute to the development of mathematical knowledge and pedagogical content knowledge⁵. Five courses focus on the development of the master's thesis, addressing scientific writing and methodological perspectives.

19 master's theses were defended during the period 2014-2016, six of them focused on issues belonging to the Mathematics Education field. Four authors are mathematics teachers – at Elementary or Secondary Education –. They constructed classroom tasks that implemented in the school were they regularly teach. Such theses end with an analysis of the whole process. The authors of the other two theses are educational advisors or teachers' educators. These works focus on the meanings teachers attribute to formative opportunities and on mathematical curricular development. Based on our analysis, we conclude that, in the PMD 4, the master's thesis is a learning opportunity centered on the reflection, analysis, and transformation of teaching practice at schools or at teachers' education initiatives.

⁵ It is important to highlight that any of these four courses explicitly mentioned mathematics. However, we supposed that mathematics teachers will elaborate classroom tasks with a focus on mathematical topics and that they will develop reflections about their own mathematics teaching practices. In this way, the courses contribute to the development of mathematical knowledge and pedagogical content knowledge.

Since this is a generalist program, the PMD 4 privileges **knowledge-for-practice** related to different pedagogical perspectives that can be used by teachers to improve their practice. This knowledge is developed, mainly, by educators. However, this is not the only nor the main formative emphasis of the PMD. Our analysis shows that this program values the knowledge teachers develop **in** practice. Such emphasis is revealed in the program's goals, in some courses – mainly the one called “Reflective conceptions and practices in education” –, and in the master's thesis. These learning opportunities recover this knowledge and take it as an object of analysis and problematization. In this way, they are important opportunities for developing **knowledge-of-practice** (COCHRAN-SMITH; LYTLE, 1999).

DISCUSSION

Although the four PMDs are directed to mathematics teachers, our analysis shows that they understand differently the **educational subject** and her formative needs. In the first place, there are differences in the target public, varying from mathematics teachers in the PMD 3, physics and mathematics teachers in the PMD 1, science and mathematics teachers in the PMD 2, and teachers specialized in any area of Basic Education in the PMD 4. Such differences are reflected on the syllabus of the programs. Particularly, those programs directed to teachers specialized on diverse areas resolve differently the tension between attending the specificity of each subject-matter and offering spaces of common and mutual exchange. This is a particularly important point when we consider Elementary teachers who teach Mathematics, Science, and Portuguese. The PMD 4 resolves this tension offering a small set of common courses – focused on a pedagogical knowledge useful for teachers who teach different subject-matters – and giving weight to the master's thesis in which each teacher may consider issues coming from their own teaching practice.

In the second place, the understandings of the educational subject are different. In some cases, it seems that the educational subject is understood as a professional lacking knowledge and techniques. Therefore, the PMD is configured as an opportunity in which the teacher will acquire such knowledge and techniques, improving her teaching practice independently of the things she already learned working at the school or during pre-service education. In other cases, the teacher is understood as a subject that produces knowledge from her teaching experiences and that encounters, in the PMD, an opportunity for problematizing such knowledge, putting it in dialogue with academical knowledge. In these cases, the idea of teacher-researcher – mentioned in the goals of PMD 2 and PMD 4 – is a key notion. Nevertheless, it is important to highlight the multiple meanings assigned to this notion: the teacher-researcher is understood as a

teacher who uses and disseminate research results in PMD 2 and as a teacher who develops an inquiry stance towards her teaching practices in PMD 4.

Moreover, each program has different **formative emphases**. We noted differences in the conceptions regarding which knowledge teachers need to improve their practices: academic mathematics knowledge, school mathematics knowledge, didactical knowledge, pedagogical knowledge, knowledge about their own practices, etc. Particularly, our analysis shows that the four PMDs assign a different role to mathematics, an issue strongly discussed in the field of mathematics teachers' education. Some programs seem to be formative initiatives in which the teachers learn "more" mathematics. In the case of PMD 3 – and, to some extent, PMD 1 also – this mathematics seems to be academic mathematics, without developing relationships between such mathematics and the one mobilized during teaching practice at school. This perspective contrasts with several research results that, although underline the importance of subject-matter knowledge, also highlight that it is not sufficient for improving teaching practice (BALL; THAMES; PHELPS, 2008; FIORENTINI; OLIVEIRA, 2013; MOREIRA; CURY; VIANNA, 2005). In this direction, Ball, Thames and Phelps (2008, p. 404) concluded that advanced mathematical knowledge does not account for the knowledge entailed in teaching and that teachers need a mathematical knowledge useful for "making mathematical sense of student work and choosing powerful ways of representing the subject so that it is understandable to students". In this direction, the practice of teaching mobilizes a **specialized** mathematical knowledge (CARRILLO et al., 2013). When this knowledge is disregarded by formative opportunities, especially the ones directed to in-service teachers – such as the PMDs – the chances of impacting the teaching practices are reduced. This is due because the teacher is left alone for building the links between the mathematics learned during the formative initiative and the one she mobilizes daily in the classroom.

We also noted that each program privileges some knowledge and relegates to the background others. A point particularly important is the possibility of developing, simultaneously, mathematical knowledge, pedagogical content knowledge, and general pedagogical knowledge. In our view, the activity of teaching involves mobilizing, in an articulated way, these three kinds of knowledge. The structure of the PMD 4 – which includes courses centered on such articulation – seems to be helpful for constructing relations between the program and the teachers' practice at school.

Our analysis reveals that the links between the knowledge addressed at each program and the teachers' professional lives at schools are diverse. PMD 1, PMD 2, and PMD 4 seem to offer, to varying degrees, opportunities for studying, theorizing, and/or inquiring about the problems and challenges emerging from teaching practice. Thus,

these PMDs build relations – in some cases stronger, in other cases weaker – among the practices discussed during the program and the demands coming from the teachers' professional practices. Therefore, these three PMDs are formative initiatives suitable for developing and problematizing knowledge-for-practice, knowledge-in-practice, and knowledge-of-practice (COCHRAN-SMITH; LYTLE, 1999; FIORENTINI; CARVALHO, 2015). This point is particularly problematic in PMD 3 since the links between the practices proposed in the program and the teaching practice at school seem to be particularly fragile.

As a consequence of these diverse perspectives, each PMD privileges different opportunities for developing teachers' learning: some programs privilege the courses and other the master's thesis. These differences become evident when we analyzed the status of the master's thesis inside the programs' syllabus and the number of credits assigned to it. Such differences regulate, to a great extent, the possibility of converting the master's thesis in a space where the teacher develops a research about her own practices, being oriented by a university teacher. In our view, this is a particularly relevant issue since it may enable to reduce the distance between schools and universities, between academic practice and school practice.

FINAL CONCLUSIONS

The documents analyzed in this article delineate the prescribed curriculum of each one of the PMDs, that is, the set of prescriptions and orientations concerning what contents should be addressed by the programs and what practices should be employed for developing such contents (SACRISTÁN, 1998). Internal regulations, syllabi, and the description of the courses provide important insights in this direction. Our analysis also included the master's theses defended during the period 2014-2016. In our view, these documents are important products generated in and from such prescribed curriculum.

We understand the curriculum as a social and historical construction, in which several agents participate. From this perspective, the documentary analysis we developed has limitations since it does not provide a vision of the knowledge and practices that are effectively developed in the PMDs. Nevertheless, we consider our analysis valuable, mainly because it reveals how the prescribed curriculum organizes and selects the knowledge privileged by each PMD, projects teaching methodologies, and mediates the culture of each program. Therefore, the documentary analysis developed in this article contributes to the field of teachers' education, revealing the horizon of practices and knowledge that are possible in each PMD. Our next step will be to analyze how this curriculum is materialized in practice, bringing the teachers' voices for studying the experiences they lived in the PMDs as well as the contributions of these programs for improving their teaching practices.

The documentary analysis developed in this article suggests that the PMDs can be considered as fruitful formative initiatives, especially when they conceive the teacher as a professional that produces valuable knowledge, and when organize opportunities for putting in dialogue such knowledge with the knowledge produced by educators and mathematics educators. From this perspective, theories developed by researchers at universities are neither the point of departure nor the point of arrival, but relevant mediators that may help to reveal the possibilities and limitations of the knowledge teachers produce in practice.

This way of understanding the subjects and the formative emphasis of teachers' education initiatives, although in resonance with research results coming from national and international projects (COCHRAN-SMITH; LYTLE, 1999; KIERAN et al., 2013; WHITE et al., 2013), is not the most frequently used to design and implement formative initiatives directed to in-service teachers. Besides, it is not the one that sustain all the PMDs analyzed in this article. This fact poses a challenge to the community of teachers' educators and researchers working at the High Education: it highlights the necessity of developing research that analyzes the experiences we are offering to the teachers and of imagining, proposing, and implementing changes seeking to transform formative initiatives in opportunities for producing knowledge and for developing teachers' autonomy. This challenge becomes even more important in the case of PMDs since they are initiatives that, throughout the time, are gathering more and more teachers.

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About the Authors

¹Ana Leticia Losano

E-mail: letilosano@gmail.com / ORCID: <https://orcid.org/0000-0002-6120-4926>

Universidade Estadual de Campinas – Brasil

PhD in Education Sciences from the Universidade Nacional de Córdoba [UNC].

²Dario Fiorentini

E-mail: dariof@unicamp.br / ORCID: <https://orcid.org/0000-0001-5536-0781>

Universidade Estadual de Campinas – Brasil

PhD in Education from the Universidade Estadual de Campinas [UNICAMP].