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ARTICLE

HOW MATHEMATICS TEACHER EDUCATORS BECOME RESEARCHERS OF TEACHING

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ABSTRACT: This study is part of a set of investigations that focus on professionals who work in the education of teachers in order to understand their need to acquire new types of experience and knowledge when they assume the position of teacher educators. In this paper, we present an interpretation of how Mathematics teacher educators become researchers of teaching through the trajectories of their lives and education. The study was developed according to the principles of narrative inquiry. Data were produced from dialogical in-depth interviews, with a biographical-narrative aspect, carried out individually with six participants, Higher Education professors who, in their work, are committed to the education of Mathematics teachers and to teaching, from which they carry out their investigations and produce knowledge-of-practice. The analytic-interpretative process, through proper narrative analysis, sought to establish an understanding of the participants' professional development experiences. The results indicate that the teacher educators have established expertise concerning research, which is not limited to investigation in the traditional academic sense, since it takes place in their dialogue with teaching—their own and that of other teachers—both in Mathematics teaching and in the education of teachers who work in the teaching of this subject. The teachers have become researchers of teaching, producing knowledge of the practices of teaching Mathematics and training teachers.

Keywords: Mathematics education, professional development, narrative inquiry, teacher education, knowledge-of-practice.

COMO FORMADORES DE PROFESSORES DE MATEMÁTICA SE TORNAM INVESTIGADORES DA DOCÊNCIA

RESUMO: Este estudo se insere no conjunto de investigações que focalizam os profissionais que atuam na formação de professores a fim de compreender sua necessidade de adquirir novos tipos de experiência e conhecimento quando assumem a posição de formadores. Neste artigo, apresenta-se uma interpretação de como formadores de professores de Matemática se constituem investigadores da docência por meio de sua trajetória de vida e de formação. Desenvolveu-se o estudo segundo os pressupostos da pesquisa narrativa. Produziu-se os dados a partir de entrevista dialógica em profundidade, com caráter biográfico-narrativo, realizada individualmente com seis participantes, docentes do Ensino Superior que, em sua atuação, comprometem-se com a formação de professores de Matemática e com a docência, a partir das quais realizam suas investigações e produzem conhecimentos da prática. O processo analítico-

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interpretativo, mediante uma análise narrativa propriamente dita, procurou estabelecer uma compreensão das experiências de desenvolvimento profissional das participantes. Os resultados apontam que os formadores estabeleceram uma *expertise* em relação à pesquisa, que não se limita à investigação no sentido acadêmico tradicional, pois se efetiva na interlocução deles com a docência, a sua e a de outros docentes, tanto no ensino de Matemática quanto na formação de professores que atuam no ensino dessa disciplina. As formadoras se constituíram investigadoras da docência produzindo conhecimento das práticas de ensinar Matemática e de formar professores.

Palavras-chave: Educação matemática, desenvolvimento profissional, pesquisa narrativa, formação docente, conhecimento da prática.

CÓMO FORMADORES DE PROFESORES DE MATEMÁTICA SE HACEN INVESTIGADORES DE LA DOCENCIA

RESUMEN: Este estudio forma parte del conjunto de investigaciones que focalizan los profesionales que trabajan en la formación de profesores para comprender su necesidad de adquirir nuevos tipos de experiencia y conocimientos cuando asumen el cargo de formadores. En este artículo, se presenta una interpretación de cómo los formadores de profesores de Matemática se constituyen investigadores de la docencia a través de su trayectoria de vida y de formación. Se desarrolló el estudio según los presupuestos de la investigación narrativa. Los datos se produjeron a partir de la entrevista dialógica en profundidad, de carácter biográfico y narrativo, realizada individualmente con seis participantes, profesoras de la Educación Superior que, en su actuación profesional, están comprometidas con la formación de profesores y con la docencia, desde las cuales realizan sus investigaciones y producen conocimientos de la práctica. El proceso analítico e interpretativo, a través de un análisis narrativo, buscó establecer una comprehensión de las experiencias de desarrollo profesional de las participantes. Los resultados señalan que los formadores han establecido una experiencia a cerca de la investigación, que no se limita a la investigación en el sentido académico tradicional, pues se efectiva en la interlocución de ellas con la docencia, la suya y la de otros profesores, tanto en la enseñanza de la Matemática como en la formación de profesores que actúan en la enseñanza de esta materia. Las formadoras se constituyeron investigadoras de la docencia produciendo conocimiento de las prácticas de enseñar Matemática y de formar profesores.

Palabras clave: Educación matemática, desarrollo profesional, investigación narrativa, formación docente, conocimiento de la práctica.

INTRODUCTION

This article comes from the result of the first author's doctoral research (COURA, 2018), aimed to understand the professional development experiences of Mathematics educators of teachers who are teaching researchers. These experiences were lived by six higher education teachers who work in the education of mathematics teachers and who are committed to it and to their profession, from which they carry out their investigations and produce practical knowledge (COCHRAN-SMITH, 2003) that offer support to their professional performance and others.

After discussing how the study participants became Mathematics teachers [3] (COURA; PASSOS, 2018a) and how they became educators of Mathematics teachers (COURA; PASSOS, 2018b), this article aims to present our interpretation of how they became teaching researchers. Thus, we carried out in-depth dialogic interviews with a biographical-narrative character with each of the participants (DOMINGO SEGOVIA, 2014) who work in six higher education institutions, located in four Brazilian states (Espírito Santo, Minas Gerais, Paraná, and São Paulo).

Therefore, this study is part of the set of investigations that have focused on professionals who work in teacher education (ALMEIDA; RIBEIRO, 2019; ANDRÉ et al., 2010; FLORES, 2014; PASSOS; SILVA; FERREIRA, 2013; VAILLANT, 2003), to understand their need to acquire new types of experience and knowledge when they assume the position of educators (ALTET; PAQUAY; PERRENOUD, 2003; CONTRERAS et al., 2019; KELCHETERMANS; SMITH; VANDERLINDE, 2017; VANASSCHE; KELCHETERMANS, 2014). These discussions are in the area of teacher education, regarding the role, performance, and knowledge needed to be an educator (COCHRAN-SMITH, 2005; CONTRERAS et al., 2017; DAL-FORNO; REALI, 2009; MURRAY; MALE, 2005), which only take shape when one considers that training the teacher is more than making him/her know the content to be taught (COURA; PASSOS, 2018b).

In Coura and Passos (2017) we identified 13 researches produced in Brazilian postgraduate programs in the areas of Education and Teaching, until 2012, focused on the Mathematics teacher educator´s education. These studies, by the amount they represent — approximately 1.5% of the 858 investigations on teachers who teach Mathematics, inventoried in Fiorentini, Passos, and Lima (2017) — corroborate the considerations regarding the knowledge gap of the teacher who works in the undergraduate courses (ANDRÉ et al., 2010; FIORENTINI, 2004; FIORENTINI et al., 2002; MIZUKAMI, 2010; VAILLANT, 2003), despite the centrality of their role in teacher education (ALTET; PAQUAY; PERRENOUD, 2003; ZEICHNER, 2005).

Although these studies have been reduced, we can say that they are part of the movement mentioned by Kelchtermans, Smith, and Vanderlinde (2017) in defense of the specificity of the work of teacher educators. They reveal evidence that there is a set of knowledge, constituted throughout professional trajectory, which Brazilian authors strictly associated with the task of training teachers. However, these studies fail to consider an "important dimension in teacher educator expertise [that] concerns their abilities as researchers — not just in the traditional academic sense of the word, but also through methodologies for studying their practices." (KELCHTERMANS; SMITH; VANDERLINDE, 2017, p. 3, our translation). This investigation focused on this gap.

In this article, to establish an understanding of how Mathematics teacher educators became teaching researchers, initially, we discuss what the concept of professional development refers to when the teacher in question is the educator. We describe Narrative Inquiry, from the perspective of Clandinin and Connely (2011), as the methodological path adopted and the process of narrative analysis used. So, we can see a result of our analysis, in which the narrated trajectories seek to show the moment/movement that marked the transition of the participants from educator teacher to researcher of teaching. In the end, we make considerations about the results of the study.

[3] As the gender of the participants was not considered in the analyses, although all of them are female teacher educators, we kept the word educators in general in the title, in the objective and in the research questions, to refer to a group of professionals that includes female and male educators.

PROFESSIONAL DEVELOPMENT OF MATHEMATICS TEACHER EDUCATORS

Teacher professional development has been associated with teacher education and understood as a

> personal, permanent, continuous, and unfinished process that involves multiple stages and formative instances. In addition to personal growth throughout life, it also includes professional training (theoretical-practical) of preservice education — aimed at teaching and involving conceptual, didactic-pedagogical, and curricular aspects — and the development and updating of professional activity in processes continuing education after graduation (PASSOS et al., 2006, p. 195)

It is "an 'inside-out' movement of the teacher" (PONTE, 2014, p. 346), a process of production and rationalization of knowledge and skills necessary for a professional exercise with autonomy to decide and control the processes under its responsibility (MINGORANCE-DIÁZ, 2001). Usually associated with the constitution of a professionality, teacher professional development is singular, multidimensional, and contextual (space and time), involves transformations in the person that the teacher is (GUIMARÃES, 2005), and depends on the investigation of the practice that he performs (COCHRAN-SMITH; LYTLE, 1999).

According to Cochran-Smith (2003), the professional development of the teacher educator would take place in a perspective very similar to what she and Susan Lytle defend for the teacher, that is, as a process of learning knowledge of the practice (COCHRAN-SMITH; LYTLE, 1999). She argues that the education of educators in different contexts and moments throughout their professional career is substantially enriched, when an investigative stance (inquiry as stance) is assumed in their work in teacher education and when they collaboratively research knowledge and professional practice, about the school context, about Higher Education and their learning, as well as their students. According to the author, this investigative stance offers an intellectual and pragmatic perspective for the professional development of teacher educators, understood as a way of learning from and about practice, through an engagement in the systematic investigation of practice, with a community over time. Other studies (ALTET; PAQUAY; PERRENOUD, 2003; FIORENTINI, 2004; MIZUKAMI, 2005; MURRAY; MALE, 2005; ZEICHNER, 2005) have pointed in the same direction, that is, that the professional development of teacher educators is essentially related to taking teacher education not only as a field of practice but also as an object of research that it develops.

In Cochran-Smith (2005), the author argues that part of the teacher educator's task is to act simultaneously as a researcher and as a professional. Conceiving him as a researcher (teacher educators as researchers) means assuming that, in fulfilling almost all the roles of teacher educators, research and practice feed each other. In the same study, the author also argues that, for many educators, this work takes place in research communities in which the participants - who can be professors, university educators, and future professors - unite their understandings, question themselves, make their knowledge public and open to criticism as well as interpret and question knowledge and research produced outside the group. To consider the teacher educator as a participant in a research community is to understand him as a subject who produces knowledge and learns.

This perspective of understanding the educator as a researcher (COCHRAN-SMITH, 2005) is very close to the professional identity of the educator-researcher (FIORENTINI, 2004), to the position that Zeichner (2005) defends for the constitution of expertise of the teacher educators and the path towards professionalism, indicated in the studies of the work of Altet, Paquay, and Perrenoud (2003). As we try to show below, all of them show a professional profile similar to the participants of this study, which we qualify as researchers of teaching, and all of them highlight the importance of research of the practice carried out by the teacher educator, in addition to a change in the role that is traditionally attributed to this teacher.

We understand that the professional development of the Mathematics teacher educator who is a researcher in teaching is a process in which teaching is its foundation, considered as a field of professional performance and research, of knowledge production. By taking an investigative stance and

systematically researching the practice of teaching Mathematics and of teacher education who teach Mathematics — their practice, the practice of other educators, of other teachers, of future Mathematics teachers —, the teacher educator can learn and produce knowledge, use it in their professional activity and make it accessible to others.

NARRATIVE RESEARCH AS A METHODOLOGICAL PATH

As we consider the professional development of the teacher educator, it has brought some consequences for the study. As Guimarães (2005) warns, assuming the intentionality and importance of the teacher's and the educator's agency in this movement demands concentrating the focus of the research on him, taking him as the subject of its construction. Thus, more than focusing on this process and associating it with an increase in skills, it is necessary to integrate the person he is, that is, it is necessary to consider his biography in the investigation. Perhaps, for this reason, the research on screen took the form it is now presented only when we defined that the participating Mathematics teacher educator would be some of those who had integrated the Coordination of the GT7 "Formation of teachers who teach Mathematics", of the *Sociedade Brasileira de Educação Matemática* (Sbem).

The 6 participants[4] — Adair M. Nacarato, Márcia Cristina da C. T. Cyrino, Maria Auxiliadora Vilela Paiva (Dôra Paiva), Maria Teresa Menezes Freitas, Maria Tereza Carneiro Soares and Nielce M. Lobo da Costa — composed the Coordination of Sbem's WG7 in some moment of their professional career. All of them have a degree in Mathematics, 5 of them have a master's degree in Education or Mathematics Education, one has a master's degree in Mathematics, and all of them have a Ph.D. in Education. All have more than 30 years of professional teaching experience, and 4 participants worked in Basic Education[5] as Mathematics teachers, before joining Higher Education teaching. Five worked in only one Higher Education Institution (HEI) during their entire professional life and 4 worked in public HEIs: three in federal universities and 1 in a state university. Six of them were supervisors in graduate programs in the area of Education or the area of Teaching for at least 5 years, taking as a reference the date on which the research was carried out. They were invited to participate in the study because we understand them as key informants (DOMINGO SEGOVIA, 2014), precisely because of the particularity they represent, that is, because they take teaching and teacher education not only as their field of practice but also as the object of their research.

We are interested in knowing the participants' professional development process, recounting it, reconstructing it identifying what influences it, and understanding how it happens. For this reason, the narrative was configured as a way to retell these stories so that, in addition to understanding, they allow development and change, so that they affect us in an existential way (CONTRERAS DOMINGO, 2016). We adopted the perspective of Clandinin and Connelly (2011) for narrative inquiry, which proved to be fruitful because, with the assumptions of narrative thinking, we can locate events, experiences in time, not as something that happened at that moment, but as an expression of something happening over time.

To carry out the study that is materialized in this article, in the data production stage, we carried out in-depth dialogic interviews with a biographical-narrative character (DOMINGO SEGOVIA, 2014) with the six participants. This interview consists of "reflecting on or remembering episodes in life, where the person tells things about his biography, in an open exchange, which allows him to delve into his life through questions and active listening to the interviewer." (BOLÍVAR, DOMINGO; FERNÁNDEZ, 2001, p. 159). Following the assumptions of narrative inquiry (CLANDININ; CONNELLY, 2011), from the interview with each teacher educator, three field texts were produced — mapping the educator´s trajectory, the transcript of the interview and field notes —

[4] The six narratives were analyzed and, to some extent, changed by the teacher educators who had the prerogative to decide what would be kept in the respective text. The research participants showed their agreement to be identified in the research as well as in their publicity texts, since their professional path, therefore, identity and subjective, and their professional development resulting from this trajectory were objects of our analysis. This procedure was authorized by the Ethics Committee of the institution linked to the doctoral research.

[5] In Brazil, Basic Education covers 12 years, being equivalent to K-12 in the United States of America (Elementaty School and High School) and, in the United Kingdom, to 11 years corresponding to Primary School and Secondary School.

which, under our interpretation, resulted in the six narratives of professional development experiences of the participants presented in Coura (2018).

In a second analytical-interpretative process, we carried out a cross-sectional analysis of these narratives, seeking to establish a diachronic flow, a chronography of important elements (DOMINGO SEGOVIA, 2014), to constitute an understanding of the participants' professional development experiences and show our interpretation about how they became researchers of teaching. We proceed with what Bolívar, Domingos, and Fernandez (2001) call narrative analysis, which generates the narration of a plot or argument through a narrative account. We seek to build descriptive understandings characterizing not only common points of each one's experiences but also narrative understandings of their experiences over time, spaces, and interactions (FIORENTINI, 2012) that we identify in their life stories. From these common points and narrative understandings, certain ways emerged in which the participants relate to the research and how the knowledge produced connects with their practice, which can be understood as categories of analysis according to which their professional development can be understood.

We present below a result of this analysis, the result of our interaction with the narratives, with the theoretical framework that instrumentalized us in this process of interpretation and with the reflection proper to the process of producing meaning from the field/research texts (BOLÍVAR; DOMINGO; FERNÁNDEZ, 2001). Thus, we used many excerpts from the interviews (written in italics) and from the academic production of the participants to illustrate the statements we made and to maintain their voices in the research text. We also resorted to dialogue with the literature to help tell the transformations and movements that took place in the lives of the participants and to reference the meanings produced regarding their professional development. Thus, like Lima, Geraldi, and Geraldi (2015, p. 39) indicate, we employ a "way of approaching what people say about events [which] is concretized by comparing what is said with other sayings, producing discourses about discourses." It is a temporal sequence that includes part of the participants' professional trajectory when they were already working in teacher education; with it, we intend to show how researchers of teaching were constituted.

FROM EDUCATOR TO RESEARCHER IN TEACHING: OTHER RELATIONS WITH RESEARCH

Understanding teacher professional development — including as a teacher educator — as a learning process based on an engagement in the systematic investigation of practice and about it enabled us to resort to one of the conceptions of teacher learning systematized by Cochran-Smith and Lyttle (1999) — knowledge of practice — to analyze the life stories and training of the participants. Considering that the practice of Mathematics teacher educators includes both first-order teaching, whose object is Mathematics in Basic Education or Higher Education, and second-order teaching, that is, teaching about education (MURRAY; MALE, 2005), we sought to identify how the participants relate to the research and how the knowledge produced is connected with their practice.

Smart consumption of research

When they became Mathematics teacher educators to help undergraduate students and teachers in their continuous process of learning to teach, the participants needed to think about teaching, focusing not only on what to teach but also on how to teach. They had also needed to think about how to structure the learning of future teachers towards more professional teaching (ZEICHNER, 2005), which was also verified when the "apprentices" were teachers in practice. The teacher educators needed to develop knowledge of their practice and make the tacit aspects of this practice explicit to their students (TACK et al., 2017), future teachers, and in-service teachers, generating knowledge in the practice of training teachers (COURA; PASSOS, 2018b).

As they followed this path, they began to establish other relationships with research and use it to support and guide their professional performance. It is about the constitution of expertise in the academic production, related to an intelligent consumption of research that was present in the stories narrated by the participants, for example, when Márcia selected the reference that she used in her classes

in the Mathematics Degree from of the theoretical framework of her training in Mathematics Education in the master's degree – "*in addition to taking the official documents, the curricular parameters, we also took articles, we took research results for the degree*" -, Maria Teresa chose "*more accessible and pleasant readings for teachers, in which mathematics is present*" and Maria Tereza discussed "*with pedagogues that mathematics is worked from the sixth to the ninth grade and how does a historical conception within a philosophy of dialectical historical materialism materialize in the classroom, what topics of mathematics are related to it*".

Regarding this expertise in the research, Cochran-Smith (2005, p. 224) referred to the ability of educators to interpret "new research studies, locating them within a larger discourse that is informed by multiple historical, empirical and epistemological perspectives", which Nielce showed, when considering that the simplification of the Mathematics Degree curricula would result in an preservice teacher education that qualified the teacher only to reproduce teachings aimed at procedures and techniques for solving mathematics exercises (LOBO DA COSTA; GALVÃO; PRADO, 2017).

The narratives of the participants indicate that the educator also exercised this intelligent consumption of research when analyzing the field of inquiry of the training of teachers who teach Mathematics in Brazil and its impact on public policies aimed at teacher education:

> *Putting all these researches together, to what extent can we influence public policies? And I saw that in nothing. [...] I feel that we care about the research, yes, but our political action is incipient, in my opinion. It still falls far short of what we can do.* (Márcia)

This analysis of the area in which they are inserted is also shown when Naccarato and Paiva (2006b) point out the difficulty that authors of investigations in the area of Education and Mathematics Education have in establishing a differentiation between what is training and what is research. This difficulty, mentioned by the authors, who are participants in this study, is reflected in existing gaps in this field – "*I think we still do not have good analysis methodologies*" (Adair) –, which they perceive when evaluating the investigations produced – "*I have participated in examination boards, with works that are very well written, but which have no content. They do a whole study of how the teachers grew up, how the teacher behaved, how they developed in continuing education. But it does not show that he has developed*" (Dôra Paiva).

According to Loughran (2014), to work in second-order teaching and do more than transmit ways of teaching content, the multiple issues, concerns, contradictions, and approaches to understanding the complexity of practice in teacher education must be based on more than the experience. Teacher educators need to be informed by research and able to guide their work according to the evidence and knowledge generated in research that they deem appropriate for their professional task. They need to know how to read, evaluate, criticize and use this investigation in their work, becoming intelligent consumers of research, as the excerpts presented indicate that the participants do. As Cochran-Smith (2005) argued that the educator was necessary, which other authors (LOUGHRAN, 2014; TACK; VANDERLINDE, 2014) ratified, the participants constituted expertise for the research, as intelligent consumers and producers of studies.

Investigations into the practices themselves

For Cochran-Smith (2005), in addition to being intelligent consumers of research, teacher educators need to have experience in carrying out investigations into their practices and teacher education programs. This expertise involves the study of the practice of training teachers and conducting empirical research in practice, to determine what the results of training courses and field experiences represent in the learning of future teachers - and teachers in practice, complementing the author's argument. –, for their professional performances at school and in the classroom, and the learning of their students in first-order teaching.

For example, Adair analyzed the training process he adopted in a group that he composed with another teacher, with students of the Mathematics Degree at the university where he worked and with mathematics teachers and observed that, with the dynamics assumed, the school teachers expanded their teaching knowledge about Geometry, the undergraduates began to build knowledge about teaching and the educators built a methodology for teacher education (NACARATO; GRANDO; ELOY, 2009). Dôra Paiva showed how the conceptions of Mathematics Licentiate students changed when they had a

space to develop professionally in search of their identity as teachers (PAIVA, 2008). Márcia characterized eight elements that provided opportunities for teachers to learn in communities of practice (CYRINO, 2013b, 2015). Maria Teresa observed that the interns' reflection was strengthened by the requirement of writing and the availability of time resulting from the use of a tool in the virtual environment as a strategy for training Mathematics teachers (FREITAS, 2010, 2011). Maria Tereza found that the result of training, when the Mathematics Degree does not integrate specific and pedagogical training, is fragile and disjointed, "when it comes to dealing with the elementary school classroom, which is essentially plural, contradictory, uncertain" (MELÃO; SOARES, 2012, p. 218). Nielce realized that "knowledge of specific content proved to be fundamental for the (re)construction of technological knowledge of content and technological pedagogical knowledge" (LOBO DA COSTA, 2017, p. 76) when she analyzed the process of technology appropriation of teachers in the first years of Elementary School.

To conduct research on their practice, such as those mentioned, Cochran-Smith (2005, p. 224-225) considers that "teacher educators need to know how to pose and explore important questions, collect multiple data sources that are convincing, analyze the data in line with their initial questions and their theoretical frameworks, and interpret the data including implications for local policy, practice, and programs", just as the excerpts from the academic production of the participants recorded in this text show what they did.

According to Kelchtermans, Smith, and Vanderlinde (2017), this expertise of the teacher educator as a researcher – not only in the traditional academic sense but also through methodologies for studying their practices – aims at a growing vision based on the data of complexity of this practice of training teachers, constituting the support for effective initiatives to improve this practice and for the composition of a public, based and explicit knowledge that portrays professional knowledge about the pedagogy of teacher education. Tack et al. (2017) make the same argument, that the research of the teacher educator should serve a dual purpose: (1) to improve practice and knowledge about teacher education, and (2) to contribute to the broader knowledge base of this field. They explain that the first objective refers to the development and improvement of local knowledge and practice and the second, to the generation of public knowledge and its dissemination to the research community in teacher education.

In other words, in addition to improving their teaching practice based on the results of their research, teacher educators are also expected to aim to fully develop their role as researchers, make their research results explicit, and share them with the teacher education community (TACK; VANDERLINDE, 2014), as well as excerpts from the academic production of the participants present in this article show what the teacher educators did.

Contributions to a knowledge base of teacher education: investigative posture

By conducting investigations, producing knowledge of their practice as teacher educators, the participants offered contributions to a knowledge base of teacher education. Thus, Adair verified "that the contexts that privilege the problematization, analysis and reflection of the pedagogical practice are potentializers of the professional development of teachers" (NACARATO et al., 2008, p. 200); Dôra Paiva argued that "as important as knowing what skills and knowledge the future teacher needs to become a good professional is knowing how they are built and developed during their training" (PAIVA, 2008, p. 93); Márcia found that, "for the development of the teacher's professional identity to occur, an opening in the training processes is necessary that favors the emergence of vulnerabilities" (CYRINO, 2015, p. 4); Maria Teresa identified that, as for the Mathematics teacher, "the professional identity and constitution do not happen in a single context, but in several contexts in which each one has the opportunity to interact" (FREITAS, 2006, p. 275); Maria Tereza highlighted the importance of "bringing to teacher training discussions that intimately involve educational policies with their motivations and developments (MELÃO; SOARES, 2012, p. 218); and Nielce considered that initial teacher education "should be organized in order to establish a more intimate relationship between theory and practice, aiming at the training of a teacher who presents, at the beginning of his professional practice, the skills and competences required" (LOBO DA COSTA; POLONI, 2012, p. 1291).

These excerpts from the participants' production show knowledge of teacher education that, as Cochran-Smith and Lytle (1999, p. 273) distinguished as knowledge of practice,

> is not bound by the instrumental imperative that it be used in or applied to an immediate situation; it may also shape the conceptual and interpretive frameworks teachers [and teacher educators] develop to make judgments, theorize practice, and connect their efforts to larger intellectual, social, and political issues as well as to the work of other teachers, researchers, and communities.

As research producers, the participants generated knowledge of the practice of training teachers, marking a change in positioning regarding the knowledge related to their professional performance. By generating knowledge of the practice of training teachers, they dedicated to theorizing and guiding their work and, to connect it to broader issues, which extrapolate their practice, their classroom, their professional context, they produced knowledge that could be useful and accessible to others, that is, that could transcend the local context and inform other educators in broader contexts.

By generating knowledge of the practice of training teachers, for Cochran-Smith (2003), teacher educators learn to be better at their work, since the constitution of this knowledge results from a process of construction, interrogation, elaboration, and criticism of their practice of training teachers and the theory formulated by others, linking action and problematization to the local context, as well as to larger social, cultural and political issues. The literature (COCHRAN-SMITH, 2003; 2005; LOUGHRAN, 2014; SMITH, 2015; TACK; VANDERLINDE, 2014) has pointed out – and we assume – that research conducted by the teacher educators is a key component in their professional development.

In this sense, Tack and Vanderlinde (2014) refer to a "researcher disposition", as the mental habit that the teacher educator must have to engage in research and, therefore, produce local knowledge about teacher education. Loughran (2014) talks about the teacher educator career as a "research journey" and argues that they have to engage in investigations to improve their knowledge about teaching, about student learning, about their training, and of teachers and future teachers. Therefore, the research needs to be an inherent part of the professional activity of a teacher educator (KELCHTERMANS; SMITH; VANDERLINDE, 2017). In this sense, Cochran-Smith (2003, p. 7) suggests that

> [...] the education of teacher educators in different contexts and at different entry points over the course of the professional career is substantially enriched when inquiry is regarded as a stance on the overall enterprise of teacher education and when teacher educators inquire collaboratively about assumptions and values, professional knowledge and practice, the contexts of schools as well as higher education, and their own as well as their students' learning.

According to this author, the investigative stance offers an intellectual and practical perspective on the education of teacher educators. It is a way of learning from and about the practice of teacher education through systematic investigation of that practice within a community of peers over time. The author emphasizes that the investigative posture is not a method, but an intellectual perspective, a way of questioning, giving meaning, and connecting the day-to-day work with other professionals and with the great social, historical dimensions, with cultural contexts and politicians. It is a continually questioning view of knowledge and practice in teacher education, a process that extends throughout the professional life, as can be seen through the positioning of the teacher educators, manifested in phrases such as: "the possibility of looking at these productions and being able to analyze them and reflect on my practice, systematizing some of these reflections (as in this article), is fundamental for my professional constitution" (NACARATO, 2010, p. 927); "*without study, without theory, you don't do things*" (Dôra Paiva); "*we have to be a teacher, we have to do research and we have to, in some way, interfere in public policies*" (Márcia); "*to train teachers, you cannot be only in theory*" (Maria Teresa); the "*attitude of a teacher educator must always be to question everything they know*" (Maria Tereza) and "*most teachers will be trained in this way. So, we researchers would need to worry about researching this area. I will try to do that, as much as possible*" (Nielce). This investigative stance represents a way of dealing with the uncertainties and contingencies of the teaching profession (COCHRAN-SMITH; LYTLE, 1999), which also applies to second-order teaching, that is, to teacher education.

The dialectic between research and practice in teacher education

The perspective defended by Cochran-Smith (2003, 2005) – and that we assume – of considering the professional development of teacher educators as a continuous process that results from an investigative posture on the work of teacher education depends on this teacher not privileging neither study nor practice separately, but rather that there is a dialectic of both, in which the lines between professional practice in teacher education and research related to teaching and teacher education are increasingly blurred. To this end, the author suggests taking the activities inherent to the work of teacher education in a problematizing way and exploring them from a research point of view, asking questions based on their daily work as a teacher and, then, exploring these questions, systematically collecting data, resorting to related theory and research and building local analyzes and practices, as well as excerpts from their academic production present in this article, reveal what the participants have been doing. For this reason, we consider that each of the teacher educator acts simultaneously as a researcher and a professional, establishing a dialectic between research and practice in teacher education.

For them, some part of this work with dialectics takes place in groups that comprise undergraduate students, Basic Education teachers, masters, doctoral students, and other teacher educators. As an example, in GRUCOMAT (Collaborative Mathematics Group- *Grupo Colaborativo de Matemática*), Adair participates in the training process that involves the elaboration, application, analysis, and systematization of activities in the Elementary School classroom (NACARATO; GRANDO; ELOY, 2009) and seeks to weave his research with those of real teachers and in their real working conditions, giving visibility and legitimacy to the investigations they carry out in their classrooms (NACARATO; GRANDO, 2015). Gepefopem (Study and Research Group on Training of Teachers who teach Mathematics- *Grupo de Estudo e Pesquisa sobre Formação de Professores que ensinam Matemática*), Márcia "*always seeks to do an integrated work of research, already involving initial teacher education*", constituting groups that were assumed as investigation scenarios, in which data are generated by interaction and continuous communication with practice, using not only of knowledge that was generated in the academy, but, above all, of those that cannot be produced outside of practice (CYRINO, 2013a). Nielce has formed "*mixed groups between school teachers, university professors, master's students, doctoral students*", in which they sought to report, think and understand the classroom and realized the importance of incorporating the teacher's actions experienced in their school context in the development of training courses (LOBO DA COSTA; PRADO, 2012).

In a similar way, Dôra Paiva worked at the Mathematics Teaching Laboratory (LEACIM-*Laboratório de Ensino de Matemática*) – "*I set up a teaching laboratory and we started to work with several projects in this laboratory together with the teachers from the city hall*" – and organized groups such as the Study Group and Research in Mathematics Education of Espírito Santo (GEPEM-ES-*Grupo de Estudos e Pesquisa em Educação Matemática do Espírito Santo*) – "*nowadays, I teach and, at the same time that I teach, for example, in the master's degree, my students participate in extension groups, outreach projects and do research*"-; Maria Teresa developed internship activities based on the approximation of future teachers in her area of work and school teachers, in a work permeated by dialogue and the exchange of knowledge between the elements involved, a two-way street between university and society, which he judged to favor excellent opportunities for important exchanges for the consolidation, formation and production of knowledge, most of the time unnoticed (FREITAS, 2000); and Maria Tereza tried to do "*research with the teacher*":

> *I think that I always tried to do research with the teacher, never research about what the teacher is doing, but always bring the teacher. So, I've been around since the 90s, late 96s, I started to work in this modality of collaborative research.*

In this type of group, members bring different types of knowledge and experiences, seeking with others to build significant local knowledge, in which research is recognized as part of a larger effort to transform teaching, learning, and the school (COCHRAN-SMITH; LYTLE, 1999) and the education of teachers who teach Mathematics. The participants produce knowledge of practice – of teaching Mathematics, of training teachers who teach Mathematics –, collectively built within local communities,

such as these groups, and in others that contemplate broader contexts, such as GT7 (Working Group: "Formation of teachers who teach Mathematics") from SBEM.

Although GT7 did not always represent the educators who participated in this study a research community made up only of teacher educators, as Cochran-Smith (2005) argued, that is, in which they question their ideas and actions related to teaching and teacher education for social justice; systematically examine the underlying values and assumptions of their different assessments of prospective teachers' classroom performance, and work to design, and then analyze, all the different ways in which they document the progress of these prospective teachers to measure, assess the impact of their preparation programs on the learning of prospective teachers; this was a space that they considered important in their life and education paths.

According to Adair, GT7 is a group that always "*feeds it in this sense, that is, what my colleagues are doing, how are they thinking, how is the field advancing or not*". For Dôra Paiva, participating in GT7 "*was a growth – because I started to learn more, to be more concerned with public policies related*" to teacher education. Márcia worked in GT7 with the intention of "*doing something collectively, as a group, but as a research group, a group of researchers*" and considered that this experience allowed her to have a more comprehensive view of Brazilian research on the training of teachers who teach Mathematics (CYRINO, 2016). For Maria Teresa, the group was a space for discussion: "*you discussed research, you discussed ideas, you discussed proposals. And all for the sake of excellence in teacher training, in the pursuit of excellence in teacher training*". Maria Tereza highlighted the production of knowledge in the area of teacher education as an influence of GT7 in its trajectory and as a differential in its training. For Nielce, integrating the coordination of GT7 was a consequence of the work she developed with teachers and the research she carried out in teacher training, and being part of the group was an experience that helped her as a teacher educator.

As Nacarato et al. (2018) emphasized, since the creation of GT7, the researchers who make up the group have been dedicated, in different academic spaces, to discussing and disseminating the research they carry out, to intervene in public policies, to articulate and identify emerging themes in the field of education of teachers who teach Mathematics in Brazil. To some extent, this group, which includes the participants, has theorized about the practice of researching the education of teachers who teach mathematics in Brazil, interpreting and questioning their production and the research of other groups, from other contexts and other fields of the knowledge (as in LOPES; TRALDI; FERREIRA, 2015a, 2015b; NACARATO; PAIVA, 2006a, 2008, for example).

AN EXPERTISE IN RELATION TO RESEARCH

Similar to the perspective that Cochran-Smith (2005) has of her role as a teacher educator, each of the participants took an investigative stance, working on the dialectic between research and practice, thereby making the boundaries between them more tenuous, that is, functioning simultaneously as a researcher and as an teacher educator. For them, part of this work also took place in communities where they developed understandings, questioned, made their knowledge public, and, thus, were open to criticism.

In their trajectories, the teacher educators recognized the need for research to inform their practices, and, to some extent, they became involved in the development of the field in which they are inserted — the education of teachers who teach Mathematics. In addition, they publish their work in research journals and participate in academic events to contribute to the establishment of a knowledge base on teacher education. For Tack and Vanderlinde (2014), this involvement with research is based on the belief that each teacher educator must be a researcher and is supported by their methodological expertise and specific knowledge in teacher education.

Thus, as they developed an expertise in relation to research, the teacher educators established themselves as researchers of teaching, that is, they committed themselves to the education of teachers and teaching, from which they carry out their investigations and produce knowledge of the practice (COCHRAN-SMITH, 2003) that support their professional performance and of others. We defend that this is peculiar expertise in relation to research, as it is not limited to investigation in the traditional academic sense, it is effective in the dialogue that the teacher educators established with the teaching, theirs and that of other teachers, both in the teaching of Mathematics and in the education of teachers

who work in the teaching of this subject. Finally, they became researchers of teaching as they began to produce knowledge of the practice of training teachers who teach Mathematics.

FINAL CONSIDERATIONS

Based on the results of this study, we argue that, in the exercise of the profession, as they worked in the education of future Mathematics teachers and/or in-service teachers, the participants came to know and do more than teach about teaching; and how they developed had a strong relationship with the commitment they established with their teaching activities, including in teacher education, and with the interaction, they consolidated between research and teaching. By placing teaching as their main function, from which they carried out their research, the teacher educators developed a way of learning from and about practice through an engagement in a systematic investigation over time. These findings are part of the movement mentioned in the literature in defense of the specificity of work and the existence of a set of knowledge necessary to perform the task of training teachers and contribute to filling the gap on the role of research in the formation of the teacher educator's expertise by show how involvement with research interfered in the trainers' professional development process.

By generating knowledge of the practice of teacher education, they are dedicated to theorizing and guiding their work. To connect it to broader issues, which extrapolate their practice, their classroom, their professional performance context, they produced knowledge that could be useful and accessible to others, that is, one that transcends the local context and informs other educators in broader contexts. With this, we identified that, as they developed an expertise in relation to research, the teacher educators were established as researchers of teaching, that is, they committed to the teacher education and placed teaching as their main function, in which they carry out their investigations and produce knowledge of the practice (COCHRAN-SMITH, 2003), offering support to their professional performance and others. Therefore, they became researchers of teaching as they began to produce knowledge of the practice of training mathematics teachers.

We tried to show that the participants took the activities specific to the work of teacher education in a problematizing way, from a research point of view, asking questions based on their daily work as teacher educators and, then, exploring these questions, collecting data in a systematic approach, drawing on related theory and research and building on local analysis and practices. By assuming this investigative stance (COCHRAN-SMITH, 2003, 2005), each of the teacher educators acts simultaneously as a researcher and a professional, establishing a dialectic between research and practice in teacher education.

This continuous and systematic inquiry, in which the teacher educators question their assumptions and build local and public knowledge appropriate to the contexts in which they work, represents, for Cochran-Smith (2003), a process of change. This movement of learning and unlearning enabled us to understand that the investigative posture plays a significant role for the professional development of the educator, in the perspective of transforming him as a person, as happened with the participating Mathematics teacher educators, who we seek to characterize as researchers of teaching. How the participants developed professionally has a strong relationship with the commitment they established with their teaching activities and with the interaction constituted by them between research and teaching.

With these considerations, we want to highlight that we seek to provide an understanding of professional development experiences, built from the knowledge related to the participants' professional performance. We focus on knowledge because it is an important component of the concept of professional development adopted — a process of production and rationalization of knowledge and skills necessary for a professional exercise with autonomy to decide and control the processes under its responsibility. Also, because, under our interpretation, it was also a significant aspect in the trajectory of the teacher educators, insofar as, over time and in the different contexts in which they worked, they sought to build up the knowledge to face the demands of their work, training Mathematics teachers or getting involved with the search. Analyzing the professional development experiences of the participants from other points of view, such as the conceptions about teaching Mathematics and/or training teachers or their position in relation to public policies related to Basic Education and teacher training, for example, is important to be carried out in other researches.

Although the analysis of professional development experiences was carried out based on common points that we identified in the participants' trajectories, we did not intend to standardize or homogenize their experiences, the movements they experienced in their life stories and training, or their professional development. Acting in such a way would go against all the assumptions we made in the study. We emphasize that the experiences, career movements, and professional development of each teacher educator are unique, they happened and were experienced by each of the participants in her way.

Thus, it is not possible to generalize the results obtained in this study. Taking such a particular group of teacher educators as research participants, considering professional development as we did, and assuming the assumptions of narrative inquiry implies producing knowledge that does not work as a conclusion. As Clandinin and Connelly (2011) argue, the contribution of narrative inquiry is more in the context of presenting a new perception of meaning and relevance about the research topic than in disseminating a set of theoretical statements that will add to the knowledge of the area. Although we have built an understanding of the professional development experiences of Mathematics teacher trainers, the scope of the results presented here is limited. The participants' experiences, narrated in this text, and the interpretation of their professional development presented here record ways of being in the training of mathematics teachers that can offer different perspectives from those usually observed in relation to work, training, and what we understand by professionalism when we refer to the Higher Education teacher who works in the training of Mathematics teachers.

With the development of this study, in addition to broader questions that demand research programs be addressed — such as the definition of a knowledge base that provides an overview of the knowledge needed by a teacher educator and the constitution of a conceptual model about the professional development of teacher educators, for example — other questions arise as possible consequences of this study. In this sense, an extension of the research presented here could contemplate the practice of these educators to understand how the professional knowledge they constituted is mobilized in the training of Mathematics teachers. By the way, the practice of teacher educators in Mathematics remains an object to be understood from the point of view of academic research.

In addition, understanding the training and professional development of Mathematics teacher educators who do not work in Higher Education is still a task to be accomplished. Investigations involving educators who work in other institutional contexts may show, for example, influences of working with Mathematics Degree interns on the professional development and/or practices of Basic Education teachers who receive them in their classrooms or how teachers of Mathematics who work in the continuing education of teachers develop professionally. On the other hand, research on the professional development of educators who are teaching researchers and who are beginning to work in the training of Mathematics teachers can complement the results of this study, because it would enable to understand this process experienced by those who are entering the profession, a different point of view from the participants, as they lived this transition for some time and under different circumstances from the current context. Therefore, with the research presented, it was possible to see many understandings still to be established in relation to the teacher educator.

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DECLARATION OF CONFLICT OF INTEREST

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

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