Chapter 210

Mapping of the production of the graduate program in mathematics education of UFOP

https://doi.org/ 10.56238/devopinterscie-210

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ABSTRACT
Considering that the disciplines have a history, are constantly evolving, and, to remain, must be updated, this work is justified. Thus, it is presented, from a consistent perspective, a study of the History of Mathematics Education whose objective is to carry out a mapping, of the creation until 2019, of the production of the Graduate Program in Mathematics Education of the Federal University of Ouro Preto (**PPGEDMAT-UFOP),** that is, one hundred and fourteen dissertations and the corresponding educational products. For this, the researchers took as reference the areas established by the National Council for Scientific and Technological Development (CNPq) and then made refinements with categorizations, because, in History, the acts of separating and joining are the first steps for the production of documents. It was possible to point out a predominance of studies related to High School, the Final Years of Elementary School, and Higher Education (face-to-face). As for the themes, the predominance of Teacher Training in Mathematics, Geometry, and Modeling-Problem Solving, indicates a trend of research carried out or in progress. Therefore, the tables that gather data obtained complement the answers to the research question.

Keywords: Mapping, Professional Master's Degree, Mathematics Education, UFOP.

1 INTRODUCTION

The history of Mathematics Education constitutes a field of investigation

The creation of the *Topic Study Group: the history of Teaching and Learning* Mathematics, in 2004 at ICME 10 in Denmark, constitutes a milestone in the history of Mathematics Education as an international area of research (Valente, 2014).

An international journal was created, *The International Journal for the History of Mathematics Education*, which publishes [ended publication in 2016] the production in the area. And the *Conferences on the History of Mathematics Education* were also created in 2009 in Iceland and Lisbon in 2011 (Valente, 2014).

The History of Mathematics Education includes studies on mathematical culture and forms of appropriation of that culture; reforms in the teaching of Mathematics such as the Modern Mathematics Movement (MMM), school programs and textbooks of Mathematics for the various levels of education and eras; training of teachers of Mathematics and their school pedagogical practices and academic research practices in Mathematics Education among other related ones.

According to Foucault (1996) apud Barros (2011, p.266)

> a discipline [field of knowledge] is defined by a domain of objects, a set of methods, a *corpus* of propositions considered true, a game of rules and definitions, of techniques and instruments: all this constitutes a kind of anonymous system at the disposal of those who want or can use it (FOUCAULT, 1996. p.30)

Thus considered, there is a need for the formation of a scientific community shared by the various practitioners of the disciplinary field, insertion of the field in the scope of undergraduate courses, foundation, and maintenance of scientific journals specialized in the field, the constant occurrence of congresses attended by practitioners of the disciplinary field in question and creation of institutions that represent the professionals of the field of knowledge (BARROS, 2011; KILPATRICK, 1997).

In Brazil, establishing itself as a field of knowledge, the History of Mathematics Education constitutes a Working Group linked to the Brazilian Mathematical Society (SBEM), WG 15 – HISTORY OF MATHEMATICS EDUCATION created in 2016. There are journals specialized in the subject, such as the Journal of History of Mathematics Education (HISTEMAT) created in 2015.

Thus, scientific articles are published and presented in related congresses such as the Ibero-American Congress of History of Mathematics Education (CIHEM), whose first edition was held in 2011 at the University of Beira Interior, in the city of Covilhã, Portugal and had its fifth edition in 2019, in the city of Bogotá, Colombia (MENDES, 2019). These congresses enable and deepen the exchange between researchers and the production of knowledge related to the History of Mathematics Education in Latin America, Portugal, Mexico, and also Spain. Thus, research in the area has grown significantly in recent years, mirroring the various perspectives and methodologies that have been followed.

In Brazil, in addition to the meetings and seminars held by the research groups, the National Research Congresses on the History of Mathematics Education (ENAPHEM) are held. The first **ENAPHEM** took place in November 2012 in the city of Vitória da Conquista, Bahia, and the **fifth edition** of the event, V **ENAPHEM**, is scheduled for November 2020, at the Federal University of Rio Grande does Norte, in the city of Natal.

There is a publication of books such as the collection History of Mathematics for Educators, edited by Livraria Editora da Física and coordinated by researcher Iran Abreu Mendes, coordinator of several projects and writer of several works in the area.

Among other researchers who have stood out in Brazil, we can mention Wagner Rodrigues Valente, who coordinates several research projects, including international cooperation, writing and organizing books and congresses. The Research Group on the History of Mathematics Education in Brazil (GHEMAT) directed by him maintains a repository of digitized documents that can be consulted even through the internet, contributing to the growth of the number of researchers on the history of mathematics education that has grown a lot. On the other hand

> The writing of the history of mathematics education by mathematics educators requires them to make a shift: learn from contemporary historians how to produce history. And in this learning and use of the theoretical-methodological tools of historians, they create the possibility of elaborating new theoretical objects of research, opening possibilities for the constitution of a new field of investigation (VALENTE, 2014, p.104).

The research groups HIFEM, GHOEM, GHEMAT, and several others also already consolidated, have contributed with a large number of books, thesis productions, dissertations, scientific initiation works, and articles, which are presented in congresses and published in journals.

For Valente (2014, p.107) the works affiliated with this strand [History of Mathematics Education] consider mathematical knowledge, and its development over time, taking into account the issues related to teaching, as he questions how the school environment treats mathematical production (...).

The History of Mathematics Education is also inserted as a discipline of curricula of Degree Courses in Mathematics. And from the above, it is heading to or already constitutes a new field of investigation.

Professional Master's Degree and Mapping

In Brazil, at the beginning of the twenty-first century, the Professional Master's Degree was created, in which the dissertation gives rise to an educational product. Thus, there has been an impact on the production of scientific articles that disseminate different strategies and practices to qualify the teaching of Mathematics in both Basic Education and Higher Education. Research in Mathematics Education has grown significantly in recent years.

In this context, the Professional Master's Degree in Mathematics Education of UFOP was created**.** The one tested in 2007 by the Coordination for the Improvement of Higher Education Personnel (CAPES), began its activities with the first class in 2008 and, by the end of 2019, had already graduated one hundred and fourteen masters. The course is face-to-face, has activities held at the Morro do Cruzeiro campus, in Ouro Preto, and has been marked by the effort to combine training focused on *real* teaching practice with the training of the researcher, to offer the master's student tools and skills that allow him to reflect on his practice and the teaching practice in general, based on readings and studies that provide a solid theoretical foundation.

Because of the above, the question that provoked the elaboration of this theoretical mapping can be presented as follows: "What themes have been investigated in the Graduate Program in Mathematics Education of UFOP, giving rise to dissertations and educational products that seek to guide the teaching-learning processes of Mathematics in the training and teaching activity of Mathematics teachers?"

It is noteworthy that the educational product is, in general, a small book intended for teachers of Basic Education, future teachers and teachers of Higher Education, and teacher trainers, as a result of a Master's research. Usually presents a proposal for teaching or teacher training developed and analyzed by the master's student and the advisor. Therefore, it is part of the requirements to obtain the title of Master in Mathematics Education and is evaluated, on the day of the defense, by the examining board.

This mapping of the dissertations and, indirectly, of the corresponding educational products, to analyze the production of **PPGEDMAT-UFOP** from 2010 to 2019, began with the reading of the abstract and the objectives of each one, in the search for the most present and least explored themes and the level of education to which they are addressed. Thus, the suggestions for Basic Education, High School, and Higher Education were selected, including Mathematics Teacher Training, made, therefore, according to the researchers' view.

It is recalled that, although a field open to research was constituted, the Mathematics Education activities described did not motivate public policies. Thus, no scholarships were allocated for this type of Master's Degree and, in particular, for Mathematics Education. In addition, the salary of the students does not meet their needs, because, in general, they are laughable. In summary: the lack of financial aid has prevented many from participating in this type of graduate study.

Theoretical Framework

Research mapping is a systematic process of surveying and describing information about research produced in a specific field of study. In this case, Mathematics Education, in a certain space (PPGEDMAT-UFOP) and period (2010 to 2019). "It is more concerned with the descriptive aspects than with its results" (FIORENTINI, GRANDO, MISKULIN, CRECCI, LIMA, and COSTA, 2016, p.18).

Several authors have made mappings or studies of the *state-of-the-art* type related to some topic, to systematize the knowledge produced and elaborate an overview of the area. But this study, while using the same basic methodological concepts, has different goals.

Romanowski and Ens (2006), about mapping, highlight the contributions it guarantees, including this: "identify innovative experiences investigated that point out alternative solutions to the problems of practice and recognize the contributions of research in the constitution of proposals in the focused area" (ROMANOWSKI and ENS, 2006, p. 39).

An example of important mapping for Mathematics Education is the one presented by Fiorentini (1994), in his doctoral thesis, at the Faculty of Education of Unicamp, "Directions of Brazilian research in mathematics education: the case of scientific production in postgraduate courses". Megid Neto (1999), also in her doctoral thesis, analyzes trends in the production of science teaching in Brazil. Each of the works, highlights the title, author, advisor(s), year of defense, level of education, and content, among other aspects. Another example that should be cited is "Mathematical Modeling: mapping of dissertations and theses produced in graduate programs in the southern region of Brazil", by Bisognin and Bisognin (2017).

In 2009, Rosa presented an overview of the dissertations and theses defended in the Graduate Program in Mathematics Education of the Pontifical Catholic University of São Paulo (PUC): "Computational environments in the context of Geometry: an overview of theses and dissertations in the Mathematics Education Program of PUC-SP from 1994 to 2007".

Schmitt and Biembengut carried out the mapping of research on mathematical modeling on the world stage: analysis of the works in the 14th study group of the International Committee on Mathematics Education. And Biembengut (2008) identifies the consequences of mapping: "visualizing the scope of field research, identifying what could be raised, and recognizing what was practically impossible. And yet, by what means, by what means, by what means" (p. 83). Published in the magazine Bolema with the title "Research in Mathematical Modeling and different trends in Education and Mathematics Education", also Malheiros (2012) conducted a survey.

Thus, it is important to consider the following: "all disciplines are historical, in the sense that they were invented by human beings and need to be constantly reinvented to continue existing" (BARROS, 2011, p. 254). And the author states:

> there are innumerable dimensions reciprocally implied for the formation and continuity of a discipline: the production of theoretical and methodological instances, the constitution of a common language among its practitioners, the definition and constant redefinition of its objects of study, a singularity that differentiates them from other knowledge, a gradual internal complexity that ends up generating new modalities within the discipline, and, finally, the most important: the human network that constitutes this or that field of knowledge in particular (BARROS, 2011, p.254-265).

Thus, it is considered that the disciplines are specific fields of knowledge and cover various spheres of knowledge production or fields of practice. According to Barros (2011), they have their history, which, most of the time, is written by those who minister to them and who renew "their views on themselves".

Thus, this research is justified by the opportunity to investigate means and methods, to enable knowledge in new ways that help the teacher promote mathematics education. Therefore, it considers the need for alternative methods in the teaching-learning process in the field of Mathematics Education. It is necessary to write the history of how this has happened at UFOP.

Knowing what has already been produced contributes to identifying points that need deepening and can be a source of new research. As this field of study has expanded greatly in recent years, it becomes necessary to periodically review its production. In summary: as a contribution to the History of Mathematics Education, school pedagogical practices and academic research practices in Mathematics Education are analyzed.

Path Traveled

The study was conducted with materials collected on the PPGEDUMAT-UFOP website (http://ppgedmat.ufop.br). We considered the one hundred and fourteen dissertations defended from 2010 to 2019 and, indirectly, the one hundred and fourteen corresponding educational products produced. Initially, the abstracts were read to identify objectives and outline thematic axes organized according to trends, differences, and similarities and better understand the data.

This is an exploratory study based initially on the limits of titles and abstracts, which can inform a lot with each work, although in a simplified way. According to Guimarães (2005), the reading of the abstract

should facilitate the interpretation, and the apprehension of the content, regardless of the complete reading of the work.

Thus, bibliographic data were identified to map the production, which resulted in general cataloging: year of defense, title, author, and advisor. Due to space constraints, however, the corresponding table is not presented.

Subsequently, each abstract was read: "in the scientific context, the abstract occupies an important role for the dissemination of the knowledge produced, as well as acts as a privileged research instrument in different bibliographies and databases" (GUIMARÃES (2005, p.4).

Garrido (1993) considers that the summary should contain: the main research objective, methodology and techniques, subjects and methods of data processing; results and conclusions, and sometimes final recommendations. On the other hand, not every abstract brings - and in the same way - the conventions predicted by the genre. Some lack the conclusion; in others, the methodological path is missing. Even the style used can vary, with more presence of narration (MEGID NETO, 1999).

It is worth mentioning the following:

> A set of abstracts organized around a certain area of knowledge (Literacy, Reading, Teacher Training, Mathematics Education, for example) can tell us a History of your academic production. However, it is necessary to think that in this History some aspects of this production were considered and that in it there are certain limitations (MEGID, 1999, p.268).

Given the above, it was sought, in the reading of each abstract of these one hundred and fourteen dissertations, to identify the focus of the research, the objectives, the theoretical framework, the methodology, the research subjects, and the main results obtained. It is recalled that the abstract is a gateway to the knowledge of scientific works and, in a certain way, offers information about the characterization of the work, mentioning the theoretical framework that underlies it and explaining aspects related to the methodology of data collection and analysis.

It is important to highlight that it was a central issue to map the possibility of different tools that could be used by Mathematics teachers in different contexts, taking into account the particularities of the students, including cases of special needs.

Then, the data were categorized about the central theme and distributed in the form of tables and graphs for better visualization and subsequent analysis. "In this case, there is a certain comfort for the researcher, because he will deal with the objective and concrete data located in the bibliographical indications that refer to the research" (MEGID, 1999, p.265).

At first, for the intended mapping, it was thought to consider the large areas of CNPq and then make refinements with categorizations, because, in History, the acts of separating and joining are the first steps for the production of documents.

> In history, everything begins with the gesture of separating, of gathering. To transform into 'documents' certain objects are distributed in another way. This new cultural distribution is the first work. In reality, it consists in *producing* documents, for the simple fact of collecting, transcribing, or photographing these objects changing at the same time their place and their status. This gesture consists of "isolating" a body, as is done in physics, and in "disfiguring" things to constitute them as pieces that fill gaps in a set proposed a *priori* it forms the collection (CERTEAU, 2013, p.22 emphasis added).

With this, it was thought to catalog the dissertations according to the major areas of CNPq, that is, 1.01.01.00-4 **Algebra**, 1.01.02.00-0 **Analysis**, 1.01.03.00-7 **Geometry** and **Topology,** 1.02.00.00-2 **Probability and Statistics**. Then we tried to encompass them in the area 7.08.00.00-6 Education since the area Mathematics Education has not yet been cataloged by CNPq. Then we considered 7.08.03.00-5 **Educational Planning** and Evaluation, 7.08.03.03-0 **Evaluation of Educational Systems, Institutions, Plans and Programs**, 7.08.04.00-1 Teaching-Learning, 7.08.04.04-4 **Learning Assessment** and 7.08.05.00-8 **Curriculum**.

However, this categorization helped little in the making of the catalog for dissemination among teachers, because the large areas aggregate many subareas and the catalog could no longer contain something more specific that was being sought. For this reason, it was discarded.

It was also understood that other classifications could be made. For example: according to the axes considered by BNCC, that is, **Geometry Quantities and Measures, Statistics and Probability, Numbers and Operations, and Algebra and Functions**. But specific themes of Higher Education could be excluded.

Because these are dissertations carried out in the Professional Master's Degree in Mathematics Education, the categories of analysis Elementary School - **Initial Series, Elementary** School **- Final Series**, **Youth and Adult Education (EJA**), **High School**, and **Higher Education** were considered. Therefore, research that determines the performance of activities in the classroom (ways of teaching-learning topics of the content) and research that deals with the Training of Teachers of Mathematics (bibliographic research linked to fieldwork).

After reading the abstracts, the categorization was carried out, according to the classification declared by the author of the work. It is important to clarify that, due to the nature of Mathematics and Education, the content of dissertations and the level of education to which they are intended make them correspond to several categories. So it was always necessary to choose one. Then each one was mapped to verify the author's conceptions and contributions provided, highlighting different aspects. And considered as a foundation of a theory of learning. In addition, the corresponding objectives were described, although in some cases the author had not stated them.

Data Presentation and Analysis

The survey and analysis of the material allowed us to observe a diversity of themes, with looks at learning, teachers, the methodologies used in the teaching-learning process, and didactic materials. It is important to say that the teaching-learning of people with special needs is included.

These dissertations address, therefore, varied subjects, such as Algebra, Combinatorial Analysis, Probability and Statistics, Mathematical Analysis (Real), Differential and Integral Calculus, Derivative, Design, Distance Learning, Fraction Teaching, Teaching and Learning for people with special needs, Functions, Geometry, History of Mathematics, Inequations, Logarithm, Mathematics and Music, Financial Mathematics and Financial Education, Mathematical Modeling, Multiplication and Division, Proportion, Problem Solving, and other related matters.

Chart 1, below, presents the quantitative summary of the dissertations by year and by subject.

Table 1 – Distribution of Dissertations by year and by subject

	AL	EC	A N	AV	FO	FU	GE	MF	MO	RP	HI	ND	T
2010	1	1	3	1	4		4			1			15
2011	1	1	3		2		5		4	2			18
2012	1		2	1		1	3	1		1		1	11
2013	2	1	1		3	1	3		4		2		17
2014			4	1			3	2	1				11
2015	1	2	1			1	1		1	1		1	9
2016	2		1	1					1			2	7
2017					3		1	1	2				7
2018		2	2		1	1	1	1	1	1	1	1	12
2019		1	1					1		2		2	7
T	8	8	18	4	13	4	21	6	14	8	3	7	114

Source: survey data

Al-Algebra, CE-Combinatorics, and Statistics, AN-Mathematical Analysis, AV-Evaluation, FO-Training, Fu-Functions, GE-Geometry, MF-Financial Mathematics and Financial Education, MO-Mathematical Modeling, RP-Problem Solving, HI-History, and ND-Not defined

The Informational and Communication Technologies (ICT), in the teaching-learning process, as in Geometry, Differential Calculus, Real Analysis, and Trigonometry, were addressed in twenty dissertations. This is considered reasonable, given what society is experiencing at the moment, and of being a valuable instrument when combined with the teaching-learning process and research.

Most of the dissertations, that is, twenty-four, deal with Teacher Education, that is, teachers and researchers-teachers. Twenty-two deal with Mathematical Modeling and directly with Problem Solving, an important way to learn Mathematics. Twenty-one study Geometry, perhaps because of the resumption after the so-called *abandonment of Geometrics*. Some dissertations deal with Combinatorial Analysis and Probability and Statistics, Financial Mathematics and Financial Education, and directly with Functions, a subject that almost all included.

Thus, in an attempt to group dissertations with subjects intertwined with each other, a new categorization was carried out. Chart 2, below, presents the distribution by the categories considered.

Table 2- Number and percentage of dissertations by category

Category		%
1- Algebra and Functions	12	10,5
2- Combinatorics, Probability, and Statistical Analysis	8	7,0
3. Mathematical Analysis (Real) and Differential and Integral Calculus	18	15,5
4 . TeacherEmpowerment	24	21,1
5. Geometry	21	18.4
6. History of Mathematics	3	2,6
7. Financial Mathematics and Financial Education	6	5,3
8. Modeling and Problem-Solving	22	19.3
Total	114	100

Source: survey data

The categories Elementary School, High School, Higher Education, Continuing Education, and Uncertainty of the level of education were also considered. And the number per year of defense. This is shown in Table 3, below.

Table 3-Distribution of dissertations by the level of education and by year of defense

From 2010 to 2019		10	11	12	13	14	15	16	17	18	19	Total
Elementary School	Early years		1					1	1	1		4
	Final Years		3	3	6	4	6	2	1	2	2	29
	EJA	1					1			1		3
Middle school		7	5	4	3	1	1		3	3	3	30
Higher education	Classroom	4	6	3	4	5	1	1		3	2	29
	The Distance	1	2	1	1	1		1				7
Continuing Education								2	2			4
Blurring		2	1		3					2		8
Total		15	18	11	17	11	9	7	7	12	7	114

Source: survey data

Table 4, below, shows that the percentage of dissertations that deal with Elementary School (31.6%) is equal to that of those that deal with Higher Education. The percentage of those dealing with the Final Years of Elementary School and those dealing with Face-to-face Higher Education are the same (25.4%). The largest is of those that deal with high school (26.3%).

It is verified that, about Elementary School, the study directed to the Final Years is prioritized, which can be understood because it is a Master's Degree in Mathematics Education and not Pedagogy.

Table 4- Distribution of dissertations by the level of education

Elementary School	Early years	4	36	31,6%
	Final Years	29		
	EJA	3		
Middle school			30	26,3%
Higher education	Classroom	29	36	
	The Distance	7		31,6%
Continuing Education			4	3,5%
Blurring			8	7%
Total			114	100%

Source: survey data

It was observed the presence of four dissertations referring to the Early Years of Elementary School, is important due to the lack of research in Mathematics Education for this level of education. Previous teaching experience can therefore enrich the list of subjects dealt with.

In addition, several abstracts report innovative experiences as a result of a process of construction and experimentation in which the proposed pedagogical activities were conducted by the professor-researchers (master's students) in the classrooms. When research is allied to practice, there is an increase in the autonomy of the teacher and the production of knowledge about teaching. The master's student becomes a researcher of his practice and is led to change the reality he studies. He modifies: he has another understanding of the reality in which he acts.

The following are some of the objects of the study cited in the dissertations.

New methodologies and didactic proposals for teaching and analysis of their results in terms of improvements in student learning

The playful, methodologies for specific contents

Pedagogical workshops, thematic tracks, projects

Use of experimental activities in teaching

The historical approach of specific content in teaching

The conceptions and pedagogical practices of teachers

Work with projects and interdisciplinarity

Training of teachers working in elementary and secondary education

School and systems assessment

Problem-solving as a teaching strategy

The approach of mathematical concepts by deaf and blind students (in regular classes and specific schools)

Computerization in teaching

Use of playful (educational games)

Learning problems and difficulties

The affective dimension in learning

Social representations of content among teachers

The issue of error

Active methodologies

The dissertation that includes application in the classroom involves teaching-learning issues, with or without the aid of technological resources; the dissertation that deals with the theoretical aspect is based on documents, scientific articles, or surveys of dissertations and theses elaborated in graduate programs, but the use of ICT in Mathematics Education (ICT) is highlighted (twenty in one hundred and fourteen).

The identification of confluences between the dissertations shows that they are guided by the qualitative paradigm, with procedures of ethnographic/participant research or the Case Study. As for the

methodologies used, there is a Case Study, Grounded theory (grounded theory), Mixed Studies and others not cited by the authors.

In the production of data, interviews (structured and semi-structured), questionnaires (closed, open, and mixed), observation, audio and video recording, field diary annotation, pedagogical practice, participant observation, action research, and documentary research are used. Predictably, data analysis is used for the analysis of content, written production of students and teachers, speeches, and documents.

Different aspects are addressed, and the foundation is a learning theory. For each of these aspects, the objectives are identified, even if the author has not declared them. However, due to space limitations, they are not recorded in this article and may be included in future work.

2 FINAL CONSIDERATIONS

The dissertations produced within the scope of the Professional Master's Degree have contributed to disseminating different teaching strategies and practices to qualify the teaching of Mathematics in both Basic Education and Higher Education. This can be evidenced by the participation of teachers in the mini-courses offered every year by the masters in Mathematics Education of UFOP in the annual event promoted by PPGEDMAT, the Meeting of Teaching and Research in Mathematics Education (EEPEM), which is in the XII edition. And the result of the research carried out has been accepted for presentation in local, regional, national, and international events and publication in journals with good classification. Most of the graduates have studied or are studying for an academic doctorate in national and foreign universities.

As each dissertation was mapped, being verified the author's conceptions, there may be a subsidy for future research of students interested in the theme. Also to elaborate a catalog, because, for Gamboa (2007), research on scientific production intends to classify recent research, verify the type of research, the contents that are being developed, characteristics, usefulness, and other purposes.

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