Chapter 2
Colombia: Mathematics Education and the Preparation of Teachers. Consolidating a Professional and Scientific Field

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Abstract In this chapter a succinct panorama of some of the background, structure, development and limitations of the initial and continuing preparation of Mathematics teachers in Colombia is presented. Particularly, some aspects of the political, social and, in some cases, academic transformations that have affected Mathematics teacher preparation will be mentioned. Also, the current tendencies in initial and graduate education will be considered. Finally, we will indicate some achievements and current challenges facing research in Mathematics Education and teacher preparation that are facilitating a consolidation of this discipline as a professional and scientific field in the country.

Keywords Mathematics teacher preparation · Research in mathematics education · Mathematics teacher education · Colombia

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General Facts About Colombia

Colombia is a country situated in northwestern South America. Colombia is bordered on the east by Venezuela and Brazil, on the south by Peru and Ecuador, on the northwest by Panamá, also it is bordered on the north by the Atlantic Ocean and on the west by the Pacific Ocean.

Its area is 1,142,903 km^2, and a maritime area of 988,000 km^2. The country has a dispute on the boundaries with Venezuela and Nicaragua.

The Colombian population in 2015 was estimated at approximately 48 million living mainly in urban areas of the Andean region with a large concentration in Bogotá, its capital.

The official language is Spanish, but indigenous languages are also recognized. The predominant religion is Roman Catholic.

In 1499, Alonso de Ojeda, made the first expedition to the current Colombia, the first steps to the Spanish colonization. Colombia was inhabited by various indigenous groups like the Chibchas, Noanamaes, Emberás and Baudoes. Later, the declaration of independence was signed (1810), although this independence process would end with the Battle of Boyacá in 1819. These events were decisive for the beginning of the Republic of Colombia. Simón Bolívar and José María Córdoba were some of the most prominent figures in the struggle for independence.

Today, Colombia is a democratic state with public power divided into executive, legislative and judicial branches.

The culture is nuanced by Spanish, African and indigenous influences, and their syncretism is expressed through the art, music, literature, food and customs.

The official currency of the country is the Colombian peso. Its economy depends, among other things, on the production of primary goods for exploitation, production for domestic consumption, oil production and mining. Colombia is also recognized for floriculture, minerals (particularly emeralds) and the large amount of fresh water.

It also has beautiful natural places like the Sierra Nevada de Santa Marta, Sierra Nevada de Cocuy, Caño Cristal (also known as the River of 5 Colors), San Andrés Island, the Cerros de Mavecure, Tequendama Falls and the Colombian Amazon Forest.

The Education System in Colombia and School Mathematics

It is natural to assume that the education of teachers in a country should be aligned with its education system. Therefore we are obliged to begin with a consideration of that assertion. It is equally natural that the preparation of Mathematics teachers should be aligned with the nature and specificity of school Mathematics. Therefore, other themes that we treat below are justified.

Features of the Education System in Colombia

Before the end of the last century the enactment of the Constitution of 1991 changed the political and social dynamics of the Nation. Education was declared a social and cultural right, obligatory and free from pre-school through grade 9. Liberty in developing curricular approaches matched to the needs of their communities was proclaimed for the educational institutions serving those communities.

To develop what had been established in the Constitution, in 1992 Law 30 was enacted to regulate higher education and Law 115 (known as the General Law of Education) in 1994 to regulate elementary and secondary education. Law 115 restricts the functions of the National Ministry of Education (MEN) to formulating national curricular programs and grants it an orientation role with respect to public policy in education. Thusly, every educational institution in the country acquired the right to define its own curriculum which must be articulated with general guidelines formulated by the MEN as part of public education policy. Among the documents that regulate such policies with respect to school Mathematics are "Curricular Guidelines in the Area of School Mathematics" (Colombia 1998) and "Basic Competency Standards in Mathematics" (Colombia 2006).

The cited Laws establish, among other conditions, that education be organized by school levels and schooling cycles as is shown in Table 2.1.

Basic Education (Elementary and Secondary) is offered to almost all children, but there is a high dropout rate. There is both public and private Basic Education. The population from lower socio-economic levels usually attends public schools while private schools are attended by students from higher socio-economic levels. In general, the standard of quality is much higher in private education as compared to public.

Table 2.1 Organization by cycles and levels in the colombian education system

Level	Schooling cycle		Age of the students	Years of schooling
Preschool education	Preschool		Between 3 and 6 years	Up to 3 years
Basic education	Elementary		Between 7 and 11 years	1st to 5th grades
	Lower secondary		Between 12 and 15 years	6th to 9th grades
Upper secondary	Academic		Between 16 and 17 years	10th and 11th grades
	Technical			
Higher Education	Technological			3 years
	Professional			5 years
	Graduate	Specialization		Up to 2 years
		Master's		Up to 3 years
		Doctorate		Up to 5 years

Higher Education also has both public and private (not for profit) providers. Graduate education is not publicly financed; therefore, students of Specializations, Master's and Doctorates pay tuition to fund such programs. The technical education cycle is considered non-formal education, and is oriented to developing a series of workplace competencies for specific crafts and trades, and does not require that students have completed academic Upper Secondary Education. It is offered by both public and private organizations and is not considered to be Higher Education.

Mathematics in the School Curriculum

The First Inter-American Conference on Mathematics Education (Bogotá, December 4–9, 1961) was a milestone in the introduction of Modern Mathematics in Colombia. This movement declined in Colombia by the end of the 1970s, in part, for reasons associated with the educational model that it implied (e.g. behaviorism, management of the curriculum, production of educational materials, teacher preparation), and in part for difficulties with the abstract nature of the Mathematics itself as the basis for curricular reform (e.g. set theory, structure and modern algebra). With this decline, space was opened for a new reform that can be understood as the Colombian response to what is commonly referred to as the "Back to Basics Movement". This reform was supported by arguments taken from Piagetian theory and arguments against set theory as the curricular referent for school Mathematics. Instead, arguments supporting system theory[1] as the most appropriate curricular referent. Therefore, a solid psychological theory was used to explain the pedagogical processes that take place in the classroom. As a result of this reform, in the second half of the 1980s, the MEN promoted a new optional approach, that the Mathematics curriculum could be organized in relation to five mathematical systems (numerical systems, geometrical systems, measurement systems, data systems and logic systems), to which were added two topics (sets, and relations and functions). For each of those, details about contents, sequence, level of depth, interrelations and development of the focus were developed.

When the implementation of this approach had been in effect for only a few years, the country underwent a substantial change with the introduction of a new Constitution, which naturally affected the vision and implementation of education. In the development of this new political charter, laws[2] were established that defined the bases for educational transformation. One of the transformations implied the

[1]To provide language to unify the different branches of Mathematics and other sciences, the concept of "system" was proposed as the basis for organizing the curricular processes in Elementary and Secondary Education, emphasizing that the approach to any mathematical system should include at least three components: the concrete, the symbolic and the abstract. For details see Vasco (1994).

[2]Law of Higher Education or Law 30 in 1992, and the General Law of Education or Law 115 in 1994.

definition and adoption of Curricular Guidelines for Mathematics (Colombia 1998) that more than programs of study, constitute road maps that, respecting the cultural diversity consecrated in the Constitution, orient the efforts of educational institutions.

The Guidelines did incorporate some aspects of the previous reforms while proposing new theoretical and methodological elements in an attempt to update the curricular structure of school Mathematics. Among the elements are three that stand out. First, is the introduction of the different types of mathematical thinking[3] (numerical, spatial, measurement, variational, and random). Second, is the contexts in which school Mathematics should be developed (mathematical, daily life and from other sciences). Finally, there is the insistence on the importance of the development of processes (solving and posing of problems, reasoning, communication, modeling, and the elaboration, comparison and practicing of procedures). Together these permit the learning of Mathematics in contexts significant to students, using problem situations as the central axis for said contextualization.

Among the theoretical elements and methodologies of the Guidelines is the call for interdisciplinarity. This is not only from the perspective of teacher preparation, but in classroom practice given that in this document elements of teacher professional knowledge and ways that teachers work in the classroom are discussed. At one point in the document the MEN points out that "… the future teacher should receive a preparation intrinsically interdisciplinary that is distinct from what has happened in the past [that is], a conglomeration of courses that students must add up at their own risk" (Colombia 1998, p. 124). And a Calculus course, for example, is added which should include its history, its epistemology, and its teaching from a modern sense of how it should be the result of inquiry in interdisciplinary and even inter-institutional work groups.

Parallel with what is reported above, in the last twenty years the Colombian education system has had an ongoing series of discussions, shaped by educational policies, on the development of basic competencies[4] (focused primarily on competencies in Mathematics, Spanish language, and Natural and Social Sciences), (general and specific) workplace competencies,[5] and citizenship competencies,[6] These competencies seek to create an equilibrium between a solid academic preparation, and preparation for work and citizenship.

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[3]For a detailed synthesis see Obando (2004).

[4]Basic competencies seek to generate conceptual constructions and the capacity to utilize scientific and humanistic knowledge in processing, interpreting and solving problems related to the surroundings, school environment, and science and technology.

[5]Workplace competencies are oriented to the development of a set of knowledge and techniques that prepare the individual to be a productive member of society. The general competencies are cross-cutting and transferable to any context in which they are present in any academic or workplace activity. On the other hand, specific workplace competencies refer to particular contexts related to activities characteristic of a group of professions.

[6]Citizenship competencies refer to the development in the individual of a set of values, actions and behaviors needed by society, a critical and reflexive nature in facing situations that present themselves in the ongoing practice of citizenship, and an active participation in the life of the community.

In this competencies development framework, specifically for the case of education in Mathematics, early in the new century a document was published with basic competency Standards for Mathematics (Colombia 2006). In that document the concept of competency was presented broadly "as a set of socio-affective and psychomotor understandings, abilities, attitudes, knowledge and cognitive dispositions appropriately related among themselves to facilitate a flexible, effective and sensible performance when faced with new and challenging activities". In this sense, more than speaking of "mathematical competence", the idea of "mathematically competent" was proposed. Those responsible for the education system were invited to see Mathematics as a human activity inserted into, and the result of, cultural processes characteristic of the time and place. They were also invited to view Mathematics as the result of successive processes of reorganization of the practices of people in relation to the quality of their lives.

The term competency promulgated in the Standards document highlighted other dimensions associated with school Mathematics. In that sense, Valero (2006) points out that:

The adoption in Colombia of the language of mathematical competence emphasizes dimensions of Mathematics Education that had not necessarily been so explicit in the past. As Vasco (2005) noted, matters of quality and equity, of the social and cultural value of Mathematics, and its contribution to the development of citizens and the consolidation of democracy in the country are dimensions now being highlighted (p. 1).

Thus, the Standards (Colombia 2006) call for mathematical development to not consume itself with disciplinary contents, but instead that the school should be rehabilitated to offer an ideal mathematical development in the development of the citizen: A citizen is formed when Mathematics is learned. The notion of a mathematically competent citizen works on the least pragmatic dimensions in relation to the notion of competency (knowing what to do in a given context). This is done in pursuit of a more holistic perspective, where the focus is the understanding of Mathematics on the part of the individual. Hence, there is the development of a set of abilities, capacities, conceptualizations, forms of action, etc., that permit in-formed (formed from within) decision making with Mathematics and from Mathematics.

The Preparation of Mathematics Teachers in Colombia's Historical Context

The Initial Preparation of Mathematics Teachers

The design and functioning of Mathematics teacher preparation programs is a "Constitutional Right". In Colombia it is oriented by national regulations and interpreted by the Higher Education institutions in which such programs are developed under State supervision (Guacaneme et al. 2011). Despite this legal

condition, reality and tradition on occasion define a *de facto* policy that supersedes the "*legal policy*". It is precisely this condition that leads to the vision of the initial preparation of Mathematics teachers for lower and upper secondary education and for general teachers for elementary education that will be presented below. Later, additional considerations on initial preparation of Mathematics teachers will be presented.

Teacher Preparation for Lower and Upper Secondary Education

In the development of the current Constitution, enacted in 1991, laws[7] were established that define the bases for the transformation of initial and continuing teacher education. Thus, for example, these laws, their decrees and resolutions: delegate the academic and professional preparation of teachers to the universities and professional institutions of Higher Education, give the name "licentiate" to graduates of an undergraduate program in education who work professionally as teachers, define a Register of Teachers used to rank teachers according to their academic and professional background and experience, require that educator preparation programs should fulfill quality accreditation processes, and establish Mathematics as one of the nine required and fundamental areas of General and Upper Secondary Education.

It is precisely a look at the regulations of the last two decades that governed the preparation of teachers in Colombia (Guacaneme et al. 2011) that permits us to recognize, among others, the following descriptions and reflections.

An Intention to Move from an Emphasis on Mathematics Towards Mathematics Education

With the new century came a new directive that promoted moving from that which is discipline specific (i.e. Mathematics) towards Pedagogy, in the new Mathematics teacher preparation programs. This directive, combined with an intense academic dynamic in the Mathematics Education community in the 1990s, promoted the opening of important discussions on the teacher preparation curriculum guided by Mathematics Education discourse. This generated a certain "territorial rivalry" among those in charge of the mathematical preparation and those in charge of Mathematics pedagogical knowledge, in which general humanistic discourse was displaced or diminished. This place for Mathematics Education was nourished by curricular dispositions consecrated for the school Mathematics proposed by the

[7]Law 30 in1992, Law 115 in 1994 and Law 1188 in 2008 (also known as the registration of qualified Higher Education programs).

MEN (Colombia 1998, 2006). Thus, the *Curricular Guidelines* (Colombia 1998) declared that school Mathematics and Mathematics Education are disciplinary fields of the Mathematics teacher. It was established that the *Basic Competency Standards for Mathematics* (Colombia 2006) "…constitute a guide for: … the formulation of programs and projects, for the initial preparation of teachers, as well as for the evaluation of in-service teachers" (p. 11).

By the end of the first decade of this new century a new normative component, the introduction of the language of basic and professional competencies for teachers, was added that brought further tension to the duality in teacher preparation. It was intended to contribute to a clearer definition of the place that professional educators had in society and the contemporary requirements that were imposed upon them by society.

The Education of the Mathematics Teachers Depending upon the School Level in Which They Would Teach

Before the end of the last century new programs were established for the initial preparation of Mathematics teachers. A Bachelor's Degree in Basic Education with an Emphasis in Mathematics (LEBEM) was created for future teachers in elementary and lower secondary. For upper secondary, the program became a Bachelor's Degree in Mathematics (LM). Those new programs were based on the characterization, identification and differentiation of what was considered particular for teachers in each of those two levels.

Nevertheless, this transformation was not accompanied by a change in the culture of work in the educational institutions that hired the new graduates. Those with the Bachelor's Degree in Mathematics continue to be hired for both lower and upper secondary, and those with the Bachelor's Degree in Basic Education are hired to teach all subjects in elementary schools.

A Place for Research in Teacher Education

The Mathematics teacher preparation regulations express various positions with respect to the relation between research and teacher education. One of the regulations refers to the need for future teachers to receive preparation in research and consult state of the art Mathematics Education research. In another it is proclaimed that lines of research exist that support the relationship between teaching and research in preparation programs. In the *Guidelines* (Colombia 1998), research is conceived as "… the place from which knowledge in a disciplinary field is created. This part of professional preparation begins with Master's degrees and is consolidated in doctorates, where the scientific community of Mathematics educators is developed" (p. 125).

Given this multifaceted view, it is natural to present the relationship between research and teacher education as a theme or challenge that merits public reflection and discussion on the part of the Mathematics teacher education community in

order to come to agreements on how to realize what is proposed. This reflection must include the fact that elementary and secondary teachers, except in a very few cases, do not work in conditions in which it is possible for them to generate and develop research projects that might improve their teaching or their students learning.

The Need to Educate in and for the Use of Information and Communication Technologies (ICT)

Perhaps the first reference to the need to include aspects relative to the use of ICT can be found in the *Guidelines* (Colombia 1998). In that document there is a summary of the relationship between technology and curriculum, and a mention that the effective use of new technologies in education is a field that requires research, development and teacher preparation. To develop this idea, the MEN published a document specifically on the relationship between technology and curriculum (Castiblanco et al. 1999). It also supported a large project called "The Incorporation of New Technologies in the Mathematics Curriculum of Lower and Upper Secondary Education in Colombia" (Castiblanco et al. 2004). That project had various effects on initial Mathematics teacher preparation programs. Some preparation programs developed complementary activities to existing courses in which the importance and the possibilities of the incorporation of technology into educational environments were considered. Other programs incorporated courses on the use of technology either as a means of developing the learning necessary to be a teacher or as instruments to promote innovative student teaching experiences.

In the second decade of the century, the Bachelor's Degree programs are facing the challenge to develop basic competencies so that graduates will use information and communication media and technologies in responsible ways, and understand the opportunities, implications and risks in using them in collaborative work and in participation in virtual communities. Nevertheless, the curricular implications that this will have on initial Mathematics teacher preparation programs in not known.

The Quality Control Processes in Teacher Preparation Programs

During the 1990s the regulatory and institutional conditions were present for the creation of a *National System of Accreditation* (whose objective is to guarantee for society that the institutions that are part of the education system reach the highest levels of quality, and achieve their purposes and objectives). A *National Council of Accreditation* (CNA) was also created and was made up of, among others, the academic and scientific communities. Thus, at that time all teacher preparation programs had to be approved by the State with respect to their quality based on an evaluation process carried out by the institution itself (using a self-evaluation process), the academic communities (using a process of peer evaluation) and the CNA.

These accreditation processes for initial teacher preparation programs on behalf of the State began simultaneously with the offering of the new programs at the

beginning of the century. They have aided in the development of a new learning environment by many teacher educators who have incorporated the design and implementation of self-evaluation processes into their teaching practice as a guarantee of program quality.

Teacher Preparation for Elementary Education

Historically, the Normal Schools had the responsibility to prepare teachers to orient educational processes (not only in Mathematics) for children in Elementary Education and, fundamentally, education at that level in rural areas. This responsibility dates from the 19th century, with the construction of the first Normal Schools for teacher preparation (Normal Schools for Males) that were charged with bringing basic literacy to the children of the country, particularly in rural areas.

Throughout their nearly two centuries of existence, the Normal Schools experienced various changes that were basically changes in educational public policy. Among the most important milestones were: (i) the moment, in the middle of the 19th century, when Normal Schools were recognized as institutions of pedagogical knowledge; (ii) in the second half of the 19th century, at which time the first Normal Schools for Females were created; (iii) the beginning of the 20th century, a time in which it was recognized that there was a need for a rural preparation for the populations living in the countryside, and an industrial and commercial preparation for those living in the cities, and, as a consequence, such preparation was considered in the Normal Schools, and Rural Normal Schools were created that were charged with preparing teachers for rural elementary schools; (iv) the emergence of the first Faculties of Education in country's universities, some of which were the result of the transformation of existing Normal Schools,[8] and the consequent limiting of the role of Normal Schools to the preparation of teachers for Elementary Schools; (v) the reconfiguration, at the end of the 20th century, of the Normal Schools into Upper Normal Schools, with the charge to prepare Preschool and Elementary teachers; (vi) the creation, at the beginning of the new century, of programs to prepare teachers for Upper Secondary schools offered by Upper Normal Schools in collaboration with universities that have Faculties of Education, and with the objective of promoting a more profound knowledge of an area that had been part of Elementary Education[9]; (vii) by the end of the first decade of the

[8]Thus the Feminine Pedagogical Institute in Bogotá, became the National Pedagogical University in Bogotá, and the Male Normal School in Tunja became the Pedagogical and Technological University in Tunja.

[9]Along these lines, and for a few years, some universities that offer programs for the initial preparation of Mathematics teachers supported the creation of programs for Upper Secondary Mathematics in Normal Schools whose graduates were then given a Bachelor's Degree by the university.

century, the agreements between the Normal Schools and the universities concerning Upper Secondary Education had been dismantled so that universities are no longer collaborating with the Upper Normal Schools so that the preparation of elementary teachers is much like the preparation in technical schools.

Additional Considerations

The Structure of Mathematics Teacher Preparation in Colombia

Near the end of the last century a policy on the structure of professional knowledge for teaching (Decree 272 of 1998) proposed that there are four nuclei of pedagogical knowledge (educability, teachability, the historical and epistemological structure of pedagogy, and social and educational realities). The curricular approaches for the initial preparation of Mathematics teachers in various programs were molded from those nuclei. Nevertheless, in 2008 it was recognized that those nuclei did not offer a satisfactory referent into which the educational reflections and actions of teachers could be fully and coherently situated (Bautista and Salazar 2008).

This is verified by identifying that the majority of initial teacher preparation programs contain a structure in which one usually finds Mathematics courses, courses on curricular knowledge and knowledge about teaching mathematical content (in which practical knowledge is included), courses that develop general pedagogical knowledge, and courses centered on aspects of communication (reading, writing and speaking). Eventually, there may also be Physics or Computer Science courses; this in programs that are preparing teachers for Mathematics and another discipline.

In general terms, for example, the Mathematics courses include Calculus, Arithmetic and Algebra, Geometry, and Probability and Statistics. The course(s) on curricular knowledge and knowledge about teaching may include a consideration of the thinking or mathematical systems presented in the *Guidelines* and *Curricular Standards* (Colombia 1998, 2006). Another possibility is courses that take a look at research in Mathematics Education.

Recruiting Students for Initial Teacher Preparation Programs

Graduates from Upper Secondary Schools have a wide variety of Higher Education programs to choose from (in both public and private institutions). Among the options offered by the universities are programs in initial Mathematics teacher preparation for Elementary, Lower Secondary or Upper Secondary levels. Thus, unlike some other countries, Colombia does not require that future teachers complete a degree before entering teacher preparation programs (for example, a

Bachelor's Degree in Pure Mathematics). That is, preparation as a Mathematics teacher constitutes professional preparation.

Thus, students who enter a Bachelor's Degree program know from the beginning that they are being educated to be Mathematics teachers. However, it must be recognized that for some students becoming a teacher is not their first career choice. Some accept admission into teacher education programs in the hope that later they will be able to transfer to a program with higher social status (e.g. engineering). Some with such intentions, change their minds and remain in teacher education. It must also be recognized that Mathematics teacher preparation programs do not have a particularly high demand, despite the fact that there is a need for more Mathematics teachers.[10]

Finally, another point to be made is that the students in teacher education programs do not have the highest scores on the admissions tests used by the universities. Perhaps that is why the government has launched a program of funding undergraduate studies for students who will enter initial teacher preparation programs.

Face-to-Face Instruction as the Main Mode of Delivery

Upon observing the national panorama of initial teacher preparation programs it is obvious that the majority of them are face-to-face. There a very few programs offered at a distance. This means that the preparation of teachers is carried out mainly in universities in large cities or in regional branches of those universities.

The Continuing Development of Mathematics Teachers

The continuing preparation of Mathematics teachers has at least two modalities: diplomas or permanent teacher development programs, and advanced preparation. Below, an analysis of graduate academic programs (advanced preparation) that currently have a significant impact on teacher development is presented.

Specialization Programs

Castrillón and Solis (2009) reported on 36 academic programs (12 % of the total) that had an area of specialization in Mathematics Education, Mathematics or Physics. They also pointed out that a hybrid or blended model of face-to-face and

[10]One indication of the need for Mathematics teachers is that the great majority of students in the last semesters of the Mathematics teacher preparation programs have already been hired by private schools before they graduate.

distance was more common that simply face-to-face. Currently there are ten programs for specialization in Mathematics Education and all but one are face-to-face. They last between two and three semesters and generally focus on the professional practice of in-service teachers. Nine of them include courses in Mathematics.

The reduction in the number is mainly explained by the fact that in the last decade the specialization programs, related to the preparation of Mathematics teachers, have been developed under a tension generated by the implementation of the Teacher Statute (Laws 1278 of 2002 and its regulatory decrees). These regulations, among other matters, govern the academic careers of teachers in the public sector, including conditions to ascend on the salary scale. One of its conditions limited the possibilities of ascending via the title of specialization and incentivized preparation at the Master's and doctoral levels. The reduction can also be explained in terms of a State policy that encouraged the creation of Master's degrees focused on teaching rather than on research.

Master's Degree Programs in Education

Castrillón and Solís (2009) identified 79 Master's Degree programs concentrated in five cities: Bogotá, Medellín, Manizales, Cali and Bucaramanga. Of this total only 10 (13 %) offer Mathematics Education.

It should be emphasized that academic programs at the graduate level are subject to national regulations. The regulations establish the goals of specialization, Master's and doctoral programs; present some of the features of such academic programs; and indicate that Master's Degree programs shall have two modalities: one focused on teaching and the other on research.

When the institutional contexts in which the programs are developed and the curricular structures that they propose are examined, it is possible to identify at least three types of programs:

- Those that arise in Faculties or Institutes of Education. Their common component is philosophical, pedagogical and educational development, articulated with a conceptual and research-based foundation in Mathematics Education. That foundation is in turn based on Didactics of Mathematics with the historical-epistemological, sociocultural and cognitive characteristics. These are much like what is often called a Master's in Education with an Emphasis in Mathematics Education.
- Programs that emerge in Faculties or Departments of Science. These programs have as their main reference a disciplinary preparation in Mathematics. That disciplinary preparation is articulated with a foundation in relation to education, teaching and curriculum, as well as research. This type of program has some of the features of a Master's in Mathematics Teaching.

- Those whose curricular structure is organized in relation to the foundations of Mathematics Education as a field of research. They establish their curricular focus in the foundations of Didactics of Mathematics, cognition, curriculum, a sociocultural focus and evaluation, all articulated with a research component. These can be called Master's in Mathematics Education.

The development of academic Master's Degree programs has also generated changes in some universities. While some have opted to replacement specialization programs with Master's focused on teaching, others have decided to preserve the specialization programs articulated with Master's programs or conserve/promote the research Master's. There is obviously an absence of a general structure for the functioning of teacher preparation programs at the graduate level.

Also, the academic community of Mathematics educators, has been moving forward with a broad debate on the meanings, scope and limitations in the implementation of Master's programs focused on teaching. Indeed, in so far as these programs have among their purposes the improvement of the professional practices of Mathematics teachers and their research component mobilizes the *praxis* in relation to their teaching practices, research groups are faced with the need to structure theoretical and methodological approaches that address the practice of teaching and the professional development of teachers of Mathematics.

Doctoral Programs

The country recognizes four doctoral programs in Education and Social Sciences:

- The Inter-Institutional Doctorate in Education[11] with an Emphasis in Mathematics Education with various lines of research: History and Epistemology of Mathematics, Language and Mathematical Reasoning in the Classroom, Language and Mathematics Didactics, Semiotic Processes in Geometry, the Transition from Arithmetic to Algebra, and Mathematics Didactics.
- The Rudecolombia[12] doctorate. This program has an emphasis in Teaching of Sciences and a course in Mathematics Education at the University of Quindío.
- The Doctorate in Education with an Emphasis in Mathematics Teaching at the University of Antioquia, in which there are emphases in Statistical Education and socio-cultural perspectives on Mathematics Education, among others.
- The Doctorate in Social Sciences, Childhood and Youth (not specifically Education), offered by the University of Manizales and CINDE, in which there have been dissertations on Mathematics Education.

[11]A program developed by the University of Valle, the National Pedagogical University, and the District University "Francisco José de Caldas".

[12]A network made up of the universities of Atlántico, Cartagena, Cauca, Caldas, Magdalena, Nariño, Quindío, Tolima, the Technological of Pereira, and the Pedagogical and Technological of Colombia.

The Diversity of Approaches

A look at the graduate programs related to the preparation of teachers of Mathematics in Colombia must recognize the diversity of their curricular structures, research components, and treatments of theory and practice. This diversity also reveals an absence of a system of advanced preparation of teachers that articulates the various levels of preparation, allows students to circulate easily through the system, and facilitates professor and student exchanges.

An examination of the activities of the research groups that support the preparation programs at various levels reveals the following areas that can be highlighted as possible descriptors of their work and a further indication of the diversity: Didactics and Pedagogy, Cognition and Evaluation of Competencies, Information and Communication Technologies, Mathematics Education, History, Epistemology, and Philosophy of Mathematics and of Mathematics Education.

The elements expressed above highlight the features of an academic community that is still in a process of formation and expansion. If the goal is to create a national identity in the advanced preparation of teachers of Mathematics, it is necessary to strengthen the intra/inter research groups that support the preparation programs at various levels, reconsidering the sense and scope of collaborative work. To do so, strategies aimed at strengthening the configuration of networks of researchers in the field and networks of teacher preparation programs must be implemented. Perhaps this strategy will support the qualitative improvement of initial and continuing teacher preparation. That is the challenge for the next few years.

Some Mathematics Education Achievements and Challenges in Colombia

Without a doubt, currently in Colombia, Mathematics Education is a developing discipline and an academic enterprise or life project of many academics. Evidence of its status can be found in the configuration of the academic community, in the recognition that its preparation programs and academics receive, and in certain actions of the State.

Indeed, as is expressed by Guacaneme and colleagues (Guacaneme et al. 2013), since the 1980s various groups dedicated to Mathematics Education have been formed in Colombia. Today they are visible on the *Scienti Platform* of the Colombian Institute for the Development of Science, Technology and Innovation (COLCIENCIAS). Equally important in the development of the community has been the emergence and the consolidation of the Colombian Mathematics Education Association (ASOCOLME). Along with ASOCOLME other communities and networks have emerged that have helped in the consolidation of various aspects of Mathematics Education. These groups include the Latin American Ethnomathematics Network (RELAET), the Colombian Network for Modeling in

Mathematics Education (RECOMEM) and the Colombian Network of Mathematics Teacher Educators. The strengthening of various national Mathematics Education events and the growing participation of Colombian researchers and professors in international events are further evidence of the state of development of the national academic community.

In the last decade the programs for initial and advanced teacher preparation have been subject to processes of self-evaluation and accreditation that have revealed their actual states of development. They have permitted an important recognition of the national community as it initiates its projection onto the Latin American scene. Equally, Colombian researchers in Mathematics Education have increased in number and have improved in preparation. Recently, the National Pedagogical University and ASOCOLME prepared a directory of individuals with doctorates in Mathematics Education. The list numbers almost 60,[13] the majority of whom carry out research in the country or are linked to it.

In a natural way the consolidation of the community is reflected in the number of research studies and publications in Mathematics Education. It is very probable that this growth is also due to the self-recognition by Colombians of the quality of their academic activity and the need to see their results.

Another aspect that has been influencing the consolidation of Mathematics Education in a positive way are government programs that support the continuing and advanced preparation of teachers. Indeed, in some regions of the country, although only a few, the governments have addressed education as a fundamental aspect of their policies and have implemented actions so that teachers, including those in Mathematics, can have access to graduate programs in Education. In a similar way, the MEN has developed processes to support the improvement of initial teacher preparation programs through actions that involve academic peers in outstanding programs.

The extent to which Mathematics Education as a discipline in Colombia is institutionalized, as is evidenced above, seems to continue to be insufficient to attend to all the needs for Mathematics teacher preparation particularly for professional development in their "local realities" and not just to improve the scores that their students receive on standardized tests. What is needed then is a *national policy on teacher preparation* that goes beyond getting teacher "buy in" with respect to the curricular orientations promoted by the MEN. Instead, it must transcend to teacher preparation that permits them to understand in situ the role of Mathematics in a comprehension of school contexts and to support the development of more mathematically competent students. The policy must give teachers a professional and academic status in Mathematics Education. That is, the professional participates actively in the mathematical cultural of Colombian society to benefit the construction of human values that transcend disciplines and knowledge.

[13]This number, still insufficient, is much great than the three who graduated before 1990.

Final Considerations

In accordance with what has been argued by Guacaneme et al. (2013), the current structure of the Colombian education system, and, hence, school Mathematics preparation, has been the product of political, social and academic transformations. As a consequence, the role of the MEN has evolved from being a "regulator" of contents, to a generator of dispositions and orientations that support school autonomy with respect to curricular organization. In general, the education system has passed from the ideal of basic literacy to the ideal of preparing a citizen with capacities and competencies oriented to both knowing and doing. Coherent with that, more autonomy has been given to the institutions that prepare teachers so that they can provide actions that permit teachers to understand their roles as social and knowledge agents of the future generations. Nevertheless, more research is still necessary to provide evidence as to the ways that these institutions can come closer to reaching their goals.

As Agudelo-Valderrama (2006, 2008) suggests, there exists among Colombian Mathematics teachers, a certain resistance to develop practices in their classrooms that are articulated with the results of national and international research. She therefore suggests that Mathematics teacher preparation institutions should put into practice strategies that position change as an active factor. Thereby, teachers should question their conceptions of mathematical knowledge, their school practices, but above all, their roles as social agents in their communities.

According to what has been presented in this document, there seems to be a consensus among the majority of the institutions that prepare Mathematics teachers that it is through a strategy centered on preparation in/from research that future Mathematics teachers will be able to generate continuous knowledge on the realities in which they work. However, there is still not sufficient evidence about how this strategy has impacted school realities, the mathematical practices in classrooms. Particularly given that in school contexts there are usually insufficient conditions to do research, and that even those who do manage to do research do not receive adequate recognition within the current rewards structure. Faced with this reality, new questions emerge concerning the relationship between teaching and research, and the way to guide research by in-service and pre-service teachers.

Finally, it is worth mentioning that currently both the MEN and the Ministry of Communications have indicated a way to get technology to highlight competencies and ways that any teacher can integrate the technology. Thus it is hoped that integration of technology in the classroom will lead to innovation. However, these actions by the ministries apparently have been undertaken without knowledge of the research that has been done on the configuration of networks and innovations by various groups and institutions concerned with the teaching of Mathematics. A space must be opened to do interdisciplinary research on the integration of technology into the teaching and learning of Mathematics, and networking strategies must be strengthened.

Appendix: Meanings of Acronyms

ASOCOLME	Colombian Mathematics Education Association
ACOFACIEN	Colombian Association of Faculties of Science
ASCOFADE	Colombian Association of Faculties of Education
BID	Inter-American Development Bank
CENDOPU Univalle	Documentation Center, University of Valle
CESU	National Council of Higher Education
CIAEM (ME)	Inter-American Committee on Mathematics Education
CINDE	International Center for Education and Human Development Foundation
CNA	National Council of Accreditation
COLCIENCIAS	Colombian Institute for the Development of Science, Technology and Innovation
ERM	Regional School of Mathematics
LEBEM	Bachelor's Degree in Elementary Education with an Emphasis in Math
LM	Bachelor's Degree in Mathematics
MEN	National Ministry of Education
MTIC	Media and Technologies for Information and Communication
RECOMEM	Colombian Network for Modeling in Mathematics Education
RELAT	Latin American Ethnomathematics Network
SCM	Colombian Mathematics Society

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