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Mathematics Teacher Preparation in Central America and the Caribbean

The Cases of Colombia, Costa Rica, the Dominican Republic and Venezuela

International Commission on Mathematical Instruction

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Foreword

The International Commission on Mathematical Instruction (ICMI) has a substantive interest in ensuring that its resources and influence extend to any country that is able to mobilize the elements of its mathematics education enterprise to make productive use of this connection. In line with this goal, ICMI in conjunction with the International Mathematical Union (IMU), and with the support of UNESCO and ICSU (International Council for Science), promotes the Capacity & Networking Project (CANP). It aims to enhance mathematics education in developing countries by supporting the educational capacity of those responsible for mathematics teachers, and to create sustained regional networks of teachers, mathematics educators and mathematicians, linking them to international support.

CANP consists of a program that is being carried out since 2011 in different developing world regions: each program has, at its center, a two-week workshop of about forty participants, half from the host country and half from regional neighbors, who interact with experts in mathematics, math education, and school policy coming from different parts of the world. It is primarily aimed at mathematics teacher educators, but each event includes also mathematicians, researchers, policymakers, and key teachers.

The Capacity & Networking Project is a major international initiative in the mathematical sciences in the developing world to help exchange information, share the state of the art research, enhance mathematics education and build a sustainable network for policymakers, scholars and practitioners across those targeted regions.

The program builds on existing activities in the region and does not seek to reproduce or compete with existing development programs.

At the moment when this book is printed (2016) five CANP workshops have been held: CANP-1 in sub-Saharan Africa (2011), CANP-2 in Central America and Caribbean Area (2012), CANP-3 in South East Asia (2013), CANP-4 in East Africa (2014), CANP-5 in Andean Region and Paraguay (2016).

The main goal of a CANP consists in building capacity in mathematics education and creating a sustainable regional network in the countries, which participate to the workshop, with a common goal of improving mathematics education in

the region. The initial two-week workshop is an occasion for launching the network and for collecting and sharing information about the situation of mathematics teaching in the region. For this, before the workshop each group of participants from a country prepares a report about the state of the art in their own country: the reports are presented, compared and discussed during the meeting. After that, they are further elaborated according the results of the discussions and constitute a final report for that CANP.

They constitute interesting documents about mathematics education in the regions touched by the different CANPs, and give a piece of information not always accessible in an easy way. For this reason ICMI decided to launch a new series of books with an international publisher, Springer, in order to make accessible non-expensive format reports to an international audience of informed policy-makers and scientists.

The present volume is the second in the series of CANPs reports: it is the result of a huge work of elaboration of the original documents presented in Spanish at CANP-2 workshop, held from August 6 to 17, 2012 in San José, Costa Rica. The event involved 66 participants from Central America and the Caribbean Region and concerned the initial and continuing formation of mathematics teachers in those countries. It was organized in a splendid way thanks to the wonderful work both of the International Program Committee, and of the Local Organising Committee, and especially of Angel Ruiz, vice-president of ICMI: as liaison person with ICMI he participated to the scientific design of this CANP and with his team took care of all its organizational aspects. In fact CANP-2 included lectures given by outstanding mathematicians and math educators, regional presentations, workshops, round-table discussions, panel presentations, and other parallel activities. Many hours were devoted to the discussion of the regional reports, which are the germs from which this book was originated, and to the creation of a Mathematics Education Network (REDUMATE: Red de Educación Matemática de América Central y El Caribe—www.redumate.org).

Angel Ruiz is also the editor of the volume: with all the other authors, he made a huge effort to have the different articles written in a suitable and uniform way. They illustrate in an updated form the initial and continuing preparation of mathematics teachers in Colombia, Costa Rica, Dominican Republic, and Venezuela.

I thank all those who have made possible the existence of this book: the editors, the authors, the excellent translator of the reports from Spanish, Patrick (Rick) Scott, the publisher, and particularly the participants to the CANP-2 event and to its follow-ups. I do think that making accessible its content to math educators, teachers, and policymakers also outside Latin America represents a useful tool for approaching the problems of mathematics education within a global landscape, but without forgetting the specific cultural and social needs of specific developing regions, in this case Central America and Caribbean area.

It is my strong hope that with the publication of these CANP books, we will have a wide updated picture of mathematics education needs and problems from relevant parts of the developing world. This will help to avoid the dangers of the alienation generated by the loss of the variety of cultural richness existing in the different regions of the world.

Torino
September 2016

Ferdinando Arzarello
President of the International
Commission on Mathematical Instruction

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Patrick (Rick) Scott, Vice President of the Inter-American Committee on Mathematics Education. He produced the English translation of the different sections and chapters of the book.

Jhony A. Villa-Ochoa (Colombia) and Edison de Faria (Costa Rica). They carried out the first review and editing process of the national reports from the four countries that are the base of this book.

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Mathematics Education Network for Central America and the Caribbean (REDUMATE). These chapters were possible by the support provided by this new organization that emerged from CANP 2.

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Cuadernos de Investigación y Formación en Educación Matemática (Journal of Research and Teacher Preparation in Mathematics Education). Center of Research and Teacher Preparation in Mathematics Education, University of Costa Rica. It published the original national reports (written in Spanish) that emerged from CANP 2.

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About the Translator

Patrick (Rick) Scott retired from the College of Education at New Mexico State University in 2006 where he had been Professor of Bilingual Mathematics Education. He then became the first Manager of the New Mexico Public Education Department's Mathematics and Science Bureau. He is Vice Chair of the U.S. National Academy of Science's Board of International Scientific Organizations, Past-Chair of the U.S. National Commission on Mathematics Instruction, Vice President of the Inter-American Committee on Mathematics Education, and International Representative of the National Council of Teachers of Mathematics. He has an EdD in Mathematics Education from Columbia University and a B.S. in Mathematics from Stanford University. He has published dozens of articles, books and reports in English and Spanish.

Chapter 1
Mathematics Teacher Preparation in Central America and the Caribbean. An Introduction

Angel Ruiz

Abstract This chapter provides a summary of the state of Mathematics teacher's preparation in Central America and the Caribbean based on four papers presented at a workshop of the International Commission on Mathematical Instruction: Capacity and Networking Project, held in Costa Rica in August 2012. The countries considered here are Colombia, Costa Rica, Dominican Republic and Venezuela. First, a description of the conditions of this region in various international comparative tests of Mathematics is established, as a prelude to offer elements of each country about the general structure of their education systems and the main features of their curricula in school Mathematics; then the initial preparation and professional development of teachers are studied. Finally, graduate programs and research in Mathematics Education are analyzed and, to conclude, the main challenges that these countries face in the current scenario are indicated. Throughout all this work, comparative elements between the four countries are given in the dimensions studied.

Keywords Teacher preparation · Mathematics · Mathematics education · Central America · The Caribbean

The second workshop of the Capacity and Networking Project (CANP 2) of the International Commission on Mathematical Instruction (ICMI—www.mathunion.org/icmi/home) was held in San José, Costa Rica from August 6 to 17, 2012. This event brought together mathematics educators, mathematicians, university administrators, and elementary and secondary teachers from Central American and the Caribbean. Financial support was received from the International Mathematical Union (IMU) and from the International Council for Science (ICSU). It was organized with assistance from the Inter-American Committee on Mathematics

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Education—IACME (the multinational affiliate of ICMI in the Americas, www.ciaem-iacme.org.). Local arrangements were the responsibility of Mathematics Education Reform in Costa Rica Project (www.reformamatematica.net). The creation of the Mathematics Education Network (REDUMATE—www.redumate.org)[1] was one of the most important outcomes of the event.

National reports on the status of initial and continuing mathematics teacher preparation were presented during the event. These national reports became important references in establishing collaborative actions related to the teaching and learning of mathematics in the region.[2] This book presents summaries of the reports: a synthesis of initial and continuing preparation for the teaching of mathematics in Colombia, Costa Rica, the Dominican Republic and Venezuela. These reports have served as a starting point for comparative analyses, showing similarities and differences while highlighting the various perspectives.

The reports consider various dimensions:

1. The structure of the educational systems.
2. The school curriculum for mathematics.
3. Initial teacher preparation.
4. The professional development programs for in-service teachers.
5. Graduate programs.
6. Research in mathematics education.

To assist the reader, some sketches of these dimensions that will be further developed below are presented. But to begin, it is convenient to offer an orientation to the region.

Central America and the Caribbean

The countries of this region of Latin America have certain characteristics in common: all are part of the Caribbean Basin; there is a shared European heritage (predominantly Hispanic) with ethnic and cultural contributions from pre-Colombian, African and Asian communities; educational achievement is not reaching the levels needed to meet development goals; there are often conditions of poverty that are among the highest in the Americas (Fig. 1.1).

The situation with respect to the teaching and learning of mathematics in Central America and the Caribbean should be considered in a larger context. One image of its reality is provided by international comparative testing.

[1] A study on these and other multinational mathematics education organizations can be found in Ruiz (2013).

[2] The complete national reports were published in Spanish in the journal *Cuadernos de Investigación y Formación en Educación Matemática* published in Costa Rica (Mathematics Education Reports 2013).

Fig. 1.1 Central America and the Caribbean. *Source* Free vector map of Middle America political with shaded relief. http://www.onestopmap.com

The achievement in Latin America on PISA, the international assessment from the Organization of Economic Cooperation and Development (OECD) (that is given to 15 year-old students) is systematically among the lowest of participating countries. The following table shows the 15 countries with the lowest scores on the 2012 PISA mathematics test. More than half of them are from Latin America (Table 1.1).

The average scores for countries participating from Latin America was approximately 397, almost 100 points lower than the OECD average and 215 points lower than Shanghai. Fully 63 % of Latin American youth scored under Level 2, which is considered to be the level necessary to function adequately in the modern world in which we are living (and that is 40 % more than was the OECD average). Less than 1 % scored at the highest two levels. Even if you do not accept all of the criteria and methodology used by PISA, these results show very weak achievement in school mathematics which presents these countries with the need to design very serious actions to improve education. Also, within the region there are significant differences, for examples there is a 55-point difference between the highest (Chile) and the lowest (Perú).

There has also been an effort on the part of UNESCO's *Latin American Laboratory on the Evaluation of the Quality of Education* to measure achievement in the third and sixth grades in schools in the region. Their two latest studies have been the "Second Regional Comparative and Explanatory Study" (SERCE) in 2006

Table 1.1 The 15 countries with the lowest achievement levels on PISA 2012

Country	Average score on PISA 2012	Percentage of students with the lowest scores (lower than level 2) (%)	Percentage of students with high scores (level 5 or 6) (%)
Chile[a]	423	52	1.6
Malaysia	421	52	1.3
México[a]	413	55	0.6
Montenegro	410	57	1.0
Uruguay[a]	409	56	1.4
Costa Rica[a]	407	60	0.6
Albania	394	61	0.8
Brazil[a]	391	68	0.8
Argentina[a]	388	67	0.3
Tunisia	388	68	0.8
Jordan	386	69	0.6
Colombia[a]	376	74	0.3
Qatar	376	70	2.0
Indonesia	375	76	0.3
Perú[a]	368	75	0.6
Average for the Latin American countries	**397**	**63**	**0.8**
OECD average	**494**	**23**	**12.6**
Shanghai-China	**613**	**4**	**55.4**

[a]Latin America. Many nations in this region did not participate, including the Dominican Republic and Venezuela
Source OECD (2014)

and the Third Regional Comparative and Explanatory Study" (TERCE) in 2013. Some results follow (Table 1.2).

These data show that the countries of the Caribbean Basin that have participated in these tests (without including México) have consistently scored below the rest of Latin America. Latin America as a region on international comparative tests has had low achievement levels with respect to the rest of the world, but Central America and the Caribbean is even weaker. On three of the tests the difference between Chile (with the highest scores) and the Dominican Republic (with the lowest scores) is more than 130 points.

The purpose of CANP 2 was to study the conditions related to mathematics education in Central America and the Caribbean, and search for elements to promote development. And the objective of this book is to offer to the international mathematics education community for the first time an academic summary of some dimensions of the development of the teaching and learning of mathematics in this specific region.

Why are only Colombia, Costa Rica, the Dominican Republic and Venezuela in this book? Although other countries in the region were invited to participate, for various academic and socioeconomic situations they chose not to. This work should

Table 1.2 Results from SERCE and TERCE (UNESCO) in Latin America: 2006, 2013

	Third grade		Sixth grade	
	SERCE	TERCE	SERCE	TERCE
Argentina	505	533	513	530
Brazil	505	540	499	520
Chile	529	582	517	581
Colombia[a]	499	519	493	515
Costa Rica[a]	538	558	549	535
Ecuador	473	524	460	513
Guatemala[a]	457	501	456	488
Honduras[a]		508		480
México	532	549	542	566
Nicaragua[a]	474	485	458	462
Panamá[a]	463	494	452	461
Paraguay	486	488	468	456
Perú	474	533	490	527
Dominican Republic[a]	396	448	416	437
Uruguay	539	551	578	567
Overall average	491	521	492	509
Average for countries from Central American and the Caribbean (not including México)	**471**	**502**	**471**	**483**

[a]Countries from Central America and the Caribbean
Venezuela did not participate in these studies
Source OREALC-UNESCO (2014)

Table 1.3 Area and population of Colombia, Costa Rica, the Dominican Republic and Venezuela

Country	Area	Approximate population in millions in 2016
Colombia	1,142,903 km^2 and territorial waters 988,000 km^2	48
Costa Rica	51,100 km^2 and territorial waters 589,000 km^2	5
Dominican Republic	48,442 km^2 and territorial waters 138,000 km^2	10
Venezuela	916,445 km^2 and territorial waters 670,000 km^2	31

be seen as a first approximation. Without a doubt, it will be important to replicate this study in other countries in Central America and the Antilles.

It is important to note that the four countries in this study are particularly diverse geographically and demographically. Below are data on surface area and population that should help to situate the reader (Table 1.3).

Colombia is the largest with the greatest population, followed by Venezuela. The Dominican Republic has an area similar to Costa Rica, but twice the population.

Colombia has an area 20 times that of the Dominican Republic and Costa Rica, and a population 10 times that of Costa Rica. Colombia and Venezuela share a long border. Costa Rica and the Dominican Republic share no borders with the rest of these countries, but the latter does share an island with Haiti. All these countries were a part of the Spanish Empire, although with diverse levels of importance. Costa Rica was the most "peripheral". All four experienced distinct processes of independence from Spain. They have all had distinct relationships with the main power in the Americas, the United States. For example, the Dominican Republic was occupied various times by the United States while Costa Rica has always enjoyed a close relationship with the country to the north. Politically, all are representative democracies, but historically they have lived quite different conditions. Their levels of economic, social and educational development are distinct which indicates the need for care in analysing these realities.

The Structure of the Educational Systems

The following table provides a visualization of the educational structure of the four countries with respect to the school years from first to twelfth (Table 1.4).

In all these countries there are, of course, pre-school opportunities and diverse higher education systems. It can be said that currently there is a shared educational structure, although the names given to the different levels can vary a bit.

Why was it decided to focus on the initial and continuing preparation of mathematics teachers? Because, although it is not the only factor that should be

Table 1.4 The structure of the educational systems in Colombia, Costa Rica, the Dominican Republic and Venezuela: Years 1 to 12

Country			
Colombia	*Elementary*	*Secondary*	*Upper Secondary*
	Grades 1–5	Grades 6–9	Grades 10–11
Costa Rica	*Elementary*	*Secondary*	
	Grades 1–6	Grades 7–12[c]	
Dominican Republic	*Basic*[a]	*Media*[a]	
	Grades 1–8	Grades 9–12	
	Elementary[b]	*Secondary*[b]	
	Grades 1–6	Grades 7–12	
Venezuela	*Elementary*	*Secondary*	
	Grades 1–6	Grades 7–12[c]	

[a]The structure of the educational system in the Dominican Republic when this book was originally drafted

[b]The structure in the Dominican Republic beginning in 2014

[c]Most secondary schools have a total of 11 years while technical secondary schools have a total of 12

Source Mathematics Education Reports (2013)

analyzed, it is a crucial dimension for understanding what happens in mathematics education, as well as a powerful route for improving the mathematical capacities of the population.

To address issues related to initial and continuing preparation of teachers in these countries several common topics will be considered:

- Institutions that offer initial teacher preparation.
- Teacher preparation for elementary (grades 1 to 5 or 6) and secondary (grades 6 or 7 to 11 or 12).
- Components of teacher preparation: content, general pedagogical, content-based pedagogy, student teaching, other subjects.
- Areas of mathematics in the programs.
- Institutions that provide professional development.
- Professional development modalities.
- Institutions that offer graduate programs.
- Maturity of research in mathematics education.

The School Mathematics Curriculum

The preparation of mathematics teachers should be considered in the larger school curricular context. Venezuela, Costa Rica and the Dominican Republic each have a mandatory, official, national curriculum. In Colombia, however, there are general orientations that are followed in the different regions of the country, but an identical national curriculum for all does not exist.

With respect to mathematics, all these countries experienced in their own way the "Modern Mathematics" reform, which had emerged as a possible solution to an important problem for mathematics education: closing the gap between the mathematical practice of professional university research mathematicians, and the mathematics in elementary and secondary schools. Using the language of sets and with perspectives taken from university mathematics there was a desire to integrate mathematics as a single discipline. It was proposed that modern symbolism be adopted, that the use of graphs be given greater importance, that much of traditional algebra be eliminated, and that something extremely serious be modified and practically eliminated: traditional Euclidean Geometry. A famous war cry of some of the reformers was "Euclid must go" (J. Dieudonné). The reform began in Europe (especially France) and the United States. Later it was expanded to Latin America and other latitudes. Textbooks and curricular changes were the main mechanisms to drive the reform. The reform failed to achieve its initial objectives and was rejected by many educators, students, and even parents. Nevertheless, the actions and ideas that the reform promoted were dominant for almost 30 years. In different ways all of these countries backed away from the reform in the 1980s and 1990s as they were influenced by constructivism, systems theory or curricular models based on competencies.

During the 1970s and well into the 1980s much of the school mathematics curriculum in Colombia was determined by "Modern Mathematics". It is perhaps

noteworthy that the *1st Inter-American Conference on Mathematics Education* (IACME I) was held in Bogotá, Colombia, in December of 1961. Its main purpose was to promote the development of the modern mathematics reform in the Americas (Ruiz and Barrantes 2011). Afterwards Colombia experienced the influence of "systems theory" until the second half of the 1990s. At the time they began to emphasize the construction of knowledge and the development of thinking using "problem situations", interdisciplinarity, action research, and a perspective based on competencies. In Colombia there are two seminal documents that orient school mathematics: *Curricular Guidelines for Mathematics* and *Basic Standards for Mathematical Competencies*, published in 1998 and 2006, respectively. These should be considered complementary. The lack of a specified national curriculum is being debated in the country.

In Venezuela the influence of modern mathematics was also felt. In 1965 the Pedagogical Institute (a very influential institution in that country) also assumed that reform model in the first three and that same year national mathematics programs with that orientation were officially approved. Venezuelans participated in the first three *Inter-American Conferences on Mathematics Education* and organized the fourth. This wave continued until 1980 when a national education law broke with modern mathematics and adopted the international perspective of "*Back to the Basics*".

The modern mathematics reform also influenced mathematics programs in the Dominican Republic where a translation of the books of the *School Mathematics Study Group* (*SMSG*) from United States was used in teacher preparation, and later on in some high schools.

In Costa Rica, as in the other countries considered, modern mathematics dominated the school curriculum beginning in 1964 when new programs with this orientation were officially approved. The universities adopted teacher preparation processes based on the new orientation. It was not until the middle of the 1990s that the modern mathematics model was officially replaced, although it had already been largely abandoned in practice. The next strong influence was constructivism (although the approach was very general), and many dimensions of behaviorism continued to exist (particularly with respect to assessment). In 2012 there was an authentic revolution in mathematics education. A new national curriculum was approved based on problem solving with an emphasis on real contexts, and that introduced an innovative vision of the use of competencies.

Initial Teacher Preparation

In this work the types of institutions where teachers are prepared, the degrees that are given, the extent to which teacher preparation is related to the national school curriculum, as well as the curricular components of teacher education, are of interest. Identifying the specific pedagogy of mathematics (mathematics teaching methods courses) is of particular relevance, as it is an indication of the extent to which mathematic education in the country has developed as an independent discipline.

In some of the cases presented here, teacher preparation is designed for secondary teaching, but also serves for teaching mathematics in institutions of higher education (in programs that require mathematics), but not for doing research in mathematics.

In these countries initial teacher preparation is provided in universities and other higher education institutions (such as "normal schools" in the Dominican Republic). In each country the names of the undergraduate degrees are different (or the same names may refer to different degrees).

In Colombia, initial teacher preparation was in normal schools, then in higher normal schools, and eventually the "normal" programs were passed to schools of education in the universities. Since the middle of the first decade of the 21st century, teacher preparation has been considered to be "technical" rather than "professional". With respect to secondary education, since the 1990s individuals with undergraduate degrees ("licenciados") have taught mathematics in secondary schools. By the end of the last century, a basic undergraduate degree with a major in Mathematics (*Licenciatura Básica con Énfasis en Matemáticas*) has been offered for lower secondary teachers and an undergraduate degree in Mathematics (*Licenciatura en Matemáticas*) for teachers in upper secondary schools. However, in practice those with the degree in Mathematics work at all levels of secondary schools, as do those with degrees in other fields. Elementary school teachers have either received a very general teaching degree or a degree in some other field.

In the last 15 years, the initial teacher preparation programs in Colombia have moved from an emphasis on mathematics to an emphasis on pedagogy, which has led to the expansion of mathematics education as a field. The main emphasis to date has been to follow a curricular model based on competencies.

In general, initial teacher preparation programs in Colombia include mathematics, curriculum, mathematics pedagogy, general pedagogy, and elements of communication to support actions in the classroom. There is also a course in either physics or computer science. The mathematics courses include Arithmetic and Algebra, Calculus, Geometry, Probability and Statistics. With respect to curriculum and pedagogy, the courses are related to the national *Curriculum Guidelines for Mathematics* or to research results in mathematics education.

Since 1996, in the case of Venezuela, initial teacher preparation from elementary through secondary has been structured with four dimensions: general, pedagogical, specialized and professional practice. For secondary schools the initial preparation is in public universities. For elementary schools, both public and private universities provide programs. There are a variety of degrees offered to future secondary teachers: Mathematics Teacher; and Bachelor's Degrees in Education with a major in Mathematics, in Mathematics, in Mathematics and Physics, in Mathematics Teaching or in Mathematics and Computer Science. The programs are for four or five years. The mathematics courses include Geometry, Calculus and Analysis, Algebra, Probability and Statistics. Except for one institution there are no courses specifically on mathematics pedagogy. Student teaching experiences vary widely across the country.

Elementary teachers that teach mathematics in Venezuela are prepared as generalists. They usually have three mathematics courses. Two of them attempt to

relate to work in the classroom and the other (Geometry) emphasizes strengthening the logical, deductive and spatial reasoning of teachers.

In Venezuela there is a deep divide between the state educational agencies and the institutions that prepare teachers. In particular, there is not a close and consistent correlation between the official national curriculum and the programs for initial preparation (there is almost no mention of the school curriculum in the courses). The majority of the characteristics of the programs for initial preparation were set in the 1990s and have not been changed very much. A relevant detail is that there is a shortage of secondary mathematics teachers.

In the Dominican Republic most of the initial teacher preparation programs for grade 1–8 are in normal schools and universities under the coordination of the National Teacher Institute for Preparation and Professional Development (*Instituto Nacional de Formación y Capacitación del Magisterio*). Recently there has been a great demand for teachers particularly for grade 1–8. The teacher education programs were divided into grades 1–4 and grades 5–8. In those programs mathematics courses were no more than 10 % of the total and mathematics teaching methods courses were almost non-existent. For upper secondary education (grades 9–12) initial teacher preparation which is called "Secondary Education with a major in Physics and Mathematics" is structured with the usual dimensions: mathematics, general pedagogy, mathematical pedagogy, general education, etc. There are also courses in physics given the double major. The mathematics courses that are usually present are Algebra, Trigonometry, Higher Algebra, Statistics and Calculus. Mathematics teaching methods are usually confined to one course associated with student teaching. In the Dominican Republic the student teaching experience varies greatly from institution to institution.

In Costa Rica the public and private universities are charged with providing initial teacher preparation for both elementary and secondary teachers. Elementary teachers receive a bachelor's degree (four years in the public universities) or a licentiate's degree (5 or more years in the public universities). The program prepares generalists with at most two or three mathematics courses; in some private universities courses from other disciplines replace the mathematics courses. For secondary teaching the initial preparation can be a three-year Teaching degree often called a "profesorado". This degree is considered to be a lateral exit from the bachelor's or licentiate degrees. These three-year programs for preparing secondary mathematics teachers have courses in mathematics, general teaching methods, mathematics pedagogy, general education and student teaching. Beginning near the end of the first decade of the 21st century the public universities have made efforts to increase the time dedicated to mathematics pedagogy. As of 2016 this process is still being developed with different levels of success. The mathematics courses include abstract algebra, linear algebra, calculus and analysis, geometry and topology, probability and statistics, and number theory. Various private universities offer initial teacher preparation programs. Although their programs are fairly similar to those in the public universities, they usually require one or two years less. In Costa Rica the programs for initial teacher preparation, particularly at the secondary level, have had to make changes related to the new school mathematics curriculum adopted in 2012.

In these countries, most initial preparation of teachers is done in a face-to-face format.

With respect to initial preparation for elementary schools a "generalism" predominates, that is, a preparation for teaching all subjects. However, in Costa Rica there is some subject matter specialization, in Colombia the title of the degree indicates the specialization, and in the Dominican Republic there are plans for such specialization.

For secondary education (grades 6 or 7 to 12) there are initial teacher preparation programs that focus on mathematics teaching. In all four countries the programs are similar, although with some differences in the proportion dedicated to various aspects of the programs. For example, in Venezuela and the Dominican Republic there is less emphasis on mathematics pedagogy than in the other two countries.

The degree to which teacher education is aligned with the national school curriculum various from country to country. In Venezuela there is very little alignment. There is somewhat more in the Dominican Republic. In Colombia there is supposed alignment, but regional autonomy in program implementation makes it difficult to confirm. In Costa Rica the universities that provide teacher education programs have made an effort to align their programs with the new national curriculum, but they have not completed the process.

The teacher education programs in these four countries do not require previous university studies (such as, for example, a bachelor's degree in mathematics). A student decides upon entering the university that they will become a mathematics teacher. However, the students are not recruited from among those with the strongest academic backgrounds.

There is use of technology in all of the initial teacher preparation programs in these countries, although each one has weaknesses and challenges. Despite requiring the use of technology in teacher education programs in Colombia, it is not clear how that leads to classroom implementation and what the impact might be. In Venezuela there is also a requirement to use information and communication technologies, but until recently they had not been incorporated into the teacher preparation at either the elementary or secondary level. There are now plans to introduce them across all disciplines. In the Dominican Republic there is some minimal use of technology but not specifically in mathematics. The new national curriculum in Costa Rica includes a relatively strong use of technology in the classroom; also the on-going curricular implementation has had a vigorous use of online communication technologies for in-service teacher development. This process is leading to new technology uses and perspectives in pre-service teacher education.

Professional Development Programs for In-Service Teachers

Professional development programs in the four countries are usually short courses of from a few days to a semester, or participation in special events such as specialized summer schools, seminars and conferences.

In Colombia there have been several plans for "permanent" professional development and diploma programs called "Specializations". The Specialization programs have been losing ground to graduate programs. However, there still are about ten Specialization programs that last two or three semesters.

Venezuela has continuous professional development programs that do not lead to an academic degree given by universities or professional associations. The programs that do lead to an academic degree are called "specialization", "master's" or "doctorate" in mathematics education.

In the Dominican Republic teacher professional development is the responsibility of the Ministry of Education. However, the Ministry charges the National Institute of Teacher Preparation and Development with its implementation. Universities in turn often are awarded contracts to provide the actual services. A special modality of professional development that has been offered is called "diploma" in teaching mathematics. It involves courses of six months with eight hours a day of study.

In Costa Rica professional development for both elementary and secondary teachers in offered by universities, professional schools, foundations and, especially, the Ministry of Education. Since 2011, the Ministry has been involved particularly in professional development in mathematics. The work has been significantly transformed by using blended (hybrid) courses that involves both face-to-face and online sessions, as well as, completely online *Massive Open Online Courses* (MOOC).

Graduate Programs

The situation with respect to graduate programs is quite diverse in these countries.

Colombia has two kinds of master's degrees: one might be called "advanced study" (profundización) and the other is research. The advanced study master's degrees have some connection to "specializations" that do not grant a degree. In 2009 there were 69 master's degree programs divided into three categories: (i) in schools or institutes of education where there is some connection to mathematics education, (ii) in schools or departments of science where the basic component is mathematics with some connection to the teaching of mathematics, and (iii) those based on Mathematics Education as an independent discipline. There is also tension between the advanced study and research master's with respect to weaknesses or shortcomings that each claims the other have: role of research in the advanced study master's, the place of teachers and connections to classrooms in the research master's.

There are four programs that offer a doctoral emphasis in Mathematics Education within doctorates in education and social sciences.

In Venezuela there are "Specialization" programs (which are considered to be degree programs) in three universities, master's programs in nine universities and one specific doctoral program in mathematics education created in 2013. However,

most of the courses in these graduate programs are pure mathematics with little contact with pedagogy, with the exception of the doctoral program which emphasizes research and theories of mathematics education. There is also the possibility to the study mathematics education as part of any of the nine doctoral programs in education. It is noteworthy that Venezuela began offering its first master's degree in Mathematics Teaching in 1974.

The Dominican Republic has some graduate programs with a "specialization" in Mathematics Education that give a degree in between a bachelor's and a master's. Only three universities offer a doctorate but none of them includes mathematics education.

Costa Rica has only one master's program that includes mathematics education, as an emphasis in a master's in mathematics with a few courses in mathematics education at the University of Costa Rica. The graduates of this program work at postsecondary institutions and therefore do not directly impact pre-university education. There are also various public and private universities in Costa Rica that offer doctorates in education but none of them have an emphasis in mathematics education.

In summary, Colombia offers good quality graduate programs including four options for work in mathematics education at the doctoral level, a strength in their educational community. Venezuela has various master's degrees and possibilities to study mathematics education as part of doctorates in education, and they do have one doctoral program specifically in mathematics education. The situation with respect to master's programs in the Dominican Republic is weak and it is precarious in Costa Rica; these countries don't have doctoral programs that include mathematics education.

Research in Mathematics Education

Another way to measure the development of mathematics education in these countries is to consider the place of research in mathematics education. The situation with respect to such research varies greatly from country to country in this region.

For several decades educational research in Colombia has been supported by academics who earned doctorates in various countries of Europe and North America. They have influenced the teaching and research in many institutions. In the last 20 years much research in mathematics education has been done by students earning master's and doctoral degrees. Although in Colombia research has been included in the goals of teacher education programs, particularly at the master's and doctoral level, there have not been many opportunities to in the action of elementary and secondary classrooms to develop such research.

In Venezuela research activities in mathematics education are part of graduate programs where it is possible to work on various lines of research with various research groups. Undergraduate programs in Venezuela also require courses in

research, although very general, and often oriented towards the basic classroom activity, but the programs themselves are not enriched by research.

In the Dominican Republic educational research is not well-developed and mostly relates to gathering basic information on school achievement. Research in mathematics education is almost non-existent.

Beginning in the 1980s research in mathematics education has been developed in Costa Rica with various strengths in some of the public universities. One important element has been the existence of a consolidated team of researchers in mathematics education that is one of the strongest in Latin America with broad international connections. However, their work has had very little influence on most mathematics pre-service teacher education programs in the universities. A significant moment occurred in 2012 that established a "before and after": a new national mathematics curriculum. Both the curriculum and associated implementation strategies have condensed in an original and clever form national and international research and experience in mathematics education. A political window opened in 2010 that allowed a group of researchers to guide a true revolution in the teaching and learning of mathematics. There are few cases in the world where the conjunction of academic research and national politics leads to such an incredible impact for the entire country.[3]

Research in mathematics education has an important place in Colombia, closely associated with graduate programs, professional associations and academic networks. In Venezuela it is associated with graduate programs, and some research groups and teacher associations. In Costa Rica, although also important, it has not impacted initial teacher preparation programs directly, but has played a decisive role in the recent design and implementation of the new national curriculum. In the Dominican Republic, there is very little research specifically related to mathematics education.

Challenges

Although the four countries face somewhat different challenges in preparing mathematics teachers, it is still possible to develop an agenda for international cooperation in the region.

One of the main challenges for Colombia is to apply the significant advances in research and graduate programs to actions in elementary and secondary classrooms, indicating the need for reforms in pre-service teacher education and in-service professional development, and as well in the objectives and curricular materials. Another challenge is to achieve alignment between the national curricular principles and the curriculum in each region.

[3]Descriptions of this experience can be found in Ruiz (2013, July) and in Mathematics Education Reform in Costa Rica 2015.

A challenge faced by Venezuela in initial teacher preparation is overcoming the deep divide that exists between mathematics and pedagogy. Other concerns are the lack of strong mathematics teaching methods courses and the need to find ways to link programs of study to classroom practices based on the national curriculum. The Venezuelan mathematics education community is designing strategies and solutions. They are the beneficiaries of a strong tradition of national public policies related to educational processes.

The Dominican Republic is confronting various challenges in improving the quality of teacher preparation: increasing the quantity of educators receiving master's and doctoral degrees, improving the role of research, and in general strengthening mathematics education as a distinct discipline. Important changes have been made recently in school curriculum and modifications to the programs for initial preparation have been proposed that are based on a paradigm based on competencies. There is hope that the programs will become more specialized according to the school levels and disciplines in which the future teachers plan to work.

Besides the need to strengthen graduate program offering in mathematics education, Costa Rica has the challenge of improving teacher preparation programs in private universities. Recently there have been many graduates of private universities with a weak academic preparation. Also, both private and public universities need to adjust their programs so that they are consistent with the new national curriculum and offer high standards with respect to quality and expectations.

In all four countries there is some indication of the presence of specific mathematics pedagogy, but not consistently and better in some countries than in others. In all the countries improving the quality and impact of mathematics pedagogy on all pre-service teacher preparation programs is a challenge. The progress of the mathematics pedagogy seems to depend largely on the level of research in mathematics education and on decisions based on beliefs about mathematics or mathematics education, or even on institutional policies.

In all these countries the relationship between the programs of initial teacher preparation and the national curriculum is deficient even when there are specific courses on mathematics pedagogy.

There are other issues that are related to the educational system or society in general. These issues present challenges that combine with those "internal" to the discipline. For example, initial teacher preparation is affected if there are weaknesses in the requirements that ministries of education have in their teacher hiring practices. There can be similar negative effects if there are weak accreditation systems for teacher education programs and institutions. Also, the quality of teacher education programs can be negatively affected if students who enter those programs are mostly lower achieving students. When all these factors are combined it is inevitable that many of the in-service teachers will not have the qualities and attitudes necessary for adequate performance of their duties. Without a doubt, all these factors affect decisions taken by teacher education institutions, ministries of education and society in general. There is international experience that can help with policy decisions related to these issues (Barber and Mourshed 2007). Here we

are faced with a very complex issue: How do we provide the required preparation in mathematics (something which is a right of every student) despite all the problems related to human resources? These issues cannot be separated from initial and continuing teacher education, and, although they will not be explicitly addressed in the following chapters, they do form part of the universe of mathematics education in these countries.

From a global perspective, these countries and others in the Caribbean Basin should identify national strengths in mathematics education that can guide processes of regional cooperation with reciprocal supports. For example, Colombia could contribute with respect to graduate programs, research and publications; Costa Rica with its results in research-based curriculum development; the Dominican Republic with it management capacities and international connections; and Venezuela with its experience with public policies.

It will be possible to make advances in mathematics education as a discipline, increase the number and the quality of mathematics teachers, improve initial teacher preparation programs, provide more master's and doctoral programs, enhance the role of a pedagogy for teaching mathematics, and develop research. Nevertheless, as had been mentioned, there will always exist macro educational and social dimensions that will affect the impact of these necessary actions. It will be crucial to find helpful perspectives and necessary operational activities, and take advantage of the historical moment in the region and in each country. International efforts that will be realized with the support of the Mathematics Education Network for Central America and the Caribbean and the Inter-American Committee on Mathematics Education will be very important.

References

Barber, M., & Mourshed, M. (2007). *How the world's best-performing school systems come out on top*. McKinsey & Company, Social Sector Office. Retrieved from http://www.mckinsey.com/clientservice/socialsector/resources/pdf/Worlds_School_Systems_Final.pdf

Mathematics Education Reform in Costa Rica. An assessment and perspectives. (2015, April). *Cuadernos de Investigación y Formación en Educación Matemática*, Year 10, N. 13. Costa Rica: Author. Downloaded from http://revistas.ucr.ac.cr/index.php/cifem/issue/view/1866

Mathematics Education Reports: Colombia, Dominican Republic, Venezuela, Costa Rica. Capacity and Networking Project 2012. (2013, November). [Special issue]. *Cuadernos de Investigación y Formación en Educación Matemática*. Year 8. Costa Rica: Author. Retrieved from http://revistas.ucr.ac.cr/index.php/cifem/issue/view/1281

Organization of Economic Cooperation and Development (OECD). (2014). *Programme for International Student Assessment 2012, Results in Focus. What 15-year-olds know and what they can do with what they know*. OCDE: Author. Retrieved from http://www.oecd.org/pisa/keyfindings/pisa-2012-results-overview.pdf

Ruiz, A. (2013, July). Mathematics education reform in Costa Rica. The praxis perspective. [Special issue]. *Cuadernos de Investigación y Formación en Educación Matemática*, Year 8. Costa Rica: Author. Retrieved from http://revistas.ucr.ac.cr/index.php/cifem/issue/view/1186

Ruiz, A. (2013, December). IACME and mathematics education international organizations in Latin America. *Cuadernos de Investigación y Formación en Educación Matemática,* Year 8,

N. 11. Costa Rica: Author. Retrieved from http://revistas.ucr.ac.cr/index.php/cifem/article/view/14706

Ruiz, A., & Barrantes, H. (2011, June). In the origins of IACME. *Cuadernos de Investigación y Formación en Educación Matemática,* Year 6, N. 7. Costa Rica: Author. Retrieved from http://revistas.ucr.ac.cr/index.php/cifem/article/view/6933/6619

UNESCO Regional Bureau for Education in Latin America and the Caribbean (OREALC/UNESCO). (2014). *Comparison of results for the second and third Regional Comparative and Explanatory Study, SERCE and TERCE 2006–2013*. Santiago, Chile: Author. Retrieved from http://repositorio.minedu.gob.pe/handle/123456789/3344?show=full

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

References

Agudelo-Valderrama, C. (2006). The growing gap between colombian education policy, official claims and classroom realities: Insights from mathematics teachers conceptions of beginning algebra and its teaching purpose. *International Journal of Science and Mathematics Education, 4*(3), 513–544.

Agudelo-Valderrama, C. (2008). The power of Colombian mathematics teachers' conceptions of social/institutional factors of teaching. *Educational Studies in Mathematics, 68*(1), 37–54.

Bautista, M., & Salazar, C. (2008). *Memorias del Tercer Encuentro de Programas de Formación Inicial de Profesores de Matemáticas*. Bogotá: Universidad Pedagógica Nacional.

Castiblanco, A. C., Camargo, L., Villarraga, M. E., & Obando, G. (1999). *Nuevas tecnologías y currículo de matemáticas. Apoyo a los Lineamientos Curriculares*. Bogotá: Ministerio de Educación Nacional.

Castiblanco, A. C., Urquina, H., Camargo, L., & Moreno, L. E. (2004). *Tecnología Informática: Innovación en el Currículo de Matemáticas de la Educación Básica Secundaria y Media*. Bogotá: Ministerio de Educación Nacional.

Castrillón, G., & Solis, K. (2009). Cartografía sobre capacidades de formación y de Investigación en Educación y Pedagogía en Colombia. Programa Nacional de Investigación y Desarrollo

Académico “Hacia la conformación de un Sistema Nacional de Formación de educadores”. Asociación Colombiana de Facultades de Educación, ASCOFADE.

Colombia, M. E. N. (1998). *Matemáticas. Lineamientos curriculares*. Bogotá: Ministerio de Educación Nacional.

Colombia, M. E. N. (2006). *Estándares básicos de competencias en Lenguaje, Matemáticas, Ciencias y Ciudadanas*. Bogotá: Ministerio de Educación Nacional.

Guacaneme, E. A., Bautista, M., & Salazar, C. (2011). El contexto normativo de formulación de los programas de formación inicial de profesores de matemáticas. *Voces y silencios: Revista Latinoamericana de Educación*, *2*(1). Retrieved from http://vys.uniandes.edu.co/index.php/vys/article/view/52/83

Guacaneme, E. A., Obando, G., Garzón, D., & Villa-Ochoa, J. A. (2013). Informe sobre la Formación inicial y continua de Profesores de Matemáticas: El caso de Colombia. *Cuadernos de Investigación y Formación en Educación Matemática, 8*(Special issue), 11–49.

Obando, G. (2004). Sobre los lineamientos curriculares y los estándares básicos de matemáticas. In P. J. Rojas (Ed.), *Memorias del 6° Encuentro Colombiano de Matemática Educativa* (pp. 35–40). Medellín: Asocolme.

Valero, P. (2006). ¿De carne y hueso? La vida social y política de la competencia matemática. Paper presented at the Foro Educativo Nacional. Retrieved from http://www.colombiaaprende.edu.co/html/mediateca/1607/articles-110336_archivo.pdf

Vasco, C. (1994). Un nuevo enfoque para la didáctica de las matemáticas. In C. Castiblanco (Ed.). Bogotá: Ministerio de Educación Nacional (Volumen I – Volumen II).

Chapter 3
Costa Rica: The Preparation of Mathematics Teachers

Yuri Morales-López

Abstract This chapter begins with a brief description of the Costa Rican education system and the stages of its historical evolution and ends with a consideration of the strengths, weaknesses, threats and main challenges currently faced by Costa Rica in its quest to improve the quality of Mathematics Education. The initial preparation of Mathematics teachers for elementary and secondary education will be described with an indication of the main characteristics of the institutions that provide the preparation and the corresponding programs of study. Elements of continuing professional development in the country will be mentioned and a review of Mathematics Education research in Costa Rica will indicate an important strength in possibilities for improving the teaching of Mathematics in this country. A profound reform of the school Mathematics curriculum approved in 2012 will also be described. It is a curriculum that utilized results from important international research and experiences in Mathematical Education with national goals to build higher cognitive capacities in this discipline. The new curriculum and its implementation (in an ambitious and bold project) has significantly affected the teaching practice in Costa Rica classrooms and the in-service professional development of teachers of Mathematics, and, also has served as an obligatory reference for change in initial preparation programs (that the majority of universities preparing teachers have begun to incorporate). In particular, the close connection between the development and success of this educational reform, and the national research efforts in Mathematics Education and the relevant international backing that the process has received will be highlighted.

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General Facts About Costa Rica

Costa Rica is a country in Central America that is bordered by Panamá to the southeast, Nicaragua to the north, the Pacific Ocean to the west, the Caribbean Sea to the East.

The land area of Costa Rica is 51,100 km^2 (19,653 sq. mi).

The population in 2016 was estimated at 4.9 million people (about 40 % live in rural areas and 60 % live in urban areas, with great concentration in the metropolitan area of San José, the Capital).

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

During his fourth voyage in 1502, Christopher Columbus arrived in Costa Rica that was populated by groups such as Bribri, Cabécar, Guaymies, Guatusos or Malekus, Borucas or Bruncas, Térrabas, Huetares, Chorotegas, Miskitos, Sumos, and Teribes. In this way began the process of Spanish colonization which finished in 1821.

Currently, Costa Rica is a democratic, free and independent republic. There are three branches of government: the Executive Branch, Legislative Branch and Judicial Branch. There is also the Supreme Electoral Tribunal that is considered a fourth Branch. All powers are independent of each other. Its army was abolished in 1949.

The culture is colored by the Spanish, African and indigenous influences, whose syncretism manifests itself in art, music, food and customs. The main foreign populations are now from Nicaragua, Colombia and the United States.

Costa Rica stands out in the region as a country with high investment in the education system. This makes it a country with qualified workers, compared to the other countries of the region. Education is free by law until the end of high school (students between 17 and 18 years old) and higher public education system is mainly supported by state resources.

Regarding the economy, the main activity is ecotourism. Costa Rica has extensive preserved areas and significant diversity in flora and fauna. Volcanoes, access to the Pacific Ocean and Caribbean Sea, national parks (forest and marine reserves) and others are some of most visited sites.

General Description of the Education System

The structure of the Costa Rican education system has various levels (cycles): preschool education, elementary education, secondary education, and higher education (see Table 3.1). At the end of the second cycle a diagnostic test is given to

Table 3.1 Structure of preschool, general basic, upper secondary and higher education in Costa Rica

Designation	Cycles	Ages and grade spans for each cycle	Offered by the MEP
General basic education	Cycle I	From 7 to 9 years (1°, 2° and 3°)	
	Cycle II	From 9 to 12 years (4°, 5° and 6°)	
	Cycle III	From 13 a 15 years (7°, 8° and 9°)	
Upper secondary	Cycle IV	From 13 to 17 years (10°, 11°, (12° depending on the branch[a])	
Designation	*Degrees*		Public and Private Universities
Higher education	Lower undergraduate (certificates and teaching degrees) Upper undergraduate (bachelor's and licentiate degrees) Graduate (specializations, master's, Doctorates)		

[a]Cycle IV (Upper Secondary) is subdivided into three branches: *academic* with a duration of two years (tenth and eleventh); *artistic*, also with a duration of two years; and *technical*, with a duration of three years (tenth, eleventh and twelfth); this last one is diversified into modalities: industrial, agricultural, commercial y services

know, among other elements, the achievement in the previous grades. It does not have implications for continuing on to the next cycle.

There is another national test that is required at end of upper secondary school: the *Upper Secondary Test*. A student's grade is determined as a weighted average of a grade called presentation (the average of grades in Social Studies and Civics, Spanish, English or French, Mathematics, Biology, Chemistry or Physics) and the Upper Secondary Test itself. Students receiving a passing grade are awarded an "Upper Secondary Diploma" (a School *Baccalaureate*). This grade is not only important for passing Upper Secondary but, also, because it is a requirement for admission to university studies.

With respect to personnel, in 1971 there were almost 18,000 teachers and administrators, and in 1981 there were about 22,500 teachers. In 1983 the number of private universities began to increase. Forty-five new private universities were created between 1986 and 2000 (at the end of 2014 there were five public universities and 52 private universities). In 2011 there were 12,195 students that received degrees from public universities and 28,115 from private.

As a result of the growing number of universities and programs related to Education, the country is producing many more certified teachers, particularly in private universities. In 2004 there were 8948 graduates from Education programs (34 % of the total) (*Estado de la Educación 1*, 2005). From 2010 to 2011 there were 21,446 new graduates in Education (*Estado de la Educación 4*, 2013, p. 36).[1]

[1]Data updated in 2014.

In 2005 and 2006 more than 8000 students a year were receiving degrees in Education. The six most common areas were: Elementary, Preschool, General Education, Educational Administration, English and Special Education. By 2009 the number of Elementary teachers in the country had risen to 26,463 (43 % of the total teaching force) (*Estado de la Educación 3*, 2011, p. 142).

Main Stages of the History of Education in Costa Rica

The history of education in Costa Rica can be seen by looking at particular periods and actions.

The Teaching House and the University of Santo Tomás

According to *Estado de la Educación 2* (2008), before the creation of the Teaching House of Santo Tomás, in the colonial period, the majority of educators were priests. In the last decades of the 18th century and first of the 19th century, education in Costa Rica began a process of the secularization of teaching; as an exclusively male career.

After Independence a new generation of teachers emerged, some prepared at the Teaching House of Santo Tomás and later at the university with the same name created in 1843 and closed in 1888. The Teaching House of Santo Tomás had been created in 1814. It can be characterized as neither elementary nor secondary, but as a mix of both (Rodríguez and Ruiz 1995).

The Constitution of 1869 included the provision that education be free, obligatory and financed by the nation.

The Reform of Mauro Fernández

Between 1885 and 1888 there was a liberal educational reform that brought important changes in improving and centralizing public education. Elementary, secondary and university education were organized. Along with this, the management and supervision of elementary education passed to the Ministry of Public Education (Barrantes and Ruiz 1995a).

The Normal School of Costa Rica

According to Barrantes and Ruiz (1995a), with the founding of this Normal School in 1914, a new national phase of education began with respect to teacher

preparation. This institution was the center of cultural and educational life in the country until the establishment of the University of Costa Rica (UCR).[2] It developed new programs of study between 1925 and 1926 (Barrantes and Ruiz 1995b).

The Creation of the University of Costa Rica

In 1940 the University of Costa Rica was created with a School of Pedagogy that was charged with preparing Elementary teachers (Barrantes and Ruiz 1995c).

The Constitution of 1949 established the structure of cycles of education. According to Barrantes and Ruiz (1995a), the professional preparation for teaching secondary Mathematics began in 1959 when UCR began to offer a Teaching degree (*profesorado*) in Physics and Mathematics. In 1966 that program was separated into a Teaching degree in Physics and one in Mathematics. In 1968 the Upper Normal School was created. Among its objectives was the preparation of upper secondary Mathematics teachers (cited by Ruiz et al. 2009), but the program did not last long.

"Modern Mathematics" in Costa Rica

Barrantes and Ruiz (1995b) suggest that until 1964 there had not been significant evolution in (secondary) Mathematics. The main topics were arithmetic, algebra, geometry and trigonometry. Differences that did exist from one program to another were mainly in how to teach the Mathematics that was offered. The change in 1964 was the product of a reform that, for several years, had been on the international panorama: the so called "modern" Mathematics reform or "New Math". Between 1960 and 1970 development in the country was inspired by the great mathematicians of the moment, mainly those united in the French group called *Nicolás Bourbaki*.

New Universities

The 1970s saw the expansion of Costa Rican universities in response to the postwar demographic growth.

In 1971 the Costa Rica Institute of Technology (TEC) was created on the model of the Monterrey Institute of Technology in México. The National University (UNA) was founded in 1973 and its School of Mathematics in 1974. In 1977 the State Distance University (UNED) was created to provide opportunity and access

[2]In Appendix there is a detailed list of the acronyms used in this report.

to higher education for persons living far from the capital, at risk populations, among others.

Because of a shortage of secondary Mathematics teachers, in 1992 Teaching degrees in Mathematics were created at UNED, UNA and UCR. This was done in a formal agreement with the MEP and with World Bank funds. Graduates of those programs are still teaching in the universities.

Initial Preparation of Teachers

Elementary and Secondary Preparation

The Case of Elementary Education

In Costa Rica, teachers for the first two cycles of Basic General Education teach various subjects to the same group of students. Generally, in Cycle I they teach four basic subjects (Mathematics, Spanish, Science and Social Studies). In Cycle II some only teach two of those four subjects if the school has enough teachers.

There is a great diversity of programs and university centers offering programs in Costa Rica. For most of them all that is required for admissions is an Upper Secondary Diploma. The UNA and the UCR do require a certain score on the admissions examination.

The Case of Secondary Education

At present the panorama is very complex because of the great number of graduates, mainly from private universities. The Mathematics teaching programs at those institutions do not receive evaluations of quality standards that are offered by the National System of Accreditation of Higher Education. Also, the National Council of Private Higher Education (that is charged with approving and supervising the private universities) does not have efficient mechanisms to guarantee program quality.

At the end of 2012, four public universities and seven private universities had approved programs for initial preparation in the area of Mathematics Teaching.

UCR has had Mathematics programs since 1959. Currently the program offers both a Bachelor's Degrees (four years) and Licentiate Degrees (five years) with a lateral exit possible so that students can get a three-year Teaching degree (*profesorado*) in Mathematics Teaching. UNA offers the same three degree programs.

UNED has been offering Mathematics programs since 1992. Currently, a Teaching degree and a Bachelor's Degree are offered in Mathematics Teaching. Beginning in 2014, they are also offering a Licentiate Degree. TEC has had a Mathematics program since 1996 called Computer-Assisted Mathematics Teaching. It offers Bachelor's and Licentiate Degrees, but not the three-year Teaching degree.

A Brief Description of the Contents of Preparation Programs

Preparation Programs for Elementary Teachers

The programs of study offered at UNA and UCR are divided into 16-week semesters. The other universities use a 12-week quarter system. A Bachelor's Degree is eight quarters. Most of them offer a Licentiate which implies three or four quarters past the Bachelor's. The public universities have a lateral exit to a Certificate,[3] upon completing five quarters (in the case of UNED) or four semesters in the case of (UNA and UCR).

In the Elementary Education programs at both the public and private universities there are courses in philosophy, curriculum, planning, evaluation and general teaching methods. The programs also include content courses in the basic disciplines: Spanish, Sciences, Social Studies and Mathematics. Some also offer discipline-specific teaching methods courses. Some programs emphasize specific disciplines. For example, the University of San José (private) offers an emphasis in Spanish and English, and only requires one content course in each of the other basic disciplines. The Independent University (private) has an emphasis in Spanish-Social Studies, and requires no Mathematics courses. Graduates from both those private universities are often contracted by the MEP for classroom assignments in which they will have to teach Mathematics.

Programs for the Preparation of Secondary Mathematics

In the public universities the schools of Mathematics teach the content courses while the schools of Education teach the pedagogical component (with the exception of TEC which does not have a school of Education). Currently, each of the four public universities (UNA, UCR, UNED, TEC) has approved programs of study at the Licentiate level.

In the case of the private universities that do offer programs on the Teaching of Mathematics, their programs of study are very similar to those at the public universities. A problematic issue is that the similarly named degrees at different universities may differ by as much as a year or more of studies (Ruiz et al. 2009).

With respect to the relationship between theory and practice, as is the case with elementary teacher preparation programs, all the public universities include a course with supervised student teaching.

[3]Certificate in UNA and UNED or Teaching degree in UCR.

Master's and Doctoral Programs

The only institution with graduate degrees in Mathematics is UCR with its academic Master's Degree in Mathematics with an emphasis in Educational Mathematics, Applied Mathematics or Pure Mathematics. The emphasis in Educational Mathematics has been offered since 2003, but has had very few graduates. Its program is mostly Mathematics courses with two courses that contain Mathematics Education. Most of its graduates work at universities. An important consideration is that the MEP does not recognize the UCR graduate degrees as superior to the licentiate degrees (for hiring personnel for secondary schools), and consequently neither in Civil Service.[4]

Continuing Preparation

The experiences with continuing preparation before 2011 were not very significant. Below information about some of those efforts will be presented. Beginning in 2011 the reform of Mathematics Education was begun in the country.

Teacher Professional Development for Grades 1 to 6

Teacher professional development for grades 1 to 6 (cycles I and II) has been offered, mainly, by the following Costa Rican institutions: The College of Graduates and Teachers of Letters, Philosophy, Sciences and Art (a professional association to which all teachers and even certain university scholars should belong by law); the Omar Dengo Foundation (which was created more than 25 years ago to promote informatics for primary and secondary students); the MEP through the Uladislao Gámez Solano Institute for Professional Development (IDP-UGS), and public universities (Barrantes et al. 2010).

The efforts of the MEP to reinforce the idea of a process of continuing and permanent preparation of teachers were considered in the National Plan for Professional Development. That plan was approved by the Higher Council of Education in 1971 with the support of UNESCO. However, the efforts have been scattered, not well articulated and without significant consequences for professional development (Venegas 2010, cited in *Estado de la Educación 3*, 2011).

Between 1991 and 1995, to support new programs of study, regional advisers and university specialists provided professional development to almost 16,000 educators (*Estado de la Educación 3*, 2011). Beginning in 2006 a *Plan to Improve*

[4]State labor regime to which belong all governmental employees, particularly teachers for both the elementary and secondary levels.

Achievement in 200 School Days (Plan 200 of the MEP) was proposed. One of the activities was the professional development of the teaching force. The last two weeks of every school year were chosen for this professional development (Venegas 2010, cited by *Estado de la Educación 3*, 2011). However, these actions have not had a significant impact on classroom practice.

Public Universities

UNED has offered professional development since 2004. Their programs last approximately two years and have been offered in various regions of the country (Hume 2009, cited by Barrantes et al. 2010).

In UNA, a university Project called *Education and Development in Costa Rica* has been offering professional development for cycle I and II teachers since 2008. This project is connected to Plan 200 of the MEP. The university provides human resources and creates materials, while the MEP establishes the topics and gives guidelines to follow (Víquez 2009, cited by Barrantes et al. 2010).

In UCR, according to Valverde (2012), the Department of Elementary and Preschool Education, in its Section of Elementary Education, has been offering professional development as modules for in-service teachers in the area of Mathematics.

Since 2008 TEC's School of Mathematics has been publishing a calendar for elementary schools in which they propose a problem for every day of the year. Using that calendar as the basis, in 2011 they provided some professional development to elementary teachers (Meza 2012).

Teacher Professional Development for Secondary Education

The priorities and guidelines from the MEP are usually planned through the IDP-UGS. Its structure is mainly administrative and, although it does have professionals in some areas, they are not enough to meet the needs in all regions of the country. Therefore this process has been carried by individuals with professional services contracts and since 2006 has been planned in Plan 200.

In March of 2010, the MEP gave Mathematics teachers a diagnostic test and generated a Project to offer them professional development. The results were low with only 43 % showing a proficiency with secondary Mathematics.[5] The public universities UNA, UCR, TEC and UNED were contracted to provide the professional development (with an agreement Conare-MEP-Mathematics). An inter-university commission was created and the first course was offered in the spring semester of 2010 (approximately 50 % of the secondary teachers who took the test

[5]Data updated in 2014.

were invited to participate). The participation included 841 secondary teachers in 41 distinct groups in 24 educational regions. A second course was planned for the first semester of 2011, but the MEP pulled its financial support and the agreement terminated.

In 2011, the nature of all the professional development for elementary and secondary teachers, offered by the MEP, changed drastically with the profound Mathematics curricular reform in all of pre-university education.

Professional Development in Events Sponsored by Universities and Mathematics Education Associations

Faced with the weaknesses in the continuing preparation offered by the MEP prior to 2010, various academic events became an alternative so that teachers (essentially secondary) could increase their preparation (although in a disorganized way and without a strategic perspective). Since the 1990s the events with the longest tradition are the *Costa Rican Symposia on Mathematics, Science and Society* (the first was held in 1993 and the 25th in 2012). These symposia have been organized by UCR's *Meta-Mathematics Research Program* in collaboration with other institutions. Other events:

- The *International Mathematics Festival* organized by the *Foundation of the National Center for Science and Technology*, that was initiated in 1998 and has been held eight times.
- The *International Congress on Computer-Assisted Teaching of Mathematics* of the TEC (eight events have been held since 1999).
- The *Meeting on Teaching Mathematics* of the Mathematics Teaching Program of UNED's School of Exact and Natural Sciences (four have been held since 2006).
- The *Meeting on Teaching Statistics, Probability and Data Analysis* (three held since 2009).
- At a regional level: the *Provincial Meeting on Mathematics Education*, organized by MEP's regional Mathematics advisers and UNA in Guanacaste with support from UNA (since 2011).

In Costa Rica there is also a *Mathematics Education Association* that, although it has no more than 30 members, has generated various activities for teacher professional development.

Research in Mathematics Education

Research in Mathematics Education has been associated with the four public universities (UCR, UNA, UNED, TEC), in most cases with the department or schools in charge of teaching Mathematics. The research in those universities has been

carried out through projects, programs and research centers. The results can be seen in conference proceeding, journals, books and in presentations at various national and international events on the teaching of Mathematics. Recently, articles have appeared in the official publications associated with the MEP.

There are significant differences in the importance given to research at each institution. Such differences are largely the results of the size and historical global maturity of each institution.

- At UNED research began recently in 2010.
- In the last decade TEC has developed research projects. Most of them have used qualitative methods. They have carried out documentary studies and various actions related to the use of technology.
- At UNA, specifically in Mathematics Education, there was outstanding work between 2001 and 2009.
- UCR has developed most of the research in Mathematics Education and has played a leadership role.

The research that was carried out between 1974 and 1990 in the School of Mathematics at UCR (and in the rest of the country) was presented at the *National Congresses of Mathematics* (in 1983, 1985 and 1990) (Ruiz et al. 2003). From 1990 until 2012 the main venue was the *Costa Rican Symposia on Mathematics, Science and Society*. The other academic events summarized above have also served as a means to report on research that has been done in the country.

The *Center for Research on Mathematics and Meta-Mathematics* (CIMM) was born at UCR in 1997. It is the only formal research center in the country that includes Mathematics Education as one of its main specializations.

Linked to the CIMM from 2001 to 2009, there was significant Mathematics Education research carried out at UNA's School of Mathematics (an institution that previously had been associated with very little such research). The generator of this special effort was a project called *Support for Research in the School of Mathematics* (designed and directed by Angel Ruiz) with the support of the University Research Office and the School of Mathematics (Edwin Chaves, the School's Director during the last 4 years of this period, played a decisive role in the success of the project). This project was responsible for many research projects, including, in 2009, the *Program for Research and Teacher Preparation in Mathematics Education* (PIFEM), dozens of publications and the organization of many academic events. At the end of 2009, with the departure of Angel Ruiz from UNA, PIFEM was closed, the formal collaboration with CIMM ended, and research in Mathematics Education at UNA decreased considerably.

One of the results of the collaboration between CIMM and UNA's School of Mathematics was the creation in 2007 of a *Program in Research and Preparation in Mathematics Education* that since 2011 has been called the *Center for Research and Teacher Preparation in Mathematics Education* (www.cifemat.com). Researchers from UNED and the MEP have also been integrated into the work of this Program and latter Center.

Since the 1980s the most important research in Mathematics Education carried out at UCR and UNA was developed under the leadership of Angel Ruiz.

An important dimension worth mentioning is the relationship that Costa Rican researchers have had with the international community, particularly Edison de Faria and Angel Ruiz: De Faria with the *Latin American Committee on Educational Mathematics* for many years, and Ruiz with the *Inter-American Committee on Mathematics Education* (since 1987) and the *International Commission on Mathematical Instruction* (since 2010). A result of the international connections fostered by Ruiz was the realization in Costa Rica of the *Capacity and Networking Project* (CANP 2). This event received more international support for the teaching of Mathematics than any other that has been held in the Central American region. It also permitted the creation of the *Mathematics Education Network for Central America and the Caribbean* (www.redumate.org).

A crucial moment in the evolution of the teaching of Mathematics in Costa Rica occurred when various researchers from the *Center for Research and Teacher Preparation in Mathematics Education* in 2010–2012 wrote a new curriculum for school Mathematics and began its implementation in 2013.

Reform in Mathematics Education: A New Curriculum

In 2010, the Costa Rican Minister of Education, Leonardo Garnier, approached Angel Ruiz concerning a possible reform of the school Mathematics curriculum. An agreement was reached with authorities at the MEP to carry out the reform from first grade to the last year of academic upper secondary. The agreement included that the curricular reform would be the first step in an integral reform strategy that would include teacher development and support materials. It was further agreed that the development would be led by a group of researchers associated with *Center for Research and Teacher Preparation in Mathematics Education*. That group would be reinforced with in-service elementary and secondary teachers, and there would be a network of advisors and reviewers in Costa Rica and other countries to support the work.

In August of 2011 the first curricular proposal was presented to the Higher Council of Education (CSE). The CSE asked that the public universities study and evaluate the proposal. Before the final approval of the curriculum, the MEP and the reform team, in the second half of 2011, performed a national process of "socialization" of the proposal with in-service teachers. This process involved more than 7500 elementary and secondary teachers, national and international experts, university academics, and specialists in curriculum design, Mathematics Education, evaluation, technology and other.

With the suggestions from the universities, in-service teachers and the writing team itself, a version of the new curriculum was presented to the CSE in April of 2012. On May 21, 2012 the new curriculum for elementary and secondary Mathematics was approved. Implementation began, gradually, in 2013.

The main approach of this curriculum is **Problem Solving, with a special emphasis on real contexts**. Although this terminology has been used in curricular experiences in various parts of the world, in the case of Costa Rica it has been done in a specific and original way with a pedagogical strategy in the classroom that breaks the dominant paradigms with respect to teaching Mathematics. Higher cognitive capacities are constructed in the students by starting from associations with real environments and with interesting challenges to promote learning and mobilize and apply knowledge adequately. Its contents and perspectives aim to overcome the dominant "mathephobia" and make a qualitative leap in Mathematics learning that will serve the citizenry in using Mathematics and the related competencies to improve the quality of life for all.

To advance this educational reform, in 2012 a megaproject was launched: *Mathematics Education Reform in Costa Rica* that integrates various types of activities (www.reformamatematica.net). The project, written and directed by Angel Ruiz, was funded by the Costa Rica United States Foundation for Cooperation (CRUSA, an NGO) for three years (within the period 2012–2016) and it was extended in 2016 for a new period 2016–2018, this time with the financial support of CRUSA and mainly the Costa Rican *Entrepreneurial Association for Development* (a network of important private business enterprises).[6]

In addition to writing the final version of the new programs, the project has developed:

- Blended (hybrid) courses (that integrate face-to-face and online sessions).
- Pilot projects (to measure the progress of the project),
- Many support documents for teachers,
- A virtual Mathematics Education community and various means of communication and dissemination,
- MOOCs (*Massive Open Online Courses*) for in-service teachers.

This synergistic combination of actions puts Costa Rica at the vanguard in the region.

This Project has disrupted the conditions of initial and continuing preparation of Mathematics teachers in the country. The nature of professional development has drastically changed:

- More support from the MEP by involving secondary and elementary teachers (for years this later group had not received much support).
- Professional development that breaks with the face-to-face tradition offered by the universities,
- The blended (hybrid) and virtual nature of the professional development,
- An emphasis on the pedagogy specific to the Mathematics, in contrast to previous professional development that treated Mathematics and general pedagogy separately,

[6]Updated data in 2016.

- Blended courses used not a "trickle down" scheme, but included two steps: one step with teacher leaders and regional mathematics pedagogical advisers (officials set by the MEP to attend both primary and secondary teacher activities at the regional level) and another with large populations of teachers, where the leaders are facilitators in this second level of courses.

The Project is in charge of all the details of the design and development of the courses directly with the teacher leaders. This has been very successful, maximizing the nourishment of an essential pedagogical leadership. The massive blended courses, although they are designed by the project and there are facilitators prepared by the project, are not served directly by the project. Instead, the IDP-UGS and MEP's regional directorates are directly responsible and, therefore, so far the national results have been quite varied. In some regions there has been great success while in others there have been serious difficulties. It will be in the medium and long term when it will be fair to evaluate the global achievement of this innovative modality for massive professional development.

With respect to initial teacher preparation, UCR, ITCR and UNED are carrying out actions to bring about consistency between their preparation programs and the new school curriculum. So far, it is UCR that has advanced the farthest in this effort.

This educational reform will need considerable time to be consolidated, but very solid steps have been taken.

It is interesting to note the international connections that Angel Ruiz has brought to this project. Not only was there CANP 2 (inaugurated by the Minister of Education and in which many ministerial advisors took part), but also in late 2011 an ex-President and the two Vice Presidents of the *Inter-American Committee on Mathematics Education* visited Costa Rica to present activities in direct support of the curricular change.

This reform of school Mathematics has put into motion in an integrated way factors that have been in development for many years, but did not necessarily guarantee what has fortunately happened. There has been significant research in Mathematics Education, high-level international connections, and a homogeneous team committed to progress in this discipline. The political circumstances (perhaps fortuitous) of a Minister of Education who supported these actions paved the way for a change in the perspectives related to teaching this subject. Details on this process from it incubation to the present can be found in Ruiz (2013).

Strengths, Weaknesses, Threats and Main Challenges

Strengths

The increase in the level of preparation and degree completion of the teacher population constitutes a human base for launching actions for progress in Mathematics Education.

The four public universities that offer Mathematics teacher preparation programs have improved their administrative conditions and curricular coherence through a process of accreditation and self-evaluation.

The existence in the country of a consolidated Mathematics Education research team, with strong national and international connections and high level political support, is an important strength.

Costa Rica has an officially approved new high quality school curriculum that is a powerful starting point. Simultaneously important actions for its implementation via the *Mathematics Education Reform in Costa Rica* project have been initiated. These two dimensions are strengths that can improve teaching and learning of Mathematics. And all the processes of initial and continuing preparation moving forward should be considered within this scenario.

Weaknesses

There are no mechanisms of support and selection in place in the universities with teacher preparation programs to be able to attract future teachers from among upper secondary graduates with the strongest academic backgrounds. The State and society do not grant teacher preparation programs sufficient self-supervision and control.

The universities that prepare Elementary teachers do not produce professionals with an appropriate mathematical preparation to achieve high standards in the teaching of this subject. Linked to this, the secondary Mathematics teacher preparation programs do not articulate the pedagogy and Mathematics courses very well. The programs do not present international Mathematics Education experiences and results, and are disconnected from classroom practice.

The State, the country's main employer of teachers, does not have clear professional profiles nor does it use adequate processes for hiring quality Mathematics teachers. The working conditions do not permit specific times during the work day for continuing preparation, classroom research and shared governance processes for improving teaching.

There is a lack of national strategic plans that integrate the different institutions (the MEP, universities, unions) to offer professional development for in-service teachers.

Threats

The absent State control of teacher preparation programs at the universities has meant that the private universities with lower program quality are now graduating more teachers. This has had repercussions on the status of the profession and in the possibilities for improving classroom teaching. If this situation persists, it will be

almost impossible to have the appropriate conditions to meet the challenges faced in Mathematics teaching.

If the teacher preparation programs (both Elementary and Secondary) in the universities do not make significant changes based on research and international best practices that converge with the new curriculum approved in 2012, it will not be possible to assure continuity in the positive changes that have been introduced in the country.

The continuity of the *Mathematics Education Reform in Costa Rica* project is not assured. Also, it is not guaranteed that the impetus generated by the reform will more forward, as it depends on the MEP. Conspiring against such continuity is the lack of State policy to **not** modify positive and successful processes simply for convenience or out of ignorance (In Costa Rica the government, and therefore the Minister of Public Education, changes every four years). Another threat is that it is possible that MEP officials who see themselves affected by curricular change and the pressure of new duties (they would like to reject) might be able to impose setbacks to the reform.

Challenges

Carrying out significant reform to the public university initial Elementary and Secondary teacher preparation programs is a challenge. It will also be necessary to reorient research in the public universities to support, significantly, not only initial preparation, but also other actions so that the ambitious educational reform processes in school Mathematics can be successful.

Increasing State control over Mathematics teacher preparation programs at private universities and creating within the MEP a competitive system for hiring Mathematics teachers that can ensure and improve the quality of the teaching force remain as challenges.

Establishing an aggressive policy of in-service teacher professional development based on a strategic plan that integrates initiatives from diverse stakeholders is another challenge.

A final challenge is to sustain the actions of the Mathematics teaching reformers and the new curriculum aims, built on international best quality parameters with national relevance.

Closing Statements

The progress in initial preparation of Mathematics teachers that can be achieved in Costa Rica will depend on the clarity, decisions and actions of many involved. What is done by the public universities will be decisive given the resources they

possess, their educational trajectory and the social esteem they enjoy. However, for various reasons there is not an absence of inertia and paralysis in this realm.

But there are not only individual institutional responsibilities. The role of the State at this time in Costa Rica is decisive. A will to more aggressively exercise control and supervision over what is happening in initial teacher preparation programs is a necessary condition. This is also a responsibility for Costa Rican society in general, particularly given that adequate paths of action are not always taken (for example, accreditation of university Education programs is not a legal requirement). Without legislative support and the backing of civil society, the State cannot act.

The "Modern Mathematics" curricular reform of the 1960s and 1970s decisively determined the teacher preparation programs for decades in Costa Rica. Now, fifty years later, a new curricular and intellectual reform proposes an impact of similar proportions. But this time, the changes that have been introduced have adopted with clarity findings that have already been consolidated on the international scene by the field of Mathematics Education that has become a scientific discipline and independent profession.

Appendix: Meanings of Acronyms

CIMM	Center for Research on Mathematics and Meta-Mathematics
CSE	Higher Council of Education
CRUSA	Costa Rica United States Foundation for Cooperation
IDP-UGS	Uladislao Gámez Solano Institute for Professional Development
MEP	Ministry of Public Education of Costa Rica
PIFEM	Program for Research and Preparation in Mathematics Education
TEC	Costa Rica Institute of Technology
UCR	University of Costa Rica
UNA	National University
UNED	State Distance University

References

Barrantes, H., & Ruiz, A. (1995a). La reforma de Mauro Fernández y las Matemáticas. In A. Ruiz (Ed.), *Historia de las Matemáticas en Costa Rica*. San José: EUCR, EUNA.

Barrantes, H. & Ruiz, A. (1995b). Los programas de matemáticas en la enseñanza primaria y secundaria costarricense entre 1886 y 1940. In A. Ruiz (Ed). *Historia de las Matemáticas en Costa Rica*. San José: EUCR, EUNA.

Barrantes, H. & Ruiz, A. (1995c). La Escuela Normal, los colegios y las Matemáticas hasta la creación de la Universidad de Costa Rica. In A. Ruiz (Ed). *Historia de las Matemáticas en Costa Rica*. San José: EUCR, EUNA.

Barrantes, J., Bolaños, H., Céspedes, M., Delgado, E., Freer, D., Padilla, E. & Víquez, M. (2010). *Estado actual de la enseñanza y aprendizaje de probabilidad y estadística, en I y II ciclos, en la educación costarricense en las Direcciones Regionales Educativas de Heredia y Pérez Zeledón.* (Licenciate's thesis). Heredia, Costa Rica: Universidad Nacional.

Meza, G. (2012). Director de la Escuela de Matemática el Instituto Tecnológico de Costa Rica (M. Alpízar, Interviewer).

Programa Estado de la Nación en Desarrollo Humano Sostenible. (2005). *Estado de la Educación 1* (1ª Ed.). San José, Costa Rica: Consejo Nacional de Rectores.

Programa Estado de la Nación en Desarrollo Humano Sostenible. (2008). *Estado de la Educación 2* (2ª Ed.). San José, Costa Rica: Consejo Nacional de Rectores.

Programa Estado de la Nación en Desarrollo Humano Sostenible. (2011). *Estado de la Educación 3* (3ª Ed.). San José, Costa Rica: Consejo Nacional de Rectores.

Programa Estado de la Nación en Desarrollo Humano Sostenible. (2013). *Estado de la Educación 3* (4ª Ed.). San José, Costa Rica: Consejo Nacional de Rectores.

Rodríguez, P., & Ruiz, A. (1995). Antes de la reforma de Mauro Fernández. In A. Ruiz (Ed.), *Historia de las Matemáticas en Costa Rica*. San José: EUCR, EUNA.

Ruiz, A. (2013). La reforma de la Educación Matemática en Costa Rica. Perspectiva de la praxis. *Cuadernos de Investigación y Formación en Educación Matemática*, *8*(Special issue). Retrieved from http://revistas.ucr.ac.cr/index.php/cifem/article/download/11125/10602

Ruiz, A., Alfaro, A., & Morales, Y. (2003). Un cuarto de siglo en la historia de la historia de las Matemáticas en Costa Rica. *Journal UNICIENCIA, 20*(2), 225–249.

Ruiz, A., Barrantes, H., & Gamboa, R. (2009). *Encrucijada en la enseñanza de la matemática: La formación de educadores*. Cartago, Costa Rica: Editorial Tecnológica de Costa Rica.

Valverde, G. (2012). *Escuela de Formación Docente en el Departamento de Educación Primaria y Preescolar; académica de la Sección de Educación Primaria de la Universidad de Costa Rica*. Interviewer: E. Thompson.

Chapter 4
Dominican Republic: The Initial and Continuing Preparation of Teachers

Ivanovnna Cruz and Sarah González

Abstract This chapter was prepared as a baseline document for the *Capacity and Networking Project*, CANP 2012. In this document a synthesis of the main aspects of the historical context of the preparation of teachers, the structures for the initial preparation of Mathematics teachers, the contents of teacher preparation based on the programs offered by institutions that have such programs, a discussion on programs of continuing teacher development, the most recent developments in initial and continuing teacher preparation, and the main strengths, weaknesses, threats and challenges of teacher preparation in the Dominican Republic are presented. It is important to emphasize the impact that reforms and constitutional changes have had on education. Therefore, in this report, the analysis of the historical context has been organized in four stages that have been identified by experts on the history of Dominican education (Almánzar in Trayectoria de la formación del docente dominicano. SEE, Santo Domingo, 2008; Fiallo and Germán in La formación de maestros y maestras en República Dominicana. Búho, Santo Domingo, 1999) who have identified the most important aspects of educational legislation related to teacher preparation. Also, it should be pointed out that the Dominican education system is structured into four levels: initial, elementary, secondary and post-secondary. The Ministry of Education (MINERD) is in charge of the initial, elementary and secondary levels. The Ministry of Higher Education, Science and Technology (MESCYT) directs post-secondary education. Currently in the Dominican Republic there are 42 institutions of post-secondary education and

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22 (52 %) of them offer programs in Elementary Education and 15 (36 %) offer programs in Secondary Education with a major in Physics and Mathematics. These institutions base their teacher preparation programs on regulations established by the *Institute for the Preparation and Development of Teachers* (INAFOCAM). This organization, under the MINERD, is also responsible for establishing the profile of entering students, as well as graduates, and for indicating the number of credits in preparation programs and the distribution of practicum and theoretical hours for each subject. The MINERD is responsible for continuing teacher development in collaboration with the continuing preparation department of the MESCYT. It is important to consider the situation described in this report to understand the working conditions of Dominican teachers.

Keywords Teacher preparation · Mathematics education · Dominican Republic

General Facts About the Dominican Republic

The Dominican Republic is situated on the island Hispaniola which it shares with the Republic of Haiti. Within the Caribbean islands, Hispaniola is the second largest, with a surface area of 48,442 km^2. The Dominican Republic is surrounded by the Atlantic Ocean to the north and to the south by the Caribbean Sea.

The population of the Dominican Republic is 9,980,243 (2013 Census). The capital of the Dominican Republic is Santo Domingo. Greater Santo Domingo has a population of around three million people. The Dominican Republic is a representative democracy. There are three branches of government: the Executive, Legislative and Judicial. Every four years the country elects its president, vice president, legislators and city government officials.

Spanish is the official language of the Dominican Republic. The Colonial City, located in Santo Domingo, with 16th to early 20th century architecture, is recognized by UNESCO as a World Heritage Site. In this country is found the first cathedral, castle, monastery, and fortress built in all the Americas.

On December 5, 1492, Christopher Columbus landed on Hispaniola island, which had been inhabited by the Taíno people since the 7th century. Santo Domingo was the first permanent European settlement in the New World and became the first seat of the Spanish Empire in the Americas.

The Dominican Republic has a growing economy; it is the ninth largest one in Latin America and the largest of the Caribbean countries. The Dominican Republic has been one of the fastest growing economies in the Americas during more than 20 years. For many years the economy of this country was known for agriculture and mining, nowadays is dominated by services, where tourism is a very strong component.

In the Dominican culture music and dance are very important, with merengue and bachata the best known. For many years baseball has been the favorite sport.

Brief Description of the Education System in the Dominican Republic

Levels and Cycles in Education in the Dominican Republic

The educational levels in the Dominican Republic are divided into:

- ***Initial***. This level is divided into three cycles: 0–2 years, 3–4 years (from 0 to 4 only in private institutions) and a third cycle that is obligatory for all 5 year olds. There are almost 240,000 students at this level.
- ***Elementary* (*Basic*)**. This level is obligatory and is divided into two cycles: the first cycle (grades 1–4) and second cycle (grades 5–8). There are approximately 575,000 students at this level.
- **Secondary**. This level is not obligatory, but is offered by the State. It is organized into two cycles. The first is common for all students. The second cycle is classified by modalities: General, Technical Professional and Arts. There are almost 1.2 million students at this level in addition to over 140,000 in a modality specifically for adults.
- ***Higher***. The Ministry of Higher Education, Science and Technology (MESCYT) is in charge of this level. It is structured into three kinds of Institutions of Higher Education (IES): Technical Institutes of Higher Studies, Specialized Institutes for Higher Studies and Universities. The Technical Institutes of Higher Studies only offer two and three-year technical programs. The Specialized Institutes for Higher Studies offer undergraduate and graduate degrees in the specializations for which they were created. The universities can grant undergraduate and graduate degrees, including doctorates. There are 42 Institutions of Higher Education in the Dominican Republic with over 435,000 students.

National Diagnostic and Obligatory Tests

In the Dominican Republic a national diagnostic test is given at the beginning of grade 4. It is intended to evaluate competency in reading comprehension and Mathematics in accordance with achievement indicators. The results of this test are used to take actions that will contribute to improving the learning process. Also, questionnaires are given to principals, teachers and students to collect information on the socioeconomic context and opportunities for learning.

There are also obligatory National Tests given at the end of each educational level. Those tests evaluate achievement in Spanish, Mathematics, Social Sciences and Natural Sciences. There are three opportunities to take them in Secondary Education and two in Elementary Education. The results have a weight of 30 % on the final grade that determines whether or not a student will be promoted.

Some Historical Facts Relevant to the History of Education the Dominican Republic

The historians, Fiallo and Germán (1999) and Almánzar (2008), have organized the most important episodes of legislation and teacher preparation that have affected Dominican Education into four periods.

From the Rise of the Dominican State to the Rise of the Normal Schools (1844–1879)
During this period the first law concerning public instruction in elementary schools was enacted and with it the Dominican education system was created. The law created regulations for the management of the schools. It further established that schools should have exercises in grammar and arithmetic operations, as well as formal tests. In 1846 the government established programs of study for both elementary and secondary schools.

From Normal Schools to Occupation by the United States of America (1879–1924)
The Normal Schools were created in 1879. In 1881 the Institute for Young Ladies was created to prepare female teachers. The Normal Schools became Central Colleges in 1885, but began to reappear as Normal Schools beginning in 1900. Farm Schools and rural schools were created. It was during this period that education became obligatory for boys and girls from 7 to 14 years old in co-educational settings.

From the End of the Occupation by the United States of America to the Dictatorship of Rafael Trujillo (1924–1961)
In this stage, the teaching force and secondary schools were reorganized, and untrained teachers were given tests so they could be formally accredited as teachers. The principles of the "New School" were established with the help of a "Chilean Mission" supervised by the Secretariat of Education. In turn, new Normal Schools were converted into centers specialized in teacher preparation. Also, new programs were established for elementary, intermediate and secondary schools.

In 1951, a law was enacted related to public schools that required elementary teachers to be graduates of a Normal School, and that secondary teachers had to have a Bachelor's Degree or doctorate.

From the Birth of Democracy to Today

This period has seen the diversification of secondary education and the universities began to prepare secondary teachers. Massive programs for the professional development of in-service elementary teachers were carried out. An Inter-University Agreement (UASD, UCMM, UNPHU, SEEBAC y UNESCO) was signed for secondary teacher preparation. This agreement led universities to create departments or schools of Education to prepare teachers in different areas. Several

new programs were established: a Ten-Year Plan with new regulations for education, the Program for the Development of Elementary Education (PRODPE), an elementary teacher preparation program in the Salome Ureña de Henríquez Teacher Preparation Institute (INFODOSU), and for secondary teachers by the universities under the supervision of the National Institute for the Preparation and Professional Development of Teachers (INAFOCAM).

Initial Preparation of Teachers

As was mentioned above, initial teacher preparation has been linked to the different historical periods. This preparation became important when the law was passed requiring teachers to be graduates of formal programs. It was supported by Inter-University Agreements, and by the creation of common programs that were developed with assistance from UNESCO.

"Modern Mathematics" was implemented in the teacher preparation process. New textbooks and continuing teacher preparation programs were also developed to support "Modern Mathematics" (González 2011).

For the preparation of teachers studying the emphasis in Mathematics and Physics textbooks were used from the School Mathematics Study Group (SMSG) and the Physical Science Study Committee (PSSC) in the United State of America where both series had been used in high schools. In Algebra courses the book by Allendoerfer and Oakley (McGraw-Hill, 3ª ed. 1972) was used. The Leithold and Swokowsky book was used for Calculus. In General Physics at the university level the books of Feynman and Sears were adopted.

In the 1990s, the State Secretariat for Education, Fine Arts and Culture (SEEBAC) established programs for the continuing preparation of teachers. At the Elementary level there was the *Program for the Development of Elementary Education* (PRODEP) while at the Secondary level four universities implemented a *Program for Professionalizing Secondary In-Service Teachers* (PPMB). Approximately 8000 teachers from throughout the country took part in PPMB.

Also in this period the General Law of Education No. 66–97 was passed. In its Article 222 the Normal Schools and the National School of Physical Education were elevated to the level of higher education. Today they constitute INFODOSU. This same law created INAFOCAM as a decentralized organization, affiliated with the Secretariat of Education and in charge of coordinating professional development programs offered to teachers.

The Structure of Initial Teacher Preparation

There are currently 42 Institutions of Higher Education (IES) in the Dominican Republic. Twenty-two of them offer programs in Elementary Education and 15 offer the program in Secondary Education with an Emphasis in Mathematics and Physics.

According to the *General Report on Higher Education Statistics 2006–2009* of MESCYT, the Education programs were the second most in demand in 2006, 2007 and 2008 with respectively 15, 14 and 12 % of the total enrollment. It slipped to fourth place in 2009 with 11 % of the total. The graduation rate for four-year Education programs is around 24 % (MESCYT 2011). Most of the students are enrolled in Elementary Education programs and less than 1 % are in the Mathematics and Physics program.

The Elementary Education enrollment is concentrated in eight of the 22 IES that offer them and have 92 % of the enrollment. For Mathematics and Physics four of the 15 have 82 % of the total enrollment for that Emphasis.

The Elementary Teacher Education Program

Institutions of Higher Education that offer Elementary Education Programs must base their program of studies on Ordinance 1-2004 that was established by the National Institute for the Preparation and Professional Development of Teachers (INAFOCAM). This ordinance sets the student entrance and graduation profiles, and the distribution of courses to be taught. It also establishes the curriculum for the program with lists of courses, the number of credits for each course, the distribution of practical and theoretical hours for each course, as well as the organization of courses into academic periods.

This ordinance also establishes two concentrations for the Elementary Education program: one for teachers in the First Cycle (preprimary to grade 4) and another for the Second Cycle (grades 5–8). The programs of study have the first year in common. Beginning with the second year, some courses are in common and some are specific to the particular Cycle.

There have been modifications to improve this ordinance, but there are still reforms in progress that are not yet reflected in the current preparation programs. The curriculum requires courses in four basic areas: Mathematics, Spanish, Natural Science and Social Sciences. The Mathematics courses are organized as Integrated Studies in Mathematics I, II, III and IV. The other areas are similarly organized. The term "Integrated Studies" refers to integrating the content with the teaching and learning methodology specific to the area. In practice, in the majority of cases, specialist report that such integration is often not achieved.

We can group the courses in six strands in which the contents for teacher preparation are organized. The strands are the following:

1. General Education: Regular courses from those offered by the IES.
2. Content Courses: Letters, Natural Sciences, Social Sciences, Languages, Technology, Arts, Electives.
3. Mathematics Content Courses.
4. Pedagogical Courses: Pedagogical Theories, General Teaching Methods, Guidance and Counseling, Psychopedagogy, Planning, Psychology.

5. Mathematics Teaching Methods.
6. Student Teaching.

For this document we have considered the programs at only the eight of 22 IES's that prepare 92 % of future Elementary teachers. Of those eight, two are public and the rest private. However, it is important to mention that INAFOCAM does supervise the programs in the private institutions.

An analysis of the programs in those eight institutions shows that no more than 10 % of the credits are in Mathematics content courses. Pedagogical courses oscillate between 26 and 40 %, but less than 8 % of those are specific to Mathematics Education. In all of the programs, student teaching is distributed in different parts of the curriculum, but always has courses on teaching methods as prerequisites.

The Secondary Education Program with a Major in Mathematics and Physics

To analyze the components of the preparation in Mathematics Education with an Emphasis in Physics and Mathematics the four Institutions of Higher Education that had about 82 % of the enrollment from 2006 to 2009 were chosen.

Below the courses are classified into the following six thematic strands:

1. General Education: Philosophy, Art, Introduction to University Life, Ethics and other general courses at each IES.
2. Content Courses: Letters, Natural Sciences, Social Sciences, Languages, Technology, Physics, Arts, Electives.
3. Mathematics Content Courses.
4. Pedagogical Courses: Pedagogical Theories, General Teaching Methods, Guidance and Counseling, Psychopedagogy, Planning, Psychology.
5. Mathematics Teaching Methods.
6. Student Teaching.

After analyzing these programs and reviewing other offerings that were not part of the report and that contributed very little to the national enrollment for this Emphasis it can be affirmed that:

(a) The programs include the majority of the contents of basic Mathematics that are taught in Secondary schools: Algebra, Trigonometry, Geometry, Advanced Algebra, Statistics and notions of Infinitesimal Calculus.
(b) Mathematics teaching methods are concentrated in one course or in another case are presented as "Mathematic Teaching and Student Teaching".
(c) The History of Mathematics is only found in two of the programs studied. In another, the history of Mathematics is integrated into a course on the History of Physics.

(d) These programs do not include technology as a specific strand. Only 2 % of the credits in the programs are related to technology topics and in no case is there a specific course on technology applied to Mathematics.
(e) Student Teaching is present in different academic periods in the programs, but one of the programs does not include Student Teaching.

It is important to note that recently standards for the initial preparation of teachers have been established. They have been published by the MESCYT in a document called *Plan for Reformulation of Teacher Preparation* (Vincent 2010). To operationalize the standards 10 dimensions have been established: Curricular structure, general preparation, content preparation, pedagogical preparation (theory and practice), pedagogical content preparation, entry level profiles, organizational structure and management capacity, teaching and support personnel, infrastructure, learning services and resources, and evaluation systems. In addition to the "dimensions" there are 47 "criteria", 191 "quality indicators" and 263 "items of evidence" (p. 137). The new programs should include a system of supervised student teaching and internships, with common parameters, clear indications of the organization and distribution of academic loads. Along the same lines, it is worth pointing out that the Ministry of Education (MINERD) is offering opportunities to prepare young people who are interested in being a part of the education system as teachers.

Continuing Preparation

The MINERD is responsible for initial Elementary and Secondary Education as well as continuing preparation of teachers in collaboration with MESCYT's Continuing Preparation Department. These two ministries organize teacher preparation to cover the needs of in-service public school teachers. INAFOCAM is in charge of implementing the preparation.

INAFOCAM has set the following objectives for the continuing preparation of teachers

- Implement preparation processes that develop teacher competencies that permit the practical use of reflexive and participatory methodologies.
- Strengthen teacher capacity and competence so they can demonstrate quality work in the contexts in which they work.
- Use professional development processes that support teachers in developing reflexive and inquiry-based practice that consider the reality of the students and the school.
- Develop school and classroom leadership in the context of the community.
- Promote a preparation that uses quality learning resources, including Information and Communication Technologies (OEI 2003, p. 12).

The institutions of Higher Education have been invited to present proposals for continuing preparation, which are evaluated by criteria set by the two ministries. The approved proposals are those that fulfill the structure established by INAFOCAM. Courses and workshops are being offered to in-service teachers all the time. Some are focused on pedagogical topics such as educational planning and evaluation of learning. Others focus on disciplinary content. The purposes and priorities of continuing preparation respond to curricular changes and innovations that the MINERD would like to implement. The tests administered to students and reports from classroom observations made by district level specialists are also used to detect continuing preparation needs.

INAFOCAM sets the prerequisites needed by teachers to be able to participate in continuing preparation programs. The main prerequisite is to be an active teacher in the public sector who teaches the subject or topic on which the course is based and to work in the region where the course will be offered. Teachers from the private sector are responsible for their own professional development. In some cases, private institutions cover the costs of the continuing preparation of their teachers.

MINERD and MESCYT develop scholarship programs so that as part of their continuing preparation teachers can participate in national and international conferences, as well as in Master's and doctoral programs.

Other professional development activities are carried out in the country by the program called *Support Policy for the Primary Grades*. This program focuses on Spanish and Mathematics. Three institutions collaborate with the MINERD on this program. Pontificia Universidad Católica Madre y Maestra (PUCMM) works in the Regional Educational Directorates in Cibao and the north, as well as in the Herrera District 15-05 of Region 15 in west Santo Domingo. The Poveda Cultural Center attends the Regional Directorates of the south and of Santo Domingo. The Organization of Ibero-American States deals with the three Regional Directorates in the eastern part of the country. This program offers professional development to primary teachers, and district general specialists and Mathematics specialists, as well as teacher coordinators and assistant principals that work with teachers.

For Mathematics in the zone it attends, PUCMM uses a series of textbooks designed for the program. The books were written to be aligned with the curriculum proposed by MINERD in order to achieve its objectives. Manipulatives have been distributed that were selected in accordance with purposes of the Mathematics classes (base ten blocks, *Cuisenaire* rods, pattern blocks, tangrams, measurement tools, etc.). The teachers are also supported by coordinators in their schools. This program originated in another initiative in the PUCMM that was funded by the U.S. Agency of International Development (USAID) that began in 2006. At least 150 h of face-to-face professional development have been offered to teachers. The mathematical concepts taught at this level and the corresponding competencies have been emphasized. A profound knowledge of the Mathematics curriculum (topics and strands, knowledge, communication, reasoning, problem solving, connections, valuing Mathematics, decision making) and efficient use of class time have also been emphasized.

Recently the country has added 4 % of the gross domestic product to provide additional resources for education. With this additional funding it is hoped that initial preparation programs will offer true opportunities for young people interested in becoming educators, as well as for in-service teachers who wish to improve their teaching. For Mathematics the MINERD plans to continue the teacher professional development that has been offered to teachers in grade 1–4, and expand it to the rest of the pre-university system. The programs must be restructured to address the standards for those levels and to respond to the curricular changes proposed in 2012.

Research in Mathematics Education

In 2008 the *Dominican Institute for Evaluation and Research on the Quality of Education* (IDEICE) was created by the National Council of Education using Ordinance 03-2008 based on the General Law of Education 66–97. IDIECE is a decentralized public institution, affiliated with the MINERD, of a technical nature dedicated to Educational Research.

However, it should be pointed out that given its recent creation the number of published research reports is still small. In reality there are no local doctoral programs that encourage research. Currently only three universities have doctoral programs, one public and two private.

Other research is carried out by INAFOCAM. Its team of researchers continuously monitors the preparation programs that it finances as well as other studies on teacher preparation in the Dominican Republic.

In 2003, the *Evaluation and Educational Research Consortium* (CEIE) was created by the Mother and Teacher Pontifical Catholic University (PUCMM), the State University of New York, and the Santo Domingo Institute of Technology. CEIE carried out the *Monitoring and Evaluation Study of the Quality of Education in the Dominican Republic*. It followed a population of 26,000 students in grades 3–8 for three years to evaluate their performance in Mathematics and reading comprehension.

Beginning in 2006, PUCMM, with support from the U.S. Agency of International Development (USAID), provided a program of professional development to more than 4000 teachers in the north of the country and one area of Santo Domingo. This program, mentioned above, included a component of Monitoring and Evaluation in which the knowledge that the teachers needed to teach the Mathematics was tested by having them take the same tests that their students took at the end of each school year. The results were used to determine needed teacher professional development and to study the impact of teacher mathematical knowledge as an explanation of student performance.

Relation Between Initial and Continuing Preparation and the School Mathematics Curriculum

Currently, in the Dominican Republic, both the school curriculum, and programs for initial and continuing teacher preparation, are being revised and modified. This modification proposes a competency model for both curricula.

New programs are being developed for continuing preparation at a national level that will provide professional development for in-service teachers.

For initial teacher preparation, in addition to offering academic specializations for future grades 1–8 teachers, there is also specialization for grades 1–4 and 5–8.

Main Strengths, Weaknesses, Threats and Challenges

Strengths

- About 92 % of students have access to a grades 1–8 education, and drop out and grade repeating rates are down.
- Diagnostic studies have determined teacher professional needs and quality standards have been set. The Ministry finances professional development programs that include classroom support to improve in-service teacher performance. Adequate programs for the continuing preparation of Mathematics do exist.
- Initial teacher preparation programs have been revised and unified.
- Training programs for Principals have been created.
- Teachers can now specialize in the level they will be teaching.
- The use of manipulatives for the teaching and learning of Mathematics has been introduced in grades 1–8.
- There is a greater consciousness in all sectors of the country of the importance of education in overcoming poverty.

Weaknesses

- Access to upper secondary education is barely 37 %. Drop out and absentee rates are high in regions where school aged children are in the workforce.
- There are many teachers with official certification, but such certification does not necessarily mean that they are indeed qualified. Many teachers are prepared by the system, but there is often a lack of commitment to the system once they are prepared.

- The majority of teachers work two shifts so there is little time for planning and design of teaching-learning strategies. Nor does such a situation facilitate the professional development of in-service teachers. Contracting teachers is sometimes the result of political party affiliations rather than professional competence.
- Special programs do not reach all regions.

Threats

- Preparation programs do not last long given the institutional weakness of the system.
- Teacher compensation policies do not permit the attraction of the strongest talents to the teaching profession.
- There are limited resources for teacher preparation and purchase of adequate materials.
- Some teacher preparation institutions do not have human resources with backgrounds adequate for carrying out their programs nor the resources and infrastructure required to offer good quality programs.
- There is little integration of Information and Communication Technologies into the teaching-learning process. Thus the technological gap between rich and poor is deepening.

Challenges

- Increase access to upper secondary education.
- Provide opportunities for talented youths to become Mathematics teachers. Structure policies that attract talented youths to the teaching profession, particularly to Mathematics teaching.
- Improve the teacher preparation programs in the Institutions of Higher Education. Provide oversight to ensure that programs fulfill the standards set by the MESCYT and MINERD.
- Improve the quality of those who work in teacher preparation. Create solid Master's and doctoral programs to prepare Mathematics teachers at the highest level.
- Create professional development programs for in-service Mathematics teachers at all levels of the system.
- Make a commitment to have better teachers in the Institutions of Higher Education that offer such programs.
- Identify excellent textbooks for Mathematics.
- Improve the teacher compensation system.

- Increase the use of Information and Communications Technologies in the teaching-learning of Mathematics.
- Prepare the needed number of strong Mathematics teachers that will permit learning opportunities to be offered to 95 % of Dominican children and youth at all levels.

Conclusions

In the last few years the Dominican Republic has made important attempts to provide certified teachers to the system. Various in-service teacher professional development programs have been developed. INAFOCAM has implemented scholarship programs that have helped many teachers. Nevertheless, these efforts have not translated into improvements in student learning.

One of the challenges for Dominican education is to create Master's and doctoral programs to prepare teachers at the highest level, with qualified and experienced professors, especially in the basic sciences. The quality of programs and courses of continuing education must be strengthened to respond to the needs that have been detected. Also, the results of research on curricular design must be linked to teacher preparation programs. There is evidence that teachers at all levels have significant weaknesses in their mathematical knowledge in general and in particular with respect to the Mathematics they teach. They also have weaknesses with respect to specialized methods and strategies for facilitating and evaluating the learning of Mathematics. Therefore, initial and continuing preparation programs must focus on these detected weaknesses.

The panorama that has been described in this report reflects that the Dominican Republic has much to do to improve education. One of the central aspects in this sense is the preparation of qualified teachers that can successfully confront the challenges faced by modern society.

Appendix: Meanings of Acronyms

AID	Agency for International Development
CEIE	Evaluation and Educational Research Consortium
CORENOR	Commission for the Restructuring of Normal Schools
IDEICE	Dominican Institute for Evaluation and Research on the Quality of Education
IES	Institutions of Higher Education
INAFOCAM	Institute for the Preparation and Development of Teachers
INFOTEP	Institute for Technical Professional Preparation
ISFODOSU	Higher Institute for Teacher Preparation Salomé Ureña de Henríquez

MESCYT	Ministry of Higher Education, Science and Technology
MINERD	Ministry of Education
OECD	Organization for Economic Co-operation and Development
PSSC	Physical Science Study Committee
POMA	Diagnostic Test for Academic Measurement
PRODEP	Program for the Development of Elementary Education
PUCMM	Mother and Teacher Pontifical Catholic University
SEEBAC	State Secretariat for Education, Fine Arts and Culture
SMSG	School Mathematics Study Group
UASD	Autonomous University of Santo Domingo
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNPHU	National University Pedro Henríquez Ureña

References

Almánzar, J. N. (2008). *Trayectoria de la formación del docente dominicano*. Santo Domingo, República Dominicana: SEE.

Fiallo, J., & Germán, A. (1999). *La formación de maestros y maestras en República Dominicana*. Santo Domingo, República Dominicana: Búho.

González, S. (2011, July-December). Aportes a la Educación Matemática en República Dominicana y Latinoamérica. *Cuaderno Pedagogía Universitaria*, pp. 16–22.

MESCYT. (2011). *Informe General sobre Estadística de Educación Superior 2006–2009*. Republica Dominicana: Innova Technology.

Organización de Estados Iberoamericanos (OEI). (2003). *Organización y Estructura de la Formación Docente en Iberoamérica*. OEI: autor. Retrieved from http://www.oei.es/quipu/dominicana/

Vincent, M. (2010). *Características de los Planes de Estudio de Formación Docente en República Dominicana. Seminario Interinstitucional Reformulación de la Formación Docente en República Dominicana*. Santo Domingo: MESCYT.

Chapter 5
Venezuela: Initial and Continuing Preparation of the Mathematics Teacher

Nelly León Gómez and Walter O. Beyer Kessler

Abstract The academy and society are interested in teacher preparation because of the implications it has for teaching practice and, consequently, for student learning. Based on this premise, the initial and continuing preparation of teachers was one of the focal points of the *Capacity and Networking Project*, CANP 2012, that was held in Costa Rica in August of 2012 sponsored by ICMI (International Commission on Mathematical Instruction) and IMU (International Mathematical Union). Each delegation participating in the event prepared a report on the situation in their country. This chapter is a summary version for the case of Venezuela (León et al. in Cuadernos de Investigación y Formación en Educación Matemática 8:89–129, 2013a). Here we begin with a description of the Venezuelan education system to then indicate elements of initial and continuing preparation of the Venezuelan Mathematics teacher that include: a brief historical contextualization; the structure and content of initial preparation, highlighting the relationships among the pedagogical and mathematical preparation and its link with professional practice; continuing preparation and the role of research in the preparation and professional development of both elementary and secondary teachers; and the connection of said preparation with the school curriculum. Finally, the most notable weaknesses and strengths will be indicated, and the main medium term and immediate challenges faced in Mathematics teacher preparation will be enumerated.

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General Facts About Venezuela

Venezuela is a federal republic located on the northern coast of South America. It borders Guyana and the Atlantic Ocean to the east, Brazil and Colombia to the South, Colombia to the west and the territorial seas of the Dominican Republic, Netherland Antilles, Puerto Rico, Virgin Islands, Martinique, Guadeloupe, Trinidad and Tobago and Dominica to the North.

It has a total area of 916,455 km^2, plus the Essequibo area of 159,542 km^2 disputed with Guyana. The population in the year 2015 was estimated in 31 million. The majority of Venezuelans live in urban areas in the north, with a great population density in the Metropolitan Area of Caracas (its capital city).

Spanish is the official language; however, the Constitution recognizes more than 30 indigenous languages. A majority of the population is Christian, primarily Roman Catholic.

In his third voyage to America, in 1498, Christopher Columbus arrived in Venezuela, where lived many indigenous groups such as Caribs, Cumanagotos, Mariches, Timoto-Cuicas and Caquetios. Spain's colonization of mainland Venezuela started at the beginning of the 16th century and continued until the independence was reached in 1811, with Simón Bolívar as the most outstanding hero.

Nowadays Venezuela is a democratic, federal and non-centralized State, with public power divided into executive, legislative, judicial, electoral and citizen authorities.

Its culture is a melting pot created by the influence of indigenous, African and Spanish traditions. Its syncretism shows up in art, culture, cuisine as well in customs.

Venezuela has the largest oil reserves and the eighth largest natural gas reserves in the world. It has a market-based economy dominated by the petroleum (https://en.wikipedia.org/wiki/Petroleum) sector. To a lesser extent it also exports other minerals such as iron, steel, gold and aluminum. It has large areas of arable land (https://en.wikipedia.org/wiki/Arable_land) and important sources of natural water.

It also has many natural beauties such as the Amazon Rainforest, Angel Falls (the world's highest waterfall), Canaima National Park, mountains of the Sierra Nevada de Mérida, Coro's Dunes and beautiful beaches in Margarita Island, Los Roques and Morrocoy.

The Venezuelan Education System

According to the current Organic Law of Education (LOE 2009), the Venezuelan education system is an organic and structured set made up of levels and modalities according to the stages of human development. It is based on the principles of unity,

Table 5.1 Current organization of the Venezuelan education system

Subsystems	Levels		Duration
Basic education subsystem	Initial education	Maternal	Boys and girls from 0 to 6 years old
		Preschool	
	Elementary education	–	6 years
	Secondary education	General secondary education	5 years
		Technical secondary education	6 years
University education subsystems	Undergraduate	Short programs	3 years
		Long programs	5 years
	Graduate (leading to a degree)	Specialization	Up to 4 years
		Master's	Up to 4 years
		Doctorate	Set by each university

Sources LOE (2009) and the National Council of Universities (CNU 2001, 2011)

responsibility and interdependence. Its purpose is to guarantee that the educational process and permanent preparation of every citizen be assured regardless of differences in age, sex, or ethnic or cultural diversity. It should attend the local, regional and national needs and potentials. The organizational structure is shown in Table 5.1.

LOE (2009) indicates that the Venezuelan State, through its Ministry of Popular Power for Education (MPPE) and Ministry of Popular Power for University Education (MPPEU), is in charge of the planning, coordination and implementation of educational policies and programs. The National Council of Universities (CNU) is the link between the MPPEU and the universities. It coordinates admissions to the institutions of Higher Education assigning a percentage of the available quotas. A National Test of Vocational Exploration is given annually to orient upper secondary graduates in choosing careers. For the teaching career there is no specific recruiting mechanism.

According to official data that was provided by the Vice Ministry of Academic Development of the MPPEU for a presentation of the United Nation's Economic and Social Council, during the 2010–2011 school year there was 71 % access in Initial Education, 93 % in Elementary Education and 73 % in Secondary Education. For that same period, a total of approximately 7,739,000 students with 6,074,000 in public schools and 1,665,000 in private were reported. There were 503,240 teachers, 28,908 educational institutions, 297,716 sections of classes and 234,094 classrooms (Reinoso 2011).

For the subsystem of University Education, the institutions are classified as: Universities and Institutes or University Colleges. In 2003, approximately 74,000 students were enrolled at this level. In the universities there were almost 50,000 students: 39,000 in public and 11,000 in private. There are five public universities

that are classified as autonomous and 30 that are classified as experimental. There are also private universities. In 2005, 14 public universities, and four institutes or university colleges offered teacher preparation programs (Peñalver 2007).

Teacher Preparation in Venezuela

Origins and Historical Evolution

It can be said that education as an obligation of the State in a systematic and organized manner began in 1870 with the Decree on Free and Obligatory Public Instruction. Soon, the first Normal Schools were created to prepare teachers for the elementary schools.

However, it was not until 1936 with the creation of the National Pedagogical Institute (IPN) in Caracas that there was preparation for secondary and Normal School teachers. A pedagogical mission from Chile supported the creation of the IPN and the introduction of the New School into the country. The inauguration of the IPN marked an inflection point in Venezuelan education. It happened at a time of political, economic and social changes that were the product of the death of the dictator Gómez in 1935, the oil boom, the slow democratization of the country, and the large exodus from rural areas to cities.

With various ups and downs, in both attention to public schools at all levels and to teacher preparation, each government applied dissimilar educational policies. Thus, in 1958 with a fall of a dictatorship there was a return to a populist educational model and the creation of a pedagogical institute in the city of Barquisimeto. In 1965 the Pedagogical Institute in Caracas adopted behaviorism and the Bourbakistic model of Mathematics. In 1969 a general reform of education at the elementary, secondary and Normal school levels brought in Modern Mathematics to elementary and secondary schools, accompanied by behaviorism and the elimination of the old Normal Schools. Teacher education became a new undergraduate program.

In the 1970s the enrollment growth in secondary schools led to the creation of new Pedagogical Institutes: in Maracay and Maturín in 1971, and the "J.M. Siso Martínez" and a one private both in Caracas in 1976. Also, various universities began progressively to offer teacher preparation programs in Mathematics. However, the pedagogical institutes still had the major role in teacher preparation.

In 1980 a new Organic Law of Education was enacted. It moved the elementary and secondary teacher education to a university level. This process culminated in 1983 with the creation of the Liberator Experimental Pedagogical University (UPEL). It absorbed the pedagogical institutes and became the main teacher preparation institution in the country. "Modern Mathematics" was eliminated and "Back to Basics" was adopted.

Finally, in 2009, another new Organic Law of Education (LOE 2009) was passed. It set out guidelines for the initial and permanent preparation for a teaching career. It also established the current structure of education that is shown in Table 5.1.

The Initial Preparation of Mathematics Teachers

Teacher preparation in Venezuela is governed by regulations presented in Resolution N° 1 in force since 1996. There the profile of an educator is conceived in the context of permanent education in which there is a constant search for professional development for personal and academic growth. A four part curricular structure has been established: General, Pedagogical, Specialized and Professional Practice. The contents of these areas must be articulated with an equilibrium between the ethical, conceptual preparation and its projection into practice in the school environment. Also, the percent of coursework dedicated to pedagogical preparation and professional practice is stipulated to be at least 30 % of the total.

Moreover, LOE (2009) in Article 15, states that Mathematics will be studied during every school year. Its purpose will be to develop the capacity for abstraction and critical thinking. To do so, innovative methods that promote learning from everyday experience will be used. In order to meet this requirement, an even greater number of Mathematics teachers has been needed at a time when there was already a deficit in the number of secondary Mathematics teachers.

Secondary Mathematics teacher preparation is offered in several public universities: the Liberator Experimental Pedagogical University (UPEL), the Central University of Venezuela (UCV), the University of Carabobo (UC), the University of the Andes (ULA), the University of Zulia (LUZ), the University of the East (UDO), the National Experimental University Simón Rodríguez (UNESR), the National Open Universidad (UNA), National Experimental University of Guayana (UNEG), the University Simón Bolívar (USB) and the National Experimental University Rafael María Baralt (UNERMB); as well as in private universities such as the Catholic University Andrés Bello (UCAB) and the Catholic University of the Táchira (UCT). These institutions all grant degrees such as: Teacher of Mathematics, Bachelor's in Education with an Emphasis in Mathematics or Mathematics and Physics, Mathematics Teaching, Mathematics and Computing. These programs last from between four and five years, usually in a semester system with face-to-face presentation. An exception is the UNA which offers distance programs (CNU 2011).

In addition to those universities mentioned above there are many institutions that prepare teachers to teach Mathematics in Elementary schools. These include the Bolivarian University of Venezuela (UBV), the National Program for Educator Preparation (PNFE) as well as Institutes and University Colleges. In both the public and private sector they grant equivalent degrees such as a teaching degree (Profesorado) or Bachelor's of Integral Education or Integral Elementary

Education. Also, they offer three-year programs that grant the degree of Higher Specialist in Integral Education (CNU 2011).

UPEL has the largest number of Education students. It offers a wide variety of specializations: Mathematics in the Pedagogical Institutes of Caracas, Barquisimeto, Maracay and Maturín, and Integral Education for Elementary teachers, who must all teach Mathematics.

With respect to the contents of the preparation of secondary Mathematics teachers, it should be pointed out that the majority of the universities follow a traditional model by components that were established in Resolution N° 1. There is an emphasis on the acquisition of knowledge and competencies that, according to regulations, should characterize the graduate as a professional with a high level of preparation in fundamental theories, principles and techniques in the teaching of Mathematics as a specific discipline. The future teacher should also have the capacity to teach Mathematics according to its processes in a permanent interaction with students. Also, the capacities as a researcher in Mathematics Education, a communicator and motivator of student creativity, and a social outreach activist in the community are emphasized.

According to this theoretical profile, a graduate teacher with a major in Mathematics should be a professional with a solid preparation in Mathematics which should be accompanied by a preparation for teaching that permits the design of learning experiences and situations related to the mathematical contents of the educational level. However, in reality the product obtained does not fulfill many of these expectations.

Table 5.2 summarizes the program of studies for five of the most important universities in the country.

In the administration of this ideal curriculum a separation into disjoint components occurs. This is no more than a reflection of the epistemological perspective that underlines the conception of teacher preparation in Venezuela. According to Parra (2006), teacher preparation has two characteristic features: a parceling of knowledge and a disconnection of theory from reality. Thus, upon graduation and taking teaching positions, new teachers encounter serious difficulties in trying to adapt what they know with the requirements of the level at which they are teaching and the cognitive development of their students. This is because both their mathematical and pedagogical preparation are inadequate, excessively theoretical and without any points of convergence.

Furthermore, the Mathematics courses are intended to be rigorous, even though there is more of an attempt to cover a lot of content rather than to arrive at a profound understanding. The majority of professors follow a traditional model of teaching based on a conception of Mathematics as a deductive and abstract discipline. They center their teaching on a didactic scheme of definition-theorems-exercises with an emphasis on the formality of mathematical language. Also, much of what future teachers learn will never be what they teach. The topics they will have to teach, and for which they should have both conceptual and pedagogical knowledge, are either not taught or are taught in an inappropriate manner.

Table 5.3 summarizes the number of Mathematics courses in five universities.

Table 5.2 Distribution credits and number of courses by the areas of preparation in five Venezuelan Universities

Area of preparation	UPEL		LUZ		UCV		UC		UNA	
	UCR (%)	N° courses	UCR (%)	N° courses	UCR (%)	N° courses	UCR (%)	N° courses	UCR (%)	N° courses
Mathematics major	40	21	47	16	67	15	37	17	35	14
Pedagogy	30	15	22	12	23	8	30	16	34	13
Professional practice	15	4	16	4	9	1	13	2	7	2

Table 5.3 Number of courses in the area of specialization in mathematics

Area	UPEL	LUZ	UCV	UC	UNA
Geometry	2	2	1	3	1
Calculus and analysis	7	4	6	4	4
Algebra	5	2	2	3	2
Probability and statistics	1	2	2	1	2
Physics	0	5	2	2	3
Others	5	1	2	4	2

The pedagogical preparation intends to present the key elements of the diverse facets of a teacher's work. Thus, the future teacher will have the theoretical tools to be used with innovative resources and strategies. However, in reality, the study of the teaching and learning processes includes some general knowledge along with techniques and instruments that trivialize educational action without an understanding of its complexity. This is made worse by the very little attention to specific pedagogical content as it is reduced to one or two courses. An exception is UNA whose curriculum has four courses on Mathematics teaching methods including a specific course on the Evaluation of Mathematical Learning. UNA also has a course on the integration of Mathematics and Sciences.

Student teaching varies across the universities. The UCV includes a course on administrative-teaching practice at the very end. UNA has student teaching courses in the last two semesters. UC and LUZ have three courses on professional practice beginning in the fifth semester. UPEL has four phases (observation, trial, research project and integration of teaching-research), with the last three at the end of the program of studies.

Teaching practice in the last two semesters at UPEL is the moment of professional identity. It is where the participants begin to visualize themselves, and are seen by others, as the teachers they will become. It is their opportunity to share the educational environment, not as mere observers, but as participants in the academic and administrative processes that take place there. It is also the time to confirm their exit profiles. They should demonstrate: a conceptual command of Mathematics; a capacity to design innovative strategies, resources and techniques that support mathematical learning in the contexts in which they will work; leadership which is translated as moral and cognitive authority in cooperative work; respect for others and a disposition to make joint decisions; a professional and personal performance sustained by ethics and values.

Future Elementary teachers who will teach Mathematics are to become integrative educators who teach all subjects in a specific grade and therefore need to know all subjects and be able to integrate them.

The program of studies for Integral (Elementary) Education follows the same structure as that of secondary teachers, maintaining the same relationship among the pedagogical, specialized and professional practice components. The Component of Specialized Preparation is distributed across the various areas in which teachers

need to be prepared: Language and Communication, Mathematics, Social Sciences, Citizenship and National Identity, Natural Sciences and Education for the Workplace. Teachers need to be able to teach those subjects with an interdisciplinary focus guided by the following integrative strands: health and the environment; interculturality; Information and Communication Technology; and liberating work, language, human rights and culture for peace, sovereignty and defense of the nation (Ministerio del Poder Popular para la Educación 2007).

The mathematical preparation of this integrative educator is reduced to two Mathematics courses and one in Geometry. In some cases there are also courses in Statistics and Computing. The purpose of the Mathematics courses is to provide a preparation that is theoretical-conceptual as well as methodological. It should be in accordance with the requirements of the Elementary Education curriculum; linked to the educational, social and human context; and include the study of number, polynomials, measurement and proportionality. The Geometry course has the declared purpose of contributing to logical, deductive and spatial reasoning of the future teacher in a problem solving environment the permits the visualization of the connections of Geometry to the physical world and everyday situations. The contents are basic elements of plane and solid geometries. According to the regulations, these courses should be taught in such a way that the future teacher will not only achieve conceptual knowledge, but will also learn how to teach that knowledge and will feel prepared to carry it to the classroom without showing any feelings of rejection or negative attitudes towards Mathematics that could be transferred to students. Nevertheless, in practice this is going to depend on the professors of these courses, many of whom are unfamiliar with the context of Elementary education, know few strategies that are applicable at that level, and know little about how children learn.

The pedagogical and professional practice preparation follows guidelines similar to those described for Secondary Mathematics teachers. The difference being that they take place in elementary schools.

The Continuing and Graduate Education of the Mathematics Teacher

If we understand continuing preparation to be all that follows after receiving an undergraduate degree, then it can be classified as: preparation that leads to an academic degree (specializations, Master's and doctorates), or preparation that does not lead to an academic degree (extension courses, updating, professional development, post-doctorates) (CNU 2001).

In Venezuela, the LOE (2009) defines permanent preparation as an integral continuous process that by means of policies, plans, programs and projects, updates and improves the level of knowledge and the performance of all those who share the responsibility of preparing future citizens. That is, permanent preparation is

regulated by the State and proceeds from initial preparation to post-doctorates, including extension courses, updating and professional development. Permanent continuous preparation, understood as the professional development of teachers, intends to provide new visions and prepare teachers for new practices in the exercise of their functions.

The educational authorities charged with such policy development are those in the Ministry of Popular Power for Education and the Ministry of Popular Power for University Education. They have not been able to design a joint policy (nor separate policies) for the continuing preparation of Venezuelan teachers. Nor has there been an assessment of needs and priorities for the education system.

In practice it is basically the universities that have assumed the role of providing continuous preparation. They have developed initiatives such as *Samuel Robinson Goes to School* (UVC), *Academic Extension Programs* (UPEL and other universities) and ULA's *Venezuelan School for the Teaching of Mathematics*. The Venezuelan Association of Mathematics Education (ASOVEMAT) has sponsored regional and national academic events.

Entities in Charge of Graduate Education

The universities that offer graduate programs that lead to degrees in Mathematics Education are:

(a) *Preparation leading to Specializations*: USB, the University of Valle of Momboy (UVM) and the National Experimental University Francisco de Miranda (UNEFM).
(b) *Preparation leading to a Master's*: UPEL,[1] LUZ, UDO, UC, UNEG and the National Experimental University Rómulo Gallegos (UNERG).
(c) *Preparation leading to a Doctorate*: in the UPEL, specifically the Pedagogical Institute of Maracay has initiated a doctorate in Mathematics Education in 2003.

Content, Methodologies and the Populations in Graduate Mathematics Education

The graduate programs in Mathematics Education emphasize mathematical contents, disconnected from contents related to teaching. They offer traditional face to face classes, except in the case of the USB which has virtual classes. These programs are for individuals who have degree as teachers of Mathematics or degrees in

[1]In the Pedagogical Institutes at Caracas, Maracay, Maturín and Barquisimeto.

Pure Mathematics. An exception is the UPEL where Elementary teachers and other professional who teach Mathematics can apply and be accepted to these programs.

The Doctorate in Mathematics Education emphasizes the preparation of researchers and the generation of theories concerning Mathematics Education.

Research in Mathematics Education and Academic Networks in Relation to Initial and Continuing Teacher Preparation

Programs and Lines of Research

Research in Mathematics Education in Venezuela is carried out mainly in graduate programs. However, there is no research agenda in Mathematics Education that is a product of those programs. The graduate programs are linked to a certain extent with research units or groups and their respective lines of study that have over time been consolidated in various universities throughout the country. They include the Center for Research in Mathematics Education at UPEL-Maturín, the "Dr. Emilio Medina" Center for Research at UPEL-Maracay, the Basic Research in Mathematics Education Unit at UNEG, the Program Teacher Thinking and Action within the Line of Research on the Teaching of Mathematics at LUZ, the Center for Research in the Teaching of Mathematics Using New Technologies at UPEL-Maracay, the Center for Research in Mathematics and Physics at UPEL-IPC, the "Juan Manuel Cagigal" Center for Research at UPEL-Miranda, the Unit for Research on Elementary Education at UC-Aragua, and the Group for Research and Dissemination in Mathematics Education created in the context of the Line of Research on Mathematics Teaching at UCV.

However, the impact of research carried out in Work Groups in these graduate programs has been very limited. The results are rarely disseminated and many proposals are not implemented. Work Groups do work related to the general Education System. They research topics such as teacher preparation, history of Mathematics in Venezuela, the relationship between Mathematics and other disciplines, and the teaching of specific topics in Elementary or Secondary schools with the use of alternative strategies.

The Relation Preparation-Research

In the undergraduate teacher preparation programs of study there is no research component. However, Resolution N° 1 expresses foundations and features in the profile of future teachers that makes it necessary to cultivate reflection and action as the starting point for transforming the teaching and learning process and for

fostering professional development. That is, the goal is to prepare teachers that base their practice on action research and employ research in their own continuous self-preparation. This is derived from permanent reflection as the catalyzing agent of inquiry and searching.

This preparation for research is carried out in courses in which theoretical-conceptual aspects of educational research are studied. Students design and carry out a research project. It is usually with an action research design to explore problematical situation in a specific educational context.

In theory, the relationship between teacher preparation and research is understood in a dual manner. On the one hand, it is thought of as preparing the future teacher to do research. On the other hand, it is considered that the preparation will be realized through research, intending that the future Mathematics teacher will develop certain research competencies. However, in the initial preparation at both the Elementary and Secondary levels, the emphasis is on the first of the two aspects mentioned above, but the preparation is not developed in a research environment.

Initial and Continuing Preparation, and the School Curriculum

In Venezuela it is evident that a disconnection between the State regulatory and planning entities, and the teacher preparation institutions exists. Especially, a marked lack of connections between curricular changes promoted by government entities and implemented at the Elementary and Secondary levels, and curricular changes in the teacher preparation institutions are now a tradition. The implementation of the Bolivarian Curricular Design began in 2007 at the school level and implied a need for the universities to redesign the teacher preparation curriculum, but that process is still incomplete.

It can be said that currently the main link between initial preparation and the school curriculum is the student teaching experience. The student teaching experience has four phases. The first is a scientific observation phase with the purpose of arriving at an understanding of three relationships: teacher-student, teacher-school and teacher-community. There follows a trial phase directed at planning, carrying out and evaluating teaching in simulated situations, attempting to integrate mathematical and pedagogical content. Then the student realizes a research project to improve or transform a problem situation that has been detected in a school. In some universities that research leads to the presentation of a thesis. Finally, the moment of the greatest link between the school and the university arrives, but because it happens in the last semesters, it loses the formative character required in Resolution N° 1.

In the development of the component of specialization in Mathematics there is little reference to the school curriculum. The disciplinary contents are approached from a conceptual and technical point of view with some rigor. However, there are

serious limitations in understanding them as objects for teaching at lower educational levels to facilitate student learning; that is, when they are part of school Mathematics (León et al. 2013b).

In the environment of continuing preparation, the link between teacher preparation and school curriculum is sporadic. It responds to immediate needs such as the adoption of a new curricular design or the implementation of some national program. In these cases, obligatory professional development courses are offered.

Strengths, Weaknesses, Opportunities and Challenges

In the initial and continuing preparation of Mathematics teachers in Venezuela some factors exist that have a positive impact (strengths), such as:

1. The existence of public policies concerning teacher preparation. As a part of political tradition, the Venezuelan Constitution has established what can be called the "Teaching State" in which the State has the power to establish rules for general action in teacher preparation that are of a compulsory nature. Also, currently the Venezuelan government is implementing projects such as CANAIMA, LEER and LIBRES, that are providing computers and textbooks. These should have repercussions in teacher performance and the teaching of Mathematics.
2. Graduate programs that have led to the development of diverse groups that have carried out and maintain an interest in doing research on the problems associated with Mathematics Education.
3. The existence of organizations for Mathematics teachers, such as ASOVEMAT, that have sustained efforts to improve teacher preparation in the country. Ties and agreements between teacher preparation institutions have been established both nationally and internationally. This has permitted fruitful interchanges and the presence in Venezuela of well-known researchers from various parts of the world.

Also, factors have been identified that have a negative effect (weaknesses) on the preparation of Mathematics teachers:

1. Much of the curricular structure of teacher preparation programs dates from the 1990s and therefore lags behind current knowledge and results from research in Mathematics Education. They also suffer from a deep fragmentation between content and pedagogy. This is also the case with some graduate programs. Additionally, the Elementary teacher preparation curricula have a weak mathematical component with only two general Mathematics courses and one geometry course.

2. Work conditions: The salary level of teachers obliges them to teach many hours of classes thus leaving little time for continuing preparation. However, the main incentive for taking courses or studying for a graduate degree is that such study leads to changes in classification that often imply salary increases. Also, there is very little follow-up of teachers by their universities or the Ministry once they take teaching positions.
3. There is a large shortage of secondary Mathematics teachers and the situation is getting worse as enrollments in secondary Mathematics teacher preparation programs have been falling.

In this context, the main threat is that current problems will become worse if corrective actions are not taken. Also, since the problems are more than just quantitative, it is possible that the numbers will be improved without improving the quality. It is even possible that quality will worsen if inadequate actions are taken.

Taking into account the strengths, weaknesses and threats that are mentioned above, the main challenges that confront the Mathematics Education community in Venezuela have to do with: collecting reliable data to accurately quantify the teacher shortage and other parameters; determining with precision the weaknesses in current Venezuelan teacher preparation programs; encouraging more secondary school graduates to study to become teachers, particularly at the secondary level; promoting a profound renovation of the curricula for teacher preparation so that the mathematical component is sufficient and corresponds to the work that graduates will do in classrooms, as well as achieving an internal consistency among the various components; promoting mechanisms for continuing teacher preparation; contributing to a decrease in the gap that exists between educational reforms and the changes necessary in teacher preparation; developing follow-up and support mechanisms for teachers who enter the workforce; producing adequate materials that contribute to the improvement of initial and continuing teacher preparation; and incorporating teachers into projects related to research, innovation and development of teaching materials.

By Way of Closing

The transformations and curricular changes over the years in Venezuela have resulted in positive results in quantitative terms, but not necessarily with respect to the quality of education. Reality reflects a sustained deterioration in the mathematical preparation of teachers. This is more noticeable with Elementary teachers as compared to Secondary teachers, but is evident in student achievement at both levels. Also, it has not been possible to repair the dichotomy that exists between preparation in disciplinary content and preparation for teaching that content, and there remains a separation of theory and practice. In fact, these problems may have deepened. Equally, the duality teacher-researcher is not evident in initial teacher preparation where research is dealt with at a mainly theoretical level.

Continuing preparation is presented mainly in graduate programs that can lead either to an academic degree or a certificate, both of which are valid for salary increases. However, there has been little impact on the mathematical and pedagogical knowledge of the teachers. Consequently, there has been little impact in their professional practice, and in improving the teaching and learning of Mathematics. Moreover, no agenda for Mathematics Education research that is the product of those programs exists that could orient the determination of the key elements that currently affect the teaching of Mathematics. Such an agenda, should be oriented to a new conceptualization of continuing Mathematics teacher preparation that overcomes the idea of training and is focused on the creation of a culture of continuous learning.

Nevertheless, the Venezuelan Mathematics Education community has manifested concerns and in the universities there are those who are taking certain actions to improve the prevailing situation. Among those actions the revision of the curricular designs for Mathematics teacher preparation should be highlighted. Here are some of the questions that are being asked. What should be the preparation of Secondary Mathematics teachers and Elementary teachers? What should be the preparation that Secondary Mathematics teachers and Elementary teachers receive in psychopedagogy, sociology, philosophy, etc.? How do you offer an integral preparation, avoiding the fragmentation between Mathematics and the teaching of Mathematics? How can there be a stronger link in teacher preparation between theory and practice? All of these concerns are up for discussion and are concerns of those preparing the future Mathematics teacher educators.

Fortunately, certain favorable conditions do exist, mentioned above in this document, that if handled properly, could lead to actions that tend to overcome flaws and lead the preparation of Mathematics teachers down more promising paths. However, here we want to make it clear that the results of any change that is undertaken, whether it be in the conception that is held concerning initial and continuing preparation, the content of that preparation, the curricular orientations, etc., will depend in good measure on what we, the teachers of Mathematics, think and do.

Appendix: Meanings of Acronyms

ASOVEMAT	Venezuelan Association of Mathematics Education
CNU	National Council of Universities
IPN	National Pedagogical Institute
LOE	Organic Law of Education
LUZ	University of Zulia
MPPE	Ministry of Popular Power for Education
MPPEU	Ministry of Popular Power for University Education
PNFE	National Program for Educator Preparation
UBV	Bolivarian University of Venezuela

UC	University of Carabobo
UCAB	Catholic University Andrés Bello
UCT	Catholic University of the Táchira
UCV	Central University of Venezuela
UDO	University of the East
ULA	University of the Andes
UNA	National Open University
UNEFM	National Experimental University Francisco de Miranda
UNEG	National Experimental University of Guayana
UNERG	National Experimental University Rómulo Gallegos
UNERMB	National Experimental University Rafael María Baralt
UNESR	National Experimental University Simón Rodriguez
UPEL	Liberator National Pedagogical University
USB	University Simón Bolívar
UVM	University of Valle of Momboy

References

Consejo Nacional de Universidades (CNU). (2001). *Normativa General para los Estudios de Postgrado para las Universidades e Institutos debidamente autorizados por el Consejo Nacional de Universidades*. Gaceta Oficial N° 37328, del 20 de noviembre de 2001.

Consejo Nacional de Universidades (CNU). (2011). *Oportunidades de Estudio en las Instituciones de Educación Superior. Proceso Nacional de Admisión*. Caracas: OPSU.

León, N., Bara, M., & Azócar, K. (2013a). Planificación de la matemática escolar como elemento clave en la formación del docente. *Paradigma, 34*(2), 177–200.

León, N., Beyer, W., Serres, Y. & Iglesias, M. (2013). Informe sobre la formación inicial y continua del docente de Matemática: Venezuela. *Cuadernos de Investigación y Formación en Educación Matemática*. *8*(Special issue), 89–129.

Ley Orgánica de Educación (LOE). (2009). *Gaceta Oficial Nº 5.929 (Extraordinario), del 15 de agosto de 2009.*

Ministerio del Poder Popular para la Educación (MPPE). (2007). *Currículo del Subsistema de Educación Primaria Bolivariana*. Caracas: Fundación Centro Nacional para el Mejoramiento de la Enseñanza de la Ciencia.

Parra, H. (2006). La formación docente en matemática alternativas para su transformación. *Equisángulo*, *3*(2). Retrieved from www.saber.ula.ve/bitstream/123456789/20309/1/articulo1.html

Peñalver, L. (2007). *La Formación Docente en Venezuela. Estudio diagnóstico*. UPEL: Caracas.

Reinoso, R. (2011). *Las estadísticas lo reflejan. En Revolución: Venezuela vanguardia educativa a escala mundial*. Retrieved from http://www.radiomundial.com.ve/article/en-revoluci%C3%B3n-venezuela-vanguardia-educativa-escala-mundial

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