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

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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.

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