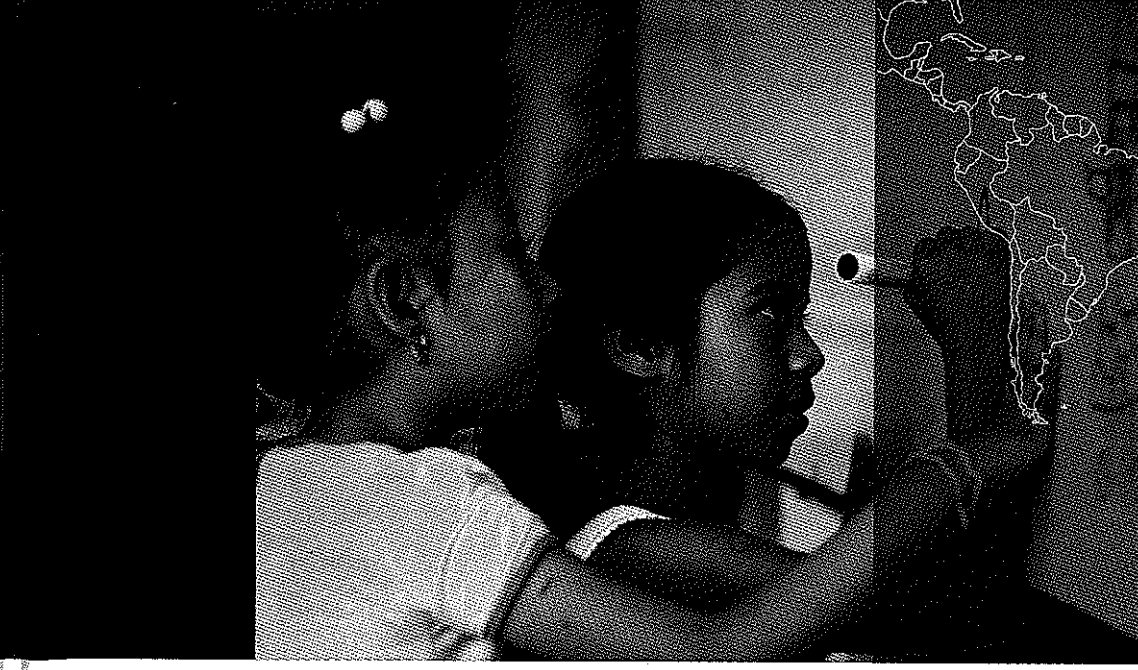

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Chapter 2

BOLIVIA: An Approach to Mathematics Education in the Plurinational State

A. Pari

Abstract: This article explores the history of mathematics education in different socio-political periods and the current status of research in this field. The chapter is divided in three periods: Pre-Hispaninc, Colonial, and Republican. Although research is scarce, there have been signs of interest in mathematics education in the Plurinational State of Bolivia.

Keywords: History of Mathematics Education; Plurinational State of Bolivia.

Life is good for two things, learning mathematics and teaching mathematics.

Siméon Denis Poisson

Mathematics Education in Bolivia, as a field of research, can be described as incipient. However, it is possible to find sporadic samples of interest in the teaching of mathematics during the last century. Even though the Bolivian contribution to international scientific production can be described as scarce and marginal, Bolivian universities have been able to increase the personnel and attention dedicated to research. Still, the context is not favorable as the State does not have a clear policy with respect to higher education and does not have funds to dedicate to research and innovation (Rodríguez & Weise, 2006).

Bolivia is a land of contrasts, not only for the nature of its geography, its soil and its climate, but also for its history, its politics and the condition in which its population lives. Its riches are considerable, but the majority of

Tiwanaku. It contains interesting historical and geographical data. Later in the nineteenth century information on the arts and literature was added.

In the twentieth century, various foreign archeologists worked in Bolivia. In 1934 the North American Andean archeologist Wendell Benner discovered the monolith that is now named after him. The Austrian Arthur Posmansky (1873–1945) published a classic four-volume work: *Tihuanacu: The Cradle of American Man.*

Among Bolivian archeologists, it was Carlos Ponce Sanginés (1925–2005) who became the necessary reference for Pre-Hispanic studies (Ponce, 2000). He initiated Bolivian archeology in the mid-1950s. He was the founder and first director of the National Institute of Archeology (1971–1982), as well as of the Center for Archeological Research on Tiwanaku (1957–1975).

The archeological evidence from Tiwanaku indicates important advances in astronomy, architecture, technology and mathematics. The Bolivian mathematics teacher Jaime Alfonso Escalante Gutiérrez used to say to his students in Garfield High School in Los Angeles that "The Aymaras knew math before the Greeks and Egyptians" (Pari, 2011; Schraff, 2009). Tiwanaku is a rich archeological site that still hides secrets within a defined area of time and space (Diez de Medina, 2005). It also contains a vast artistic depository of textiles and ceramics.

In 2000 UNESCO declared Tiwanaku to be a Cultural Patrimony of Humanity. Currently there is interest in recovering the cultural practices of different groups in order to be able to understand them. In that context various works should be mentioned: *The Tiwanaku: Portrait of an Andean Civilization* by Alan Lewis Kolata (1993); *Mathematics Was Born in Tiwanaku, Bolivia: The reason for the natural numbers* by Fidel Rodríguez Choque (2008); *Tiwanaku Capital of Mystery: Five Meditations and Two Tales* by Fernando Diez de Medina (2005/1986), and *The Mathematics of the Puerta del Sol of Tiwanaku* by Jorge Emilio Molina Rivero (2000).

The other Pre-Hispanic culture that developed in the Andean region was the Inca. Education in the Incan Empire went through a period of formation in which the teaching of the children of the nobles was carried out by wise men called "Amautas". It was an oral, practical and experimental education.

There were specialists who were like statisticians or accountants who were called "Quipucamayos". They preserved data in knots of colored thread called "quipus". The houses where the Quipucamayos met were

its population is poor. It has soil and a variety of climate sufficient to assure that everyone is properly fed, yet many are undernourished. Today, at the dawn of the twenty-first century, Bolivia continues to be a State of contrasts and paradoxes. It is a developing State with marvelous possibilities that struggles to look to the future while its feet are chained to the past and its heart is divided.

Within this framework, Bolivian mathematics education has been and continues to be determined by institutional factors, politics, and popular social movements. One of the difficulties faced in presenting this document is the lack of information from mathematics education as a field of research.

The History of Mathematics Education in Bolivia

Some important aspects of the political history and history of education in Bolivia are presented below in order to situate Mathematics Education in the country. Three historical periods will be considered: Pre-Hispanic, Colonial (sixteenth and seventeenth centuries) and the Republic (nineteenth and twentieth centuries).

The Pre-Hispanic Period

The Pre-Hispanic era covers a period of time in the history of the Americas that ended with the arrival of the Spanish on the American continent. The conquistadors and colonizers from the Old World found peoples in South America with various levels of cultural development. Specifically, on the Andean Plateau various cultures were developed: Viscachani, Pucara, Wankarani, Chiripa, Mollo, Kolla Tiwanaku and Inca. The most advanced at the time of the Spanish arrival was the Inca. A study of these cultures is beyond the scope of this chapter. Nevertheless, here is a brief mention of Tiwanakota culture "whose remains can still be found as megalithic monuments engraved with inscriptions that no one has been able to translate (Elbarquero, 2006; Kolata, 1993).

The Tiwanakota spoke Aymara, a language that is still spoken by many Bolivians. Not much is known about the origins and duration of the Tiwanakota culture (Diez de Medina, 1986).

The earliest available written records (Kolata, 1993) are those left by the Spanish conquistador and chronicler Pedro Cieza de León (1549) who wrote "Chronicles of Perú and a New Spain" after his visit to

Tiwanaku. It contains interesting historical and geographical data. Later in the nineteenth century information on the arts and literature was added.

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There were specialists who were like statisticians or accountants who were called "Quipucamayos". They preserved data in knots of colored thread called "quipus". The houses where the Quipucamayos met were

called "Yachaywasis" and commoners were not allowed; thus, education was very class-oriented. The first school for the children of the nobles was created by the leader called "Inca Roque" in Cuzco.

The basic Incan educational principles that still exist in some indigenous villages in the Bolivian highlands and valleys were based on three fundamental themes:

- *ama sua* (Don't be a thief).
- *ama llulla* (Don't be a liar).
- *ama kjella* (Don't be lazy).

These norms were indisputable values for all the population and were followed as models for behavior (OEI, 1988, p. 3).

In 1532 the Incan Empire was invaded and conquered by the Spanish under the leadership of Francisco Pizarro.

Period of Conquest and Colonization (Sixteenth and Seventeenth Centuries)

The first Spaniard to arrive in what today is Bolivia was Diego de Almagro. In 1535 he arrived at Lake Titicaca and the Valley of La Paz. When Almagro died in 1538, Francisco Pizarro sent his brother Gonzalo to conquer the provinces of Charcas and Collao, which had not been colonized by the Almagro expedition.

Pedro Anzúrez founded Chuquisaca in 1538. Potosí emerged in 1546, La Paz in 1548, and Cochabamba in 1574. Meanwhile, colonization from the River Plate region to what is today Bolivia led to the founding of Santa Cruz in 1561. However, it was the discovery of silver in Potosí in 1545 that led that city to become a key point for Spanish exploitation in the Americas. During the colonial period the mines of Potosí were the principal producers of silver in all the Americas.

The immense deposits of silver led the colonizers to focus on mineral exploitation. However, the riches of the mines, ethnic inequalities, and rivalries among the conquistadors caused a turbulent history in High Perú (now Bolivia) during the sixteenth, seventeenth and eighteenth centuries.

Among the most important institutions in the Spanish governing of the Americas were the Royal Courts ("Reales Audiencias"). The highest legal authority in High Perú was the Royal Court of Charcas in the department

of Chuquisaca. Better known as the Court of Charcas, it was created by decree of King Felipe II on September 18, 1559:

> The Court of Charcas is created in 1559, although one of the first documents indicating a need for said Court is the "Agreement of the Council of the Indies on the advisability of locating the Court in the Villa de la Plata", on April 20, 1551 (A. G. I., Estado 140, Caja 7, Leg. 31): The principal goal of Your Majesty is to govern those new territories in the Indies, providing them with an abundance of justice, because that is how the Christian religion is founded and our faith kindled and the natives are well-treated and receive adequate instruction in them, and that is what experience has taught us ..." (González & Bravo, 2008, p. 1042).

According to the historian, journalist and ex-President of Bolivia Carlos D. Mesa Gisbert (May 3, 2013), "Charcas had a greater significance in the seventeenth and eighteenth centuries than the Republic of Bolivia at the beginning of its independence." The conquest had material as well as spiritual motives, even though one of the main aims of the Spanish monarchs was the spread of the Catholic religion. In fact, a church was constructed in every city or town that was founded.

Colonial education was for the children of creoles, mestizos, rich businessmen, and land holders who received lessons in reading and writing in their homes from teachers called home tutors ("leccionisantes"). There was no free obligatory elementary education during the colonial period nor was there tutoring for the majority of the indigenous population. There was no teaching program and the Catholic Church had a monopoly on instruction in the hands of priests from various orders. Parochial classes were implemented. Thus, the only educational action was catechistic, which negated any possibility of valuing local cultures.

The first schools

The first educational institution in Bolivia was founded by Father Alfonso Bárgano in 1571. In 1599, Bishop Alfonso Ramírez founded the Saint Christopher Seminary School in Chuquisaca, which was also known as the Red School because its emblem was a red medallion. Another school was founded on February 22, 1621 by the order of Francisco Borja, Viceroy Prince of Esquilache. It was called the Santiago School. On April 10 of the

same year its name was changed to Saint John the Baptist or the Blue School because of its emblem (OEI, 1988).

Education continued to be classist and only children of the gentry could attend. That is, women and indigenous children were excluded. In 1792, Brother José San Alberto, Archbishop of La Plata created the School for Poor Children in Chuquisaca, also known as Saint Albert's School (OEI, 1988).

The emergence of the Bolivian university

In 1623 the first Bolivian university was created in the department of Chuquisaca. At the time, Chuquisaca was the center of economic, social and intellectual power. It was also the home of the Saint John the Baptist School (the Blue School) (Serrudo, 2006, p. 56):

> In 1623, enjoying the privileges and prerogatives and immunities of royal schools, the "Blue School" was allowed to offer bachelor's, master's and doctoral degrees in the arts, theology, canons and laws, to be accepted by any university (OEI, 1988, p. 4).

On March 27, 1624 the University of St. Francis Xavier of Chuquisaca was created by Father Juan Frías de Herrán, provincial head of Jesuits in Perú. It was given that name to honor Father San Francisco Xavier, the new Apostle of the Indies, so his name could protect the achievement of the students (Serrudo, 2006, p. 56).

In line with the paradigms of the times, the teaching objectives of the University of St. Francis Xavier were those of the Jesuits and the Catholic Church in general: spreading the gospel to "save souls and eradicate idolatries" (Serrudo, 2006, p. 56). Initially the university prepared lawyers based on three scholastic disciplines. It functioned regularly until 1767, when the Jesuits were expelled from the university. After the expulsion of the Jesuits, the university entered a second stage of development and the Carolina Academy was created in 1778 to provide legal practicums for the graduates (OEI, 1988, p. 4). The Academy gave new life to the university and by 1780 it had reached the same level as the University of Salamanca. Nevertheless, it was not until 1798 that the Spanish government recognized it as a Royal and Pontifical official institution with all the privileges of the University of Salamanca (OEI, 1988, p. 4).

The university education was criticized for its failure to apply science to the development of the region. However, pure and exact sciences were not necessary for the means of production at the time. Moreover, there was no evidence of the utility of the incipient science (Serrudo, 2006, p. 56).

The Period of the Republic (Nineteenth and Twentieth Centuries)

The nineteenth century represents the final stage of colonial period and the beginning of the Republic of Bolivia. The Court of Charcas, called High Perú, achieved independence from Spain and its autonomy from the viceroyalties of Perú and River Plate. Political instability and economic collapse ensued (Mesa, 2012). Thus, republican life began for Bolivia on August 6, 1825, with its capital in Sucre. With the exit of Field Marshall Antonio José de Sucre, there was a political crisis until Andrés de Santa Cruz assumed the presidency (1829–1839). According to Mesa (2012), it was during that period that Bolivia had the most solid state, possibly the only one in its history. This period is bound to the personality of Andrés de Santa Cruz.

However, by the end of the nineteenth and beginning of the twentieth century, Bolivia was living with grave post-revolutionary consequences and a crisis of identity and economic devastation (Lozada, 2004). It had a population of about two million inhabitants, but only about 7% had an elementary education. Bolivia approached the twentieth century bloodied by wars and international treaties.

On the other hand, the decline in the mining of silver had to do with changes in monetary policies and increased industrialization, which made tin more attractive in the powerful countries. This generated not only changes in production, but in power as well, and led to a civil war in Bolivia — called the Federal War — from 1898 to 1899. This civil war pitted La Paz against Sucre in trying to become the capital to begin the new century. It was an encounter between the conservative forces with an oligarchic ideology representing the silver mining interests in the south (Sucre and Potosí) against the liberals with a federalist orientation in the north (La Paz and Oruro) who defended the interests of tin miners. In this context, Bolivian history should be viewed from three dimensions: economic, political and social (Mesa, 2012). Beginning at that time, the center of development and political decisions was in the west with La Paz at the

center. This persisted until the consolidation of production in the east in the 1990s (El Diario, 2011).

The emergent ideology attacked the old regime and broke the power of the Catholic Church declaring that education would be non-denominational and that the indigenous population would no longer have to provide domestic service to the parish churches. As Lozada (2004) stated, "In the rural areas of the country the liberals promoted the founding of educational entities dedicated to indigenous education and in the cities they assumed the creation of a national identity as the principal task" of the State.

The National Revolution had begun by the middle of the twentieth century, particularly in 1952, led by Víctor Paz Estenssoro. Political opposition and social movements continued into the twenty-first century. The most notorious confrontations were the Water War in 2000 and the Gas War in 2003, concluding with the election of Evo Morales as President (Neso, 2013). These are the most important events or phenomena of republican life in Bolivia. Education in general — and mathematics education in particular — has been determined and even limited by the complex circumstances with which the country has lived.

Elementary and secondary education

In the early years of the republic, elementary education as such did not exist and there was not even a single printing press in the country (Aramayo, n.d.). Nevertheless, Simón Bolívar was very interested in public education and assigned his own teacher, Simón Rodríguez, as Director General of Public Education (OEI, 1988). Bolívar and Rodríguez initiated school legislation in December of 1825 with Decree 11:

> ... education is established as the first duty of the government and it should be Uniform and General ... an elementary school should be established in every department's state capital ... to receive children of both genders ... (OEI, 1988).

By the Law of January 9, 1827 elementary, secondary and central schools were established:

> Reading, writing, religion, moral doctrine, and agriculture should be taught in elementary schools by the method of mutual teaching. In addition to elementary schools, every provincial capital should establish secondary schools to improve reading and writing, religion, moral doctrine, Spanish grammar, **the four rules of arithmetic**, agriculture, industry and veterinary medicine [emphasis added]. In addition to the aforementioned Department school, there should also be central schools to thoroughly teach arithmetic, grammar, drawing and design. These schools should admit only those students judged by their teachers to have demonstrated aptitude.
>
> On the other hand, in the cities of La Paz and Potosí — where there were mines — schools of mineralogy were created to teach ***geometry*** and ***subterranean architecture***, elements of chemistry and mineralogy, and the art of extracting and melting all kinds of metals, for which they constructed small laboratories.
>
> In the capital of the Republic, in addition to the disciplines taught in the departmental schools, history of literature, ***complete mathematics***, chemistry, botany, painting, sculpture, engraving and music should be taught. They also considered establishing a literary center called the National Institute.

This plan was at the time without a doubt a great step for education. Some of the provisions were implemented and others remained on paper, but it did give guidelines to which Bolivian education could aspire. Nevertheless, the teaching methods were teacher-centered, with little or no student participation. In other words, it was based on rote learning.

Educational reforms in Bolivia

Throughout the twentieth century, Bolivian education went through various transformations or reforms. The first reform that should be mentioned was an unsuccessful attempt in 1874 at decentralization that was called the municipalization of education. At the beginning of the twentieth century, liberal governments proposed the modernizing of education and were supported by foreign experts such as Georges Rouma.[1] In the 1930s, a

[1]Rouma was a Belgian pedagogue born in Brussels in 1881, who died there in 1976. He graduated as an elementary teacher in 1900. Nine years later he received the title of Doctor in Social Sciences and his dissertation was entitled *The Graphic Language of the Child*. Beginning in 1902 he collaborated with Ovidio Decroly, a medical doctor, in the study of language difficulties among children. When he was contracted by the Bolivian government, Rouma was a young researcher just

model of indigenous education was developed in Warisata. In the 1950s not only were Bolivian natural resources nationalized, but education received its first Bolivian Education Code in 1955. The code is a document that unifies the whole system while at the same time divides it into urban education on the one hand and rural education on the other. In 1994, a Law of Education Reform, referred to as Law 1565, was approved. Currently the Avelino Siñani–Elizardo Pérez Law of 2010 is in the process of being implemented.

The Bolivian education code (1955)

It was during the presidency of Victor Paz Estenssoro that the first Education Code was approved. The code was supported by Article 157 of the 1947 Constitution that indicated that education was the highest function of the State:

> Education is the highest function of the State. Public teaching will be organized according to the system of the unified school. The obligation of the school system in general is from seven to fourteen years. Elementary and secondary instruction is free (Art. 157).

Until the National Revolution, education in Bolivia was a monopoly of a minority in service of foreign interests that exploited the country's riches. Large sectors of the population remained uneducated and unable to contribute significantly to the development of the nation.

In the 1960s and 1970s there was a significant reform in the teaching of mathematics at the international level that affected almost all countries. The contents of that reform are well known: introduction of set theory, modern symbolism, the elimination of Euclidean geometry, introduction to algebraic structures and axiomatic systems, the algebraization of trigonometry (Barrantes & Ruiz, 1998).

George Papy is associated with the New Math in Latin America (Pérez, 1980, p. 1). However, New Mathematics had preceded its introduction into elementary and secondary classrooms. The Bourbaki group as early as 1950

25 years old with pedagogical training in the best ways to understand modern education, therefore his pedagogical proposals were for an education that took into account psychological, physical and social elements of the socio-cultural environment in which children lived (Iño, 2010, p. 26).

had realized a synthesis of new tendencies in mathematical language (Papy, in Pérez, 1980, p. 1).

The New Math was implemented almost everywhere. It arrived in Bolivia with the support of the Simón Patiño Pedagogical and Cultural Center that assumed the challenge of promoting it throughout the country.

> A team composed of Belgian educators and teachers from various districts in the city of Cochabamba was organized to implement it. This team took charge of preparing teachers to join in a multiplier effect in the nine departments. This movement was not very successful and ended in 1985 without achieving the goals it had proposed (Grigoriu, 2005, p. 86).

One of the major difficulties was that not all teachers were well-prepared, particularly in rural schools. Later there were various attempts at reforms and counter-reforms. Behaviorism was the prevailing pedagogical model.

Educational reform of 1994

Bolivian education was reformed in 1994, almost 40 years after the National Revolution had implemented the Bolivian Education Code. Among the contributions of the Education Reform Law of 1994 were including communities in the educational process, and recognizing intercultural and bilingual education. The Bolivian educational system was structured into four levels: initial, elementary, secondary and tertiary. The initial level has two cycles, elementary has three, and secondary has two (Ley de Reforma Educativa, 1994). The elementary level became an open institution at least in aspirations if not always in reality (Grigoriu, 2005).

This educational reform emphasized elementary education and teacher preparation:

> The curricular focus at the elementary level gives attention to diversity, satisfying basic learning needs of the population, and gives attention to society's emerging problems. Based on these principles, there is a focus on an orientation toward the development of competencies, preparation for work, bilingualism, and the integration of students with special needs (Grigoriu, 2005, p. 58).

Within this framework, the mathematics contents of elementary and secondary are organized as follows: number and operations, data processing,

spatial sense and geometry, and measurement (Grigoriu, 2005). Previously mathematics content had been organized as arithmetic, algebra, geometry and trigonometry.

The government has published and distributed textbooks in indigenous languages and Spanish for the elementary level. At the secondary level, there has not been much support in terms of textbooks. At the end of the twentieth century the textbooks of the Cuban mathematician Aurelio Angel Baldor were still being used throughout Bolivia, particularly in rural areas.

Information on the preparation of mathematics teachers in normal schools and universities will be presented below.

The Bolivian university

As in the majority of South American countries, the history of the Bolivian university begins in the colonial era with Spanish influence on academic aspects and with a profound Catholic vocation (Serrudo, 2006). The Bolivian educational system is made up of public, private and special institutions (Ley de Educación, 2010: capítulo 1, artículo 1).

Public universities receive their funding from the State General Treasury. Their academic and administrative actions are based on their autonomy, as well as on a co-government by faculty and students, but the latter has at various times been abolished to be re-established in the interest of democracy (Serrudo, 2006). Although private universities receive no financing from the government, their regulations, programs and plans of study must be approved by the government. They can grant academic diplomas, but Titles by National Decree are granted by the State (Constitución Política del Estado Boliviano, Art. 188°). Special are not considered private and are instead actually part of the National System of Bolivian Universities and are recognized by the Executive Committee of the Bolivian University. On the other hand, private universities belong to the National Association of Private Universities (Márquez, 2004).

The universities created in the nineteenth century were the Higher University of San Andrés (La Paz), the Higher University of San Simón (Cochabamba), the University of Gabriel René Moreno (Santa Cruz), the Autonomous University of Tomás Frías (Potosí), and the Technical University of Oruro (Oruro) (CEUB, 2011, p. 10).

The first university created during the colonial period was the Higher, Royal and Pontifical University of San Francisco Xavier in Chuquisaca in 1624, with Jesuit influence. It was two centuries before the second Bolivian university was established, following the Supreme Decree of November 30, 1830, signed by President Andrés de Santa Cruz. The first university founded under the Supreme Decree was called the Junior University of La Paz. In 1831, the Constituent Assembly declared it to be the Higher University of San Andrés of La Paz. In Cochabamba, during the same government in 1832, the Higher University of San Simón was created. It had its origins in the Academy for Legal Practicums.

On December 15, 1879, during the government of Hilarión Daza, the fourth university district was created. On January 11, 1880, the University of Santa Cruz was established and in 1911 it became the Gabriel René Moreno University.

In 1892, under the presidency of Mariano Baptista and via a Law Decree, university districts were created for Oruro and Potosí, and subsequent regulations created the Autonomous University of Tomás Frías and the Technical University of Oruro.

Following the creation of those universities in the nineteenth century, several more public universities were created in the twentieth and twenty-first centuries: University of Juan Misael Saracho in Tarija in 1946, Mariscal José Ballivian Technical University of Beni in 1967, XX Century National University in 1993 with a branch in the Mining District of Llallagua in the department of Potosí, and, finally, the Public University of El Alto in 2000 in the city of El Alto, La Paz.

There are several universities that are classified as "special". The Catholic Bolivian University in La Paz was created in 1966. The "Mariscal José Ballivian" Military Engineering School, also in La Paz, was founded in 1950. In 1985 the Universidad Andina Simón Bolivar with branches in Sucre and La Paz was incorporated to provide graduate studies. In 2009 the Police University Mariscal José Antonio de Sucre was incorporated.

Beginning in the second half of the twentieth century, private universities began to emerge. However, it was in the 1990s that there was a virtual explosion of such institutions and their contribution cannot be denied.

Of all the public universities, only three offer degree programs in mathematics: the Higher University of San Andrés in La Paz, the Higher University of San Simón in Cochabamba, and the Autonomous University of Tomás Frías in Potosí. Of the more than 50 private universities, only the University of Simón I. Patiño in Cochabamba offers a degree in mathematics.

The founding of the Normal School for Teachers and Private Tutors

During the government of Ismael Montes (1904–1909) the Minister of Instruction, Daniel Sánchez Bustamante, recognized the need for institutions to prepare future elementary and secondary teachers. Therefore, in 1909 he founded the Normal School for Teachers and Private Tutors for the Republic in Sucre. The Belgium mission led by Georges Rouma was responsible for the new normal school. According to Iño (2010), the professors of mathematics and physics were Constan Lurquin, professor of mathematics; José Maria de Araujo, professor of physics; and Mariano Oropeza, professor of arithmetic, geometry and algebra.

This normal school was a boarding school for youths who wanted to be the future teachers of Bolivia. They were selected by the government and had all expenses paid (room, board, clothing, textbooks, health costs, and personal hygiene articles) during the four years of study in which they attended 35 hours of classes per week (Lozada, 2004).

The admission requirements were:

- Be between 16 and 20 years old.
- Pass an examination on **elementary notions of arithmetic**, Spanish, ethics, history, geography, and handwriting.
- Evidence good behavior before an examining board through a school certificate or other means deemed acceptable by the board.
- Pass an oral examination before an examining board composed of the President of the university in which the candidate resided, the Principal of the Primary School for Boys, and the National Inspector of Instruction.

Initially, it prepared elementary teachers and later secondary teachers as well. Beginning in 1937 it had two sections: elementary and secondary. When it began to prepare secondary teachers its Secondary Department had four sections: Philosophy and Letters, Mathematics and Physics, History and Geography, and Biological Sciences.

In 1917 the Normal School of La Paz was also created under the leadership of Georges Rouma and the Belgium mission. According to Lozada (2004), Rouma created the Normal School of Sucre while the government for the first time promoted rural indigenous education with the creation in 1931 of the Normal School of Warisata.

The Normal School of Warisata

The Normal School of Warisata was founded in 1931 during the government of Daniel Salamanca. One of its protagonists was Elizardo Pérez Gutiérrez who had graduated from the Normal School of Sucre in 1914 (Iño, 2010). There were many details in the vicissitudes that needed to be overcome in creating this school. Its creation marked a new era and a new path for the education of the masses in Bolivia. Warisata was a unique experience, not only for Bolivia, but for the entire American continent (Lozada, 2004). It was the major revolutionary expression in the field of education and it was the exploit that liberated the indigenous population. It helped to bring about the revolution of April 1952, the Agrarian Reform, and liberation from the federal yoke. These events would not have been possible without this decisive transformation of the indigenous mind.

The background for Warisata can be found in the founding of clandestine schools by Avelino Siñani, himself indigenous, at a time when formal education for the indigenous population was prohibited. The intellectual Elizardo Pérez joined with Siñani and together they established indigenous schools and began to plan a normal school for indigenous teachers. In 1917, Pérez was an educational inspector in La Paz. In that capacity, he visited the humble school in the district of Warisata. His visit would have had no transcendence had he not happened upon a private school run by Siñani, clear evidence of the importance of private schools in Bolivia. Pérez and Siñani found there mutual support for their ideas.

The Education Code of 1955 assured the existence of both urban and rural normal schools. In the Education Reform of 1994, the normal schools were transformed to Higher Normal Institutes. Finally, with the Avelino Siñani–Elizardo Pérez Law of 2010, the name became Higher School for Teacher Preparation. Also created was the Complementary Teacher Preparation Program for in-service teachers to meet the need to transform the education system with support from teachers in the framework of the Socio-Communal Productive Educational Model that was designed to contribute to the creation of a multinational state. The degree offered by the Complementary Teacher Preparation Program is a bachelor's degree equivalent to that offered by the Higher School for Teacher Preparation (Ministerio de Educación, 2013).

The idea of complementary teacher preparation programs had arisen in the 1990s in some universities to allow access to a bachelor's degree.

However, the courses stressed general theoretical matters with little emphasis on pedagogical material. They had even less focus on teaching methods for specific scientific disciplines.

Universities offer bachelor's degrees in pedagogy and a few offer bachelor's degrees in mathematics though usually oriented to pure and applied sciences. Mathematics teachers are prepared only in the normal schools, which are now called Higher Schools for Teacher Preparation. This exclusiveness was and continues to be a factor that limits the participation in teacher preparation of the few mathematicians that do work in Bolivian universities. Also, the professional preparation of mathematics teachers is very heterogeneous and there definitely is no degree in mathematics education.

Mathematics in Bolivian universities

The degree program in mathematics arrived in Bolivia much later than those in law and medicine. Additionally, only four Bolivian universities offer mathematics degrees: three public and one private.

The Higher University of San Andrés created the degree program in mathematics in 1967 in the Faculty of Pure and Natural Sciences. The Autonomous University of Tomás Frías began to offer a similar degree in the Faculty of Pure Sciences in 1972. In the Higher University of San Simón, it was created in the Faculty of Science and Technology in 1985. At the beginning of the century, the private University of Simón I. Patiño established a degree in mathematics. It also hosted the XXVI National Congress of the Bolivian Society of Mathematics in 2013.

The professional profile of the mathematician in Bolivia has been described as follows: "The mathematician is a person who dedicates himself to mathematics."

- Creates mathematics (Research)
- Disseminates mathematics (mathematics teaching)
- Applies mathematics to other areas of knowledge (Expert advice to other disciplines)

The Higher University of San Simón has bachelor's degrees in mathematics and engineering mathematics. The first prepares professionals in pure mathematics and the second has an emphasis in applied mathematics. The other universities just have a bachelor's degree in mathematics. The program lasts ten semesters divided into three cycles: basic, intermediate and orientation (Reunión Sectorial de Carreras de Matemáticas, 2008). To facilitate

learning, mathematics has been structured into the following areas: algebra, analysis, geometry and topology, and applied mathematics.

Rimer Zurita Orellana (2003) has done a comparison study of university systems in Bolivia and Switzerland. He based his comparison on the academic programs and stated:

> Although it appears that the list of courses is more extensive in Bolivia than in Switzerland, often more than one course in Bolivia is needed to cover just one course in Switzerland. Many of the courses in Bolivia, particularly those in the first year, are courses in the last year of high school in Switzerland. Another difference is that often in Bolivia not all the material in a course is actually covered, while in Switzerland it is all covered. Finally, in Switzerland, in the first three years they cover all the topics — even additional one — that are in the five year program in Bolivia.

Similar informal observations can be made about university programs in Spain. Although no rigorous study has been carried out, the observation is valid for reflection. Similar observations can be made about high school education in the two countries.

According to data from the universities that have degree programs in mathematics and from the Bolivian Society of Mathematics, there are no more than about 50 professional mathematicians with degrees ranging from bachelor's to doctorate in Bolivia (Portal UMSS). As Efraín Cruz has said:

> There are very few of us in the department with doctorates, but a good group is now engaged in doctoral study ... the research that has been done is mostly reviews of the literature, but we hope that soon we will receive support from the international community.
>
> This number, only taking teaching into consideration, is insignificant in relation to the actual needs of the higher education system. The pressing needs for professional mathematicians in specific fields where mathematics is applied, and even more for the transference of universal mathematics knowledge to meet the needs of the countries, are not being adequately met.
>
> The gradual placement of primary and secondary teacher education programs from higher normal schools to universities will require the recruitment of professional mathematicians.
>
> Society has yet to understand the need for professional mathematicians in various multidisciplinary projects. However, the

situation is improving, which means that in the near future more mathematicians will be needed.

The permanent expansion of advances in science and technology demands that developing countries such as Bolivia need professionals who adequately transfer and assimilate such knowledge. The bachelor's degree in mathematics prepares students to study at the master's and doctoral levels as well as to work in specific areas of applied mathematics (Cruz, personal contact).

It is very important that some mathematicians have an interest in mathematics education, especially those who have made teaching mathematics their major activity. Also, all Bolivian mathematicians should work for the consolidation of the Bolivian mathematics community. That surely would benefit the country.

The mathematics program at the Higher University of San Andrés publishes *The Bolivian Journal of Mathematics* (*Revista Boliviana de Matemáticas*) and *Fascicles* (*Fascículos*). Porfirio Suñagua, head of the mathematics program in the Faculty of Pure and Natural Sciences at the Higher University of San Andrés from 2001 to 2004, in the prologue to the *Bolivian Journal of Mathematics* #3 indicated that the first *Scientific Journal* of the program was edited in 2000 and the first *Fascicle* in 2002.

> ... in 2000 the program edited its first scientific journal as a result of the research projects presented at the World Mathematical Year. The next year, volume 2 was published. In 2002, the first *Fascicle* published all the research papers from the week-long 35th anniversary of the mathematics program (Suñagua, 2004).

The Bolivian Society of Mathematics

Since its founding in 1991, the Bolivian Society of Mathematics has organized congresses, seminars and colloquia at the regional and national levels. In July of 2013, the 16th Kurt Gödel Bolivian Congress of Mathematics was held (Andia, Los tiempos, July 25, 2013).

Even though the Bolivian mathematics community is not particularly strong, the Society has been able to attract national and international speakers to its congresses (from Germany, Argentina, Brazil, Chile, Costa Rica, United States, Spain, Switzerland, México, Perú, etc.). Many

academic contacts have been generated that have permitted many students and some professors to be able to pursue graduate studies. The Bolivian Society of Mathematics has also programmed parallel sessions on mathematics education directed at teachers of mathematics at different levels.

The Bolivian Society of Mathematics Education was created in 1995 to promote professional advancement and improvement of mathematics teaching (Grigoriu, 2005). As of 2005 it had 200 official members and each year sponsors a National Congress for an average of 600 Bolivian mathematics teachers. In 1997 it hosted the 4th Southern Cone Meeting on the Teaching of Mathematics and the 4th Iberoamerican Congress on Mathematics Education (IV CIBEM) in 2001 (Grigoriu, 2005).

Distinguished teachers of mathematics

Detailed descriptions of Bolivian teachers are scarce. The various movements and reforms were full of prescriptions, but there are no profound descriptions of teaching. There is no doubt that there are many Bolivian mathematics teachers whose teaching practices should be documented. Among them are Santiago Conde, Begoña Grigoriu, and Humberto Giacoman. However, a history of Bolivian education must mention the famous teacher of mathematics Jaime Alfonso Escalante Gutiérrez (1930–2010), who came to prominence for his work at Garfield High School in Los Angeles, California. His story was immortalized by Hollywood in *Stand and Deliver* (1988), starring Edward James Olmos.

Jaime Escalante was born in La Paz on December 31, 1930, to a family of educators. His parents were teachers in a school in Achacahi, so Jaime grew up among Aymara children. His mother, who had high aspirations for her children, took them to the city on the first opportunity she had (Pari, 2011; Scraff, 2009; Mathews, 1988).

Upon finishing high school at the Colegio San Calixto, Escalante enrolled in the normal school that had been created by Georges Rouma in La Paz, but he did not agree with the teaching methods that were being used there (Pari, 2011). Before finishing his pedagogical studies, he was invited by one of his teachers, Humberto Bilbao, to study mathematics and physics. Later, several institutions competed for his services (Pari, 2011; Mathews, 1988). He went to Puerto Rico for graduate studies in sciences and mathematics. He returned to Bolivia, but because of the political and economic instability in Bolivia, he decided to emigrate to the United States.

Upon arriving in the United States, with his limited English and without a teaching credential recognized by the State of California, he had to start over. For admission to Pasadena City College, he finished the two-hour placement test in mathematics in 20 minutes with a perfect score (Mathews, 1988). He studied English, electronics, and mathematics at night while working during the day. He first worked in a restaurant, and then at Burroughs Corporation. Upon earning his teaching credential, he took a job at Garfield High School, even though it meant earning much less than at Burroughs. This was a decision that would change his life forever — and the lives of those he touched. His success at this new position earned him international recognition. He was awarded the Presidential Medal for Excellence in Education by President Ronald Reagan in 1988, the Andrés Bello Inter-American Prize for Education by the Organization of American States (OAS) in 1992, and 10 honorary doctorates. More information about his success at Garfield — and on the prizes and recognitions he received — can be found in Mathews (1988), Schraff (2009), and Pari (2011).

Escalante returned to Bolivia in 2000 intending to share his experiences with his Bolivian colleagues. Nevertheless, authorities at the Ministry of Education and elsewhere in the government gave him no support or recognition. He is an example of the phrase from Jesus "No prophet is accepted in their own land". He did manage to present various seminars and workshops that were very well attended by teachers from different levels. For Escalante, mathematics was defined in four words: concept, language, process and application (Pari, 2011). Teachers need to understand the discipline, know how to motivate, manage personal relationships, but motivating is the most important (Pari, 2011). Students need to learn responsibility, honesty and a positive attitude; the most important is a positive attitude to mathematics.

The Avelino Siñani–Elizardo Pérez Law

At the end of the twentieth and beginning of the twenty-first centuries, there were political changes in Bolivia. The country with its multiethnic composition became known as the Plurinational State of Bolivia (Estado Plurinacional de Bolivia) (NCPEB, 2008).

On December 20, 2010 the Avelino Siñani–Elizardo Pérez Educational Law was passed. This legal regulation initiated a new process of educational

transformation in Bolivia, enshrined in the new constitution that insists that

> Every person has a right to receive an education at all levels that is universal, productive, free, integral and intercultural, without discrimination (Ley Avelino Siñani–Elizardo Pérez, Art. 1, Part 1).

According to Mario Yapu[2] (in Mayorga, 2012, p. 53), the law begins with an ideological reflection, a vision of society, and not with a serious analysis of the technical terms of what the Educational Reform of 1994 was. The foundations of education appear in a list of adjectives: decolonizing, liberating, community, democratic, universal, unique, diverse, plural, integrating, inclusive, intercultural, productive, scientific, etc.

This torrent of terms has generated certain doubts and questions such as this one from Carlos D. Mesa[3] (2012): "New education or new adjectives?" And this is the question from many Bolivians, because the law has not specified the technical aspects and the contents.

The teachers ask: What are the new contents that we are going to teach in this new paradigm, this new educational model? (Yapu, in Moyano, 2012, p. 54).

Perspectives on Mathematics Education

After the creation of the Bolivian Society of Mathematics in 1991, teachers of mathematics saw the need to create the Bolivian Society of Mathematics Education in 1995.

The Bolivian Society of Mathematics, through its national congresses, has allowed mathematicians and mathematics teachers to learn about opportunities for graduate study in mathematics and mathematics education. There has also been the emergence of several fields of research: control theory, dynamic systems, matrix theory, mathematics education, etc.

[2]Yapu is a sociologist and anthropologist who received a doctorate in sociology from the Catholic University of Louvain in Belgium. He is a professor and researcher on research methodology and topics in education. He is the author of various books and Academic Director at the University for Strategic Research in Bolivia.

[3]Investigative journalist and former President of Bolivia.

Both societies have seen the need to promote the consolidation of the Bolivian mathematics community so that professionals in mathematics and mathematics education can generate a focus characterized by the socio-cultural dimension of Bolivian society, as well as initiatives aimed at teacher development and research in ethnomathematics.

It is important to look at the past in order to understand and give a correct interpretation of the present, but we should not pontificate on history nor remain with our feet trapped and our hearts divided by the past. Of course, there are many difficulties to be overcome and challenges to be met. To do so we need the collaboration of all who are involved (teachers, principals, the community, government officials and students) for the sake of achieving a quality educational system for the preparation of mathematics teachers. We need to create graduate courses, particularly in the universities that can rely on the departments of mathematics and help teachers with the interest and desire to achieve disciplinary and instructional qualifications specific to mathematics.

The MEMI program (Improvement of the Teaching of Mathematics and Informatics) began in Cochabamba in 1992 (Grigoriu, 2005). Sponsored by the Faculty of Technology at the Higher University of San Simón, it had support from the Freudenthal Institute of the Utrecht University in The Netherlands. Currently, MEMI has its own installations in the university including classrooms equipped with computers, projectors, etc. It continues to develop activities and supports teachers by organizing courses, workshops and seminars related to the teaching of mathematics (Zegarra, 2013, personal contact).

The initiative of Jaime Escalante upon his return to Bolivia led to many seminars and workshops throughout Bolivia and in other Latin American countries. He awakened the interests of many teachers by showing that it is possible to enjoy the learning of mathematics.

Another proposal to consider is that of Eduardo Valenzuela Siles,[4] who has offered to donate basic software licenses for the Universal Data Manager (ADM).

> Bolivian scientist Eduardo Valenzuela Siles offered advanced mathematical software that facilitates the teaching and learning of teachers and students with complex exercises in physics, calculus, algebra and more to the Ministry of Education.

[4]Valenzuela is a Bolivian scientist living in Germany.

There are many more initiatives of teachers who work in Bolivia and abroad, but they are not documented. They simply happened and are often forgotten. This work invites mathematicians, mathematics teachers and researchers to document the mathematics teaching experiences of educators and institutions. We have a commitment to our country and to our profession.

Bolivian society is beginning to understand the importance of the development of mathematics, its teaching and its learning. On the one hand, professionals are earning graduate degrees in mathematics abroad. On the other, political authorities are advancing innovative initiatives from a constructivist and socio-productive community approach, with an emphasis on ethnomathematics.

To some, it would seem as if teachers are bewildered by this new approach. However, once the initial shock is overcome, teachers would be better prepared to develop school mathematics in a way different than the traditional one. This clearly shows that we must work for the innovation of mathematics teaching, and for the improvement of the initial and continued training of teachers — goals of mathematics education.

Conclusions

This chapter consists of two parts. First, we make an approach to the history of mathematics education in Bolivia, framed in the socio-political and educational events in the country. Then, we describe issues related to research in mathematics education and its development. We have divided the history in three periods: Pre-Hispanic, Colonial, and the Republican.

Although it is true that the creation of mathematics degrees in Bolivian universities happened in the second half of the past century, it is also true that they show a sustained quantitative and qualitative growth at the state level. In the 1990s the Bolivian Society of Mathematics and the Bolivian Society of Mathematics Education were created. All of this favors and facilitates the development and consolidation of the Bolivian mathematics community (mathematicians, teachers of mathematics and students).

Furthermore, the innovative initiatives contemplated by the Education Reform of Bolivia need the active participation of the Bolivian mathematics community so that the development of mathematics will correspond to social and local needs, as well as to the needs of the Plurinational State of Bolivia.

We hope that this chapter will not only show the scarce production in mathematics education research in Bolivia, but that it will also help us to reflect upon and discuss creative means by which to attain equity in education. The Plurinational State of Bolivia has the need to realize educational possibilities that have yet to be discovered and probed.

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Chapter 3

BRAZIL: History and Trends in Mathematics Education

Beatriz S. D'Ambrosio, Juliana Martins, and Viviane de Oliveira Santos

Abstract: This chapter begins with a brief history of mathematics education in Brazil, contextualized within the socio-political and educational events in the country. Research in ethnomathematics and mathematical modeling provide the foundation for curriculum reform and teacher preparation initiatives that strive to achieve greater social justice and equity for Brazilian children.

Keywords: History of mathematics education; ethnomathematics; mathematical modeling; mathematics education; social justice; equity.

Brazilian mathematics education is a young field of research, establishing itself in the latter half of the twentieth century. In this chapter we describe the history of mathematics education in Brazil, from colonial times to more contemporary developments. During this journey we will highlight a few aspects that characterize Brazilian mathematics education today and finally conclude the chapter with a discussion of current trends, including new directions in teacher education and aspects of curriculum reform.

The History of Brazilian Mathematics Education

In order to situate the history of mathematics education in Brazil, we have included in our discussion some important aspects of the political and educational history of the country. Our discussion is organized around the same periods used by D'Ambrosio (2011) to describe the history of mathematics