

Chapter 4

Mathematics Education in Multilingual Contexts for the Indigenous Population in Latin America

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4.1 Introduction

Within internationally published research in mathematics education dealing with multilingualism, little is known about the challenges faced in the education of the Indigenous peoples of Latin America. This chapter has a double contribution. On the one hand, it will present trends in the mathematics education of Indigenous people in Brazil, Colombia, and Peru. This presentation intends to inform an international mathematics education audience about the common traits as well as particular developments of Indigenous mathematics education in the continent.

On the other hand, and based on the information presented, we discuss three interrelated issues. First, the education of Indigenous populations in Latin America needs to be understood in the framework of Spanish and Portuguese colonization. Within colonization, the project of religious conversion and evangelization is a constitutive element of the models of education, multilingualism, and mathematics. Through history, the struggle between different Indigenous communities and state policies and programs have made it evident that (mathematics) education is a terrain of cultural politics for indigenous communities.

Second, in the construction, negotiation, and implementation of different models for Indigenous education, varying from monocultural monolingualism, to bilingualism, and more recently cultural and linguistic diversity, conflicting claims about

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what counts as Indigenous languages and cultures have been present. Indigenous education in Latin America is a space of struggle for the recognition of Indigenous worldviews and knowledge; as such, it is a space where language, knowledge, and identity go hand in hand. In this context, issues of language revitalization as well as tension between oral traditions and written registers are important discussions that shape education and mathematics education.

Third, the current move towards the recognition of cultural and linguistic diversity also poses challenges as to what counts as the mathematics of the Indigenous people and the mathematics of the mainstream cultures in the context of the life of communities and also in schooling. Different state policies of Indigenous mathematics education have resulted in diverse meanings and appropriations of ethnomathematics. Here research in mathematics education has provided tools to deal with these challenges.

In the three main sections of this chapter, we address each one of these issues. Our strategy is intentionally descriptive of the historical development and current situation in three countries: Brazil, Colombia, and Peru. We use the descriptions of these national contexts to depict both commonalities and differences in the discussion about how mathematics education in the cultural and linguistic diversity of the Latin American Indigenous population is highly political.

4.2 Models of Indigenous Education in History

Latin American countries share similar histories around the treatment of their Indigenous communities. The intersection points can be traced back to the Spanish and Portuguese incursions into the continent in the sixteenth century. Colonization represented a process of extermination and domination of Indigenous communities. The natives in this period were treated as *nonhuman, wild savages*. At that time, the definition of “wild” was structured around three components: “unaware of the Castilian language, the Christian religion, and the larger society model” (Roldán & Gómez, 1994, p. 65). From the very beginning of the contact between European and native South American civilizations, language and religion appeared as a decisive factor structuring relations with Indigenous peoples. The Iberian monarchies entrusted to the Catholic Church the tutelage of Indigenous peoples, to carry out their spiritual salvation through evangelization, with the work of missions being central in such task. Religious conversion and with it, cultural assimilation, led to the loss of cultural traditions like written codices and languages. The hard and extenuating work for the economic exploitation of the natural richness of the Americas was also associated with the systematic extermination of large proportions of the native population. In some cases, religious conversion and the exoticization of the “wild” native resulted in the annihilation of Indigenous people. The most extreme case of the eradication of an Indigenous people is that of the Charrúas, the aboriginal settlers of the Uruguayan territory.

In the first quarter of the nineteenth century, independence from the European empires took place. The creation of national states and republics produced a change in philosophy towards the few native populations left. Indigenous people were not

seen any more as belonging to an inferior species, but rather as *potential citizens*. The work to integrate them was once again left under the tutelage of the Catholic Church. The policy of the Church to control the education and the language of the natives remained alive in Brazil, Peru, and Colombia until the last decade of the twentieth century. Even some of the early efforts to register Indigenous languages were associated with religious movements. For example, the Summer Institute of Linguistics (SIL), an organization supported by Christian factions in the USA, created alphabets for various Indigenous languages in the continent and advanced the recording and study of native languages, for the purpose of evangelizing the natives in their indigenous language. Educational initiatives during this period correspond to a transition model (Larson, Davis, & Ballena, 1979, p. 57), in which it is hoped that indigenous students will move from their cultural and traditional practices to become part of the national society. The instrumental use of language and of religion was fundamental in taking that step.

In the course of the 1960s and 1970s alternative institutional educational programs emerged around *bilingualism* in schools. In Peru, the Universidad Nacional Mayor de San Marcos was the first to start a pilot program of research and experimentation of bilingual education with the Quechua-speaking population in the area of Quinua, Ayacucho Department. Since then and within the Peruvian government's Language Development Plan, studies on bilingualism were strengthened. Years later, that university was able to influence the idea of a National Policy for Bilingual Education in the framework of the 1972 Peruvian Education Reform (López and Küper, 1999).

In the 1970s in Brazil and Colombia a series of political processes and social movements started to discuss and promote changes in public policies for Indigenous peoples. There was a critique of the transitional bilingual model, which had prevailed for more than two centuries. In Colombia, the Regional Indigenous Council of Cauca and the Tayrona Indigenous Confederation were founded. These organizations demanded the presence of bilingual Indigenous teachers in schools to respect the history and traditions of the communities. In Brazil, the Indigenous Missionary Council was created in 1972. Two years later, this Council organized the first of a long series of "Indigenous assemblies." The first Indigenous organization in Brazil, the National Indigenous Union, was created in the 1980s and it made alliances with non-Indigenous NGOs and with the Alliance of the People of the Forest in Amazonia, which included non-Indigenous rubber gatherers in Amazonia.

The first experiences of bilingual education for Indigenous peoples were characterized by their linguistic bias, downplaying the enculturating role of education. In the early 1980s, and as a reaction to the focus on language, the concept of *interculturality* emerged strongly. It involved the search for educational models that are specific, differentiated and bilingual and that recognize the importance of Indigenous cultures and languages. Such a view is expressed in educational policy documents and programs in Peru (Bilingual Education Experimental Project of Puno and General Directorate of Bilingual Education) and Colombia (Office of Ethnic Education). It also permeated the production of bilingual teaching materials in mathematics. Elements of the sociocultural practices of the communities were incorporated. Although these initiatives were not sufficiently grounded in indigenous worldviews, such programs played a role in the discussions that took place in Brazil

about Indigenous teacher education and preparation of materials for bilingual Indigenous schools.

During the 1980s, many countries entered a process of change in their political constitutions, which had a huge influence on educational development. Leaving a narrative of national unification, the new constitutions became pluralistic and acknowledged the *cultural and linguistic diversity* of the population. This move facilitated reclaiming the rights of Indigenous nations and safeguarding their worldviews, cultural practices and languages. In Peru, the Political Constitution of 1979 promoted the study and knowledge of Indigenous languages and guaranteed the right of the Quechua, Aymara and other communities to receive primary education in their own languages. It declared that Indigenous peoples have the right to preserve their ethnic and cultural identity and that the state should recognize and protect the ethnic and cultural plurality of the nation. In Brazil, the Constitution of 1988 included the rights of Indigenous peoples to the preservation and maintenance of their values, languages, and cultures. The Political Constitution of 1991 in Colombia declared a multiethnic and multicultural state. In the three countries, after the new political constitutions, several indigenous languages were recognized as official, and many initiatives were developed aimed at including the cultural specificities of each group in the educational system. This context drew more attention to the need for indigenous teachers in schools and led to the development of Indigenous teacher education programs to prepare these teachers.

The attempt to create and establish bilingual, intercultural, and culturally specific Indigenous schools resulted in curricular changes in the three countries during the 1990s. It also increased the participation of Indigenous teachers in writing bilingual materials. Since 2000, the development of Indigenous, bilingual education in each of our countries has a sociocultural orientation that makes education relevant and increases quality. This may be due to several reasons. First, there is a record of 30 years of implementation of experiences in bilingual education. Second, educational initiatives are decentralized and organized around each Indigenous people, as an attempt to take into account their views and wishes. Finally, sociocultural research in mathematics teaching and learning has advanced progressively in the region. This has motivated a search to explicitly include in local curricula the mathematical knowledge of each people.

Nevertheless, interest in Indigenous worldviews has not only produced better conditions for dealing with bilingualism and mathematics teaching but also generated new challenges and emerging tensions. We elaborate on them in the rest of the chapter.

4.3 Dynamics and Tensions Between Languages and Cultures

The historical changes in models of education of Indigenous peoples in Latin America are not unique to the continent. Meaney, Trinick, and Fairhall (2012) discuss the political tensions experienced in the (mathematics) education of Māori

people in New Zealand, and also review similar discussions in Australia, Africa, and North America. Their research highlights the two main topics of this section, namely language revitalization and the creation of written registers on the basis of an oral tradition of knowledge. These two dynamics of language are of particular interest given how Indigenous language, worldviews, and identity intersect in one of the powerful tools of the colonizer, namely, mathematics.

4.3.1 Language Extinction, Revitalization, and Development

In Brazil, Colombia, and Peru there is a great diversity of cultures and languages. Notwithstanding that, sociolinguistic studies conducted in the three countries depict a critical scenario for the vitality of Indigenous languages. Table 4.1 summarizes the situation.

The study carried out by UNICEF and FUNPROEIB (2009) discussed the status of preservation of Indigenous languages in Latin America. In general, Indigenous communities with better organization and more efficient and consistent adaptive strategies have coexisted for centuries with the national society and its dominant language. Their strategies result in the vitality of Indigenous languages and their articulation with the Spanish language. Language vitality is also strong in communities living in isolation, whereas in communities with recent and increasing contact with the national community there will be a tendency to lose language use, leading to a decrease in vitality.

More open political constitutions in the countries around the 1990s promoted changes in the colonial model of a monolingual language policy. Indigenous communities were granted rights over their land, cultures, and languages. This change went together with the development of language policies decreasing the speed of language extinction and preserving and maintaining Indigenous languages. One of the results of such a trend was the formulation of educational policies for preservation, aimed at generating special professional development of Indigenous bilingual teachers, as well as the creation of alphabets and written registers for these indigenous languages.

These new settings have greatly impacted the possibilities of claiming an Indigenous cultural identity, not only from a legal and institutional point of view but also from the point of view of Indigenous peoples themselves. We are taking here the notion of identity as a discursive concept. Identity is seen as a construct that happens in and through language. According to Woodward (1997), identity construction processes are always built in relation to and maintained by history and culture and are dependent upon the nature of social relationships established over time.

The inseparability of identity, language, and culture has resulted in the politicization of research on Indigenous languages and education. From the denial of the Indigenous in colonial policies to the awareness of multilingualism and multiculturalism, many Indigenous education policies have adopted a naïve, but still colonizing, approach to the “development” of Indigenous languages and cultures.

Table 4.1 Indigenous groups, their languages and their language vitality

Country	Basic statistics			Vitality			Languages by number of speakers			
	Indigenous groups	National population (%)	Indigenous languages	Linguistic families	Endangered languages	Severely endangered	1–99	10–999	1,000–50,000	>50,000
Brazil	305	0.47	184	42	24	10	34	106	44	1
Colombia	91	3.3	66	13	19	5	25	33	33	2
Peru	60	15.9	47	19	4	17	6	20	17	4

Sources: For Brazil (IBGE. Instituto Brasileiro de Geografia e Estatística, 2010); for Colombia (Landaburu, 2004; UNICEF and FUNPROEIB, 2009); for Peru (INEL. Instituto Nacional de Estadística e Informática, 2009; Ministerio de Educación del Peru, 2013, pp. 13–16)

Simultaneously political discourses have evidenced tensions in the meeting between Indigenous identities and the dominant cultures, their languages and related forms of identity represented in schooling. For example, the development of Indigenous languages leads to their normalization, as a prerequisite to achieve a standard style of writing. In Peru in 1985, the Quechua and Aymara alphabets were normalized, and at present 21 more Indigenous languages have been normalized. However, the processes of negotiation for settling alphabets and rules of writing have not ended.

There have been integrationist policies or policies oriented to the revitalization and maintenance of the cultural and language practices of minority groups. Concerning the latter, various educational programs have been developed with a focus on language and culture. These programs have generated the production of alphabets and written registers for some Indigenous languages. The categorization of these languages as “written” or “unwritten,” or having an alphabetic system or not is a politically highly contentious issue which is part of the history of the power relationship between the colonial power and dominant groups and Indigenous communities. Indigenous worldviews conceive as legitimate texts registers of various kinds, such as inscriptions, fabrics, or pictograms, which are part of their cultural artefacts. The fact that the linguistic structures of the Indigenous languages have been recognized as extremely complex (UNICEF and FUNPROEIB, 2009) is of importance when moving into the discussion of the relationship between language and mathematics (Parra, 2013). This is of particular relevance for understanding how different national histories have dealt with the “lack” of alphabetical registers in Indigenous languages.

4.3.2 Tensions Between Oral and Written Registers

Indigenous teachers and communities have argued for the need to raise awareness of the political dimension and impact of introducing schooling and writing in their communities. Criticism has been raised of the inclusion of local cultural knowledge in the curricula. In discussions about mathematics education for Indigenous people, a major point is the relationship between orality and writing, because the introduction of alphabetical writing in contexts shaped by an oral tradition creates many tensions. We can see these tensions in standardization processes, technical problems in the production of alphabets, teaching materials, loanwords, neologisms, and processes of re-semanticization. Moreover, these tensions are related to the ultimate purpose of writing oral languages to affirm cultural identity. Written languages find a role in the school, and they create the necessity of exploring social uses for that writing outside the school.

When addressing the relationships between orality and writing in Indigenous contexts of mathematics education, a source of tension is the fact that Indigenous languages have strong oral traditions, while Portuguese and Spanish have a strong written tradition. With respect to Indigenous students’ development of mathematical thinking, local mathematical knowledge and Indigenous worldviews appear close to each other. This is evidenced in oral expression and graphic representations that are valid only in the limited scenario of one culture. School mathematical knowledge, by contrast, demands a different type of link with the students’

sociocultural context. It implies the use of expressions not only at the oral, concrete, and graphic level but also at a symbolic one.

The oral-written tension can also be discussed in situations where oral patterns and other forms of symbolic representation that make part of the language practices of these communities appear in written texts, such as, for instance, when aspects of orality influence the writing of mathematical problems, as discussed by Mendes (2007). The writing of these problems in Indigenous languages and in Portuguese by Indigenous teachers have a narrative form. The problems are presented without question(s), which is the expected form. They preserve the discursive characteristics that could be associated with language use to solve problems in daily life. The narrative form incorporates alphabetical and numerical writing and visual representation, i.e., drawings are part of the narrative. They transfer oral narrative characteristics of an everyday problem situation into writing and give a narrative function to drawings that appear in the problem. This type of writing of mathematical problems in a narrative form brings to light the difference between oral and written traditions. “Narrative is a strong trait in the process of production, incorporation and maintenance of social and cultural knowledge and norms among indigenous groups” (Mendes, 2007, p. 224).

The development of a bilingual and intercultural mathematics education for Indigenous students entails another challenge related with expressions in Indigenous languages, since their structure may sometimes complicate the understanding of symbolic expressions. For instance, the expression “ $7 > 4$,” in Spanish is read “7 es mayor que 4” [7 is greater than 4], while in the Amazonian language Shipibo Conibo is expressed as “7 riki 4 bebon iká,” an expression that has a different syntactic structure. In Shipibo Conibo this expression means “7 is in front of 4,” appealing to the order of natural numbers, instead of their cardinality. In the same way, there are tensions generated by the mismatch between some Indigenous concepts and those used in mathematics. In some Andean cultures, time and space form a conceptual unit, termed in Quechua as *pacha*, where there is no distinction between the two (Yáñez Cossío, 1990, p. 4). Another example is that in some Indigenous numeration systems, the terms for integer numbers in the Indigenous language could be a useful resource from a pedagogical point of view. For example, “in Quechua, Aimara and in some Amazonian languages the numbers up to ten have each one a name. From ten on, they are named “ten and one,” “ten and two,” “ten and three”... “two tens,” “two tens and one,” etc. This structure facilitates both understanding of the decimal positional numbers system and the construction of algorithms for the basic operations” (Villavicencio, 2013, p. 36). All these tensions can be seen either as obstacles to overcome or as opportunities to enrich the cultural dialogue of different mathematical knowledge.

4.4 Relevant Mathematics Education in Indigenous Contexts

The changes towards diversity in linguistic and educational policies took place at the heart of cultural, social, and political claims of a national nature. Due to this, the dynamics of multilingual education are not restricted to bilingualism and they are

not separated from conceptions, policies, and projects based on interculturality in each country. With regard to mathematics education, and in order to contribute to the cultural reaffirmation of Indigenous peoples, we understand mathematics as a cultural phenomenon and thus recognize the mathematics of each Indigenous people.

Although we use distinct perspectives for the concept of *ethnomathematics*, we find common ground in our countries with respect to the importance of research on connections between language, culture, and mathematics. Drawing on D'Ambrosio (2011, pp. 111–112), ethnomathematics is not only the study of the mathematics of various ethnicities but also more than that; it is a spatially and temporally differentiated study of the various *technes* or *ticas* (ways, techniques, abilities) of *matema* (to explain, to understand, to deal, to coexist) in different *ethnos* (natural cultural and socioeconomic contexts). Since cultural encounters take place in a network of power relations, these relations set in operation a hierarchy of knowledge that declares what counts as official, valid, or even invalid (Knijnik, 1996).

The cultural forms particularly associated with mathematics are produced in the weaving of cultural understanding as interactive processes or as a web of meanings, using Geertz's (1973) idea of culture as a web of significance. If culture is produced like a web of meanings in interaction, there is a close connection between language and culture. This is because we do not understand language only in a verbal sense, as a vehicle of expression of culture, but as a symbolic system. Thus language can be seen as the stage of cultural production.

Ethnomathematics in the mathematics curriculum of basic education for Indigenous peoples in Brazil, Colombia, and Peru has the aim of contributing to cultural reaffirmation of Indigenous students, through their language and in the context of their worldviews. The inclusion of mathematical aspects of local cultures in the school curriculum is not planned to build a bridge that serves to facilitate students' learning of Western mathematics. Rather, it is a strategy for building cultural identity. This idea is aligned with the ethnomathematical aim of understanding and making visible the cultural forms in which mathematical thinking is produced. The routes that each country has taken into formulating relevant mathematics education for Indigenous are diverse.

4.4.1 Officializing Ethnomathematics in Peru

In Peru, current mathematics education in Indigenous contexts comes from the systematization of accumulated experiences. The documentation on this matter dates from the 1950s. Arithmetic texts produced by SIL were used by students and teachers in Amazonian bilingual schools (Larson et al., 1979). In the 1980s, the study "Numeration, algorithms and application of numerical and geometric relations in the rural communities of Puno" identified the mathematical knowledge of Quechua and Aymara communities (Villavicencio, 1983, pp. 135–141). The results were taken into account in the Experimental Project of Bilingual Education in

Puno. In this pilot project and other similar ones, as well as in the creation in 1989 of a section in the Ministry of Education responsible for Bilingual Education, a new attitude towards and awareness of Indigenous mathematics started.

Since 2003, educational law establishes interculturalism as a mainstream trend in the entire education system. This includes an intercultural mathematical education for all, i.e., for Spanish speakers and speakers of Indigenous language. This law also contributes to the recognition of ethnomathematics as part of the official discourse. For the purpose of implementing and developing an intercultural and bilingual education, ethnomathematics is operationally understood as the knowledge of a cultural group, identifiable as part of their worldview, manifested through the activities of counting, measuring, locating, designing, playing, and explaining.

For basic mathematics education and monolingual Spanish speakers, learning is planned through school activities that enable students to acknowledge the presence of mathematics in Indigenous cultures. In the mathematics education for students whose culture and language are Indigenous, the Peruvian government promotes and implements a pedagogical proposal in the context of the Bilingual Intercultural Education program (Dirección General de Educación Intercultural Bilingüe y Rural [DIGEIBIR] 2012). This proposal has been developed in consultation with Indigenous representatives and the participation of teachers and wise men from the involved communities. The pedagogical approach for mathematics in this educational model is problem solving, in addition to the focus on democratic, intercultural, and welfare rights.

When a school year begins, an elementary teacher in the above mentioned program identifies the students' language proficiency using a psycholinguistic diagnosis tool. There are four levels of proficiency. In classrooms where children speak mainly Indigenous language, the intercultural approach starts with learning-oriented activities of ethnomathematical knowledge, using strategies from their cultural practices, complemented later with school mathematics. While school mathematics has its own codes that can be verbalized in different languages, ethnomathematical non-Western knowledge is inseparable from the corresponding native language and culture. Hence, in multilingual Indigenous contexts, an intercultural bilingual mathematics education is necessary. With respect to the teaching and learning of school mathematics, the language of instruction is chosen, taking into account the students' proficiency in the indigenous languages and Spanish.

For several reasons, mathematics education in Indigenous Peruvian schools has not encountered adequate technical support. Since 2012, the Ministry of Education started prioritizing the education of Indigenous peoples when it was made evident that Indigenous students' achievement in mathematics was low. However, bilingual education strategies may have a positive impact on these students' achievement. López (1998) found that "children served by the PEEB-P [bilingual education program in Puno province] outperformed their peers in the control schools in terms of reading comprehension, oral proficiency of Spanish and mathematical problem solving" (p. 70). Results indicate that learning achievements are better when mathematics education for indigenous children is bilingual, in Andean languages (Quechua or Aymara) and Spanish.

In a study in rural schools in Puno within the bilingual and intercultural approach, Cueto and Secada (2003) did not find statistically significant differences between students' performance in monolingual Spanish and students in these schools. Rather than accepting these results as evidence that the introduced program does not work (or just does not "harm"), the authors argue that the program is not running adequately. They suggest that:

Any effort to create a truly operational program should take into consideration the language teacher and his mastery of reading and writing, the values and beliefs of the students and their parents about the importance of indigenous languages, and the support given to the program inside and outside classroom (Cueto & Secada, 2003, p. 19)

Studies providing more evidence about the quality of mathematics education in Indigenous contexts are still needed.

4.4.2 Using Language to De-colonialize Indigenous Education in Colombia

During the last 20 years in Colombia, there has been a growing development of multilingualism in mathematics education, emerging from Indigenous communities and researchers. Such development corresponds to a wider context, in which a bottom-up process has now reached policy levels. This section shows important elements of that process for mathematics education as the political changes in the country since 1991 have helped Indigenous communities to legitimately claim the right to defend their cultural identity.

In the 1980s, Indigenous peoples of Cauca were working on creating school readiness booklets on arithmetic. As a result of ethnolinguistic work, Queixalos (1988) created "neonumerations" for the Sikuani language, and Cauty and Ramos (1990) for the Nasayuwe. These first attempts had the intention of creating a basic register for arithmetic and numerals in these languages. It was even intended that these new registers would enter schools. They were introduced in schools, but the dominant use of Spanish in out-of-school situations was difficult to challenge.

By tracking the evolution of curricular proposals for Indigenous education, whether governmental or initiated by Indigenous people, a vacuum on the subject of mathematics can be seen. More often than not, mathematics is considered to be an autonomous differentiated discourse that cannot be addressed using Indigenous knowledge. There has been a tendency, therefore, to deal with mathematics in Spanish. In the few cases where mathematics is connected with Indigenous cultures, it is reduced to arithmetic, with numeral translation, and implemented in school problems of trading. This situation can be related to the fact that during the 1980s, Indigenous movements lacked theoretical tools to associate elements of mathematics with cultural practices.

In the mid-1990s, Ochoa and Peláez (1995), supported by an Indigenous association, presented the mathematical knowledge of the Tule people and a mathematics that

they called “Western.” They explained the idea of number in the Tule worldview, topological notions, some classifiers and operations with numbers. They also exposed basic school mathematics tied to arithmetic and its operations. In their text, we find together, but separately, two conceptions of mathematics. Issues of language are made evident in the bilingual writing in both Spanish and Tule language.

Cauty and Tovar developed a project with the Wayuu people, reported in Cauty (1998). The project provided a new approach to structure the fieldwork dynamics for articulating Indigenous claims with advances in mathematics education and ethnomathematics. Cauty engaged in the difficult task of translating an algebra textbook into the Wayuunaiki language. He convened an interdisciplinary and intercultural team of experts: traditional knowledge-holders, linguists, and mathematicians. They worked on creating new knowledge, generating explanations of different concepts from cultural legacies, academic mathematical knowledge, and the structure of Wayuunaiki. It became clear that such an endeavor was not about making literal translations, or equivalences word to word, but about building networks of explanations and representations around concepts and practices. The process could not only be steered by the mathematical knowledge of the dominant society. The product was not a translated text, but a process that brought together different peoples and knowledge. They proposed new words and alternative conceptualizations in mathematics, which expanded the original fields of knowledge of each culture. One contribution of this work was to overcome the idea that arithmetic is the only content to be worked in Indigenous education. Another element was to suggest a multidirectional approach that evidenced how this type of encounter cannot be a translation from academic mathematical knowledge to words used in the native language, tacitly maintaining a relationship of hierarchy between the two cultures. It was also necessary to describe with Western mathematical representations some topics and features of the Wayuu worldview, which were conceptualized by the Wayuu as hallmarks of their rationality.

Since then, there has been an increase in research on Indigenous knowledge associated with mathematics in different Colombian communities. Such work privileges a strategy of dialogue of knowledge which emphasizes cultural and cosmological issues, while it downplays a linguistic focus (Aroca, 2007; Parra, 2003).

In 2006, some of the Cauca communities expressed interest in researching their worldview, forming an Indigenous intercultural research center, and within it a research team on Nasa people’s mathematics. Such a team was formed by Indigenous teachers who had been involved in the Nasa-alphabet unification as well as in the standardization of the writing process. The team also involved experts in mathematics and language, with experience in Indigenous education. The work process reflected some elements of Cauty’s proposal, but coordinated with the Nasa people’s ways of producing knowledge. The work was collectively developed in different shelters, with the participation of knowledge-holders, elders, children, teachers, and educational authorities.

Previous published information about the mathematical practices of the Nasa people was refuted, complemented, and increased. The discussions during the exploration took place in the Nasayuwe language and the teachers recorded,

transcribed, and summarized the elements found in them. When the community elders expressed mathematical concepts, unexpected words that had fallen into disuse or were not known to newer generations appeared. Some common words also gained a new meaning. Considering issues of localization, there emerged old expressions in Nasayuwe for movement and stillness. Words indicating specific lapses of time during the day were commonly used as time markers. Also the existence of some local measure units for weight, length, and volume led the researchers to propose a word for the concept of “measure unit.” When conceptual issues appeared, e.g., velocity or continuity, common words gained a new meaning, as the constant and uninterrupted presence of the territory and its spirits has a particular word in Nasayuwe. That word was proposed to express the concept of continuity. The road, that sometimes disappears, was used as an image for “the discrete” as a mathematical concept. Research findings were published in a bilingual book, in which Indigenous teachers were the authors (Caicedo et al., 2009). The book includes several stories of the oral tradition and rescues what the community considers as mathematics.

The book also raises conceptual elements to be developed by other teachers in their process of *Educación Propia*. *Educación propia* (in Spanish) is an educational approach resulting from 35 years of political negotiation between Indigenous organizations and the Colombian government. This approach encapsulates three meanings of the word *propia*: *propia* as *their own* or belonging to them, *propia* as *adequate* for their needs, and *propia* as other forms of knowledge and education that get *appropriated* by the community for their political struggles (Parra, 2011). In the same way, attuned to government regulations on Indigenous education, Viluche and Yujo (2006) and Tamayo (2012) have initiated studies on mathematics education in other communities, discussing the Western disciplinary classification and displaying its failure to deal with cultural practices. Appreciation of the integrity and holism of Indigenous thought generates resistance to the act of isolating elements of cultural practices and to typifying them as mathematical.

4.4.3 Problematicizing Schooling and Mathematics Education in Brazil

In Brazil, issues related to mathematics education for Indigenous peoples emerged linked to discussions about Indigenous schools. Although school was understood as a historical space of value imposition and assimilation for incorporation into the market economy, Indigenous communities began to claim schools as a place to build intercultural relationships based on political autonomy (Ministerio de Educação do Brasil, 2007). Therefore, Indigenous education, particularly mathematics education, cannot be divorced from Indigenous students’ realities in seeking to meet the Indigenous communities’ aspirations and respect for group cultural issues (Correa, 2002).

The discussions about mathematics education have been influenced by ethnomathematics research in contexts of Indigenous communities and also by processes of Indigenous teacher education in different projects in the country, such as those by Costa (2008) and by Mendes (2001). As stated by Sebastiani Ferreira (2004), the movement of teacher education with teachers as researchers in Indigenous cultures is crucial. Indigenous teachers assume a key role in research practices around language and cultural knowledge in their communities with the purpose of incorporating and articulating the community's knowledge in relation to school mathematics practices. Many Indigenous teachers have this perspective when questioned about why mathematics should be taught in Indigenous schools. One indigenous Xacriabá teacher asserted:

We have to know the math also, since the activities are not just from textbooks, but in relation to our people. Mathematics in Indian schools is very important to our day-to-day. We are living in it. (Mendonça, 2006, p. 5)

The rights claimed by Indigenous communities call for an Indigenous School Education characterized by the “assertion of ethnic identities, the recovery of historical memory, the appreciation of languages, and knowledge of indigenous peoples and the revitalized association between school/society/identity, in accordance to societal projects defined autonomously by each indigenous people” (Ministerio de Educação do Brasil, 2007, p. 21). Indigenous schools are being proposed as intercultural spaces where situations of teaching and learning are related to the political and cultural identity of each Indigenous people. As said by a Guarani teacher:

I see that this school should have all conditions of an Indigenous people, the Guarani-Kaiowá people, Terena, Xingu, Xavante [...] whatever. But it has to be a school of that group, that nation, which teaches the language, dances, rituals, ceremonies, which is a school with proper autonomy of the local community. (Rodrigues, Ferreira, & Domite, 2009, p. 9)

In the same way, Indigenous peoples have linguistic rights to participate in school learning processes conducted in students' mother tongues. Those rights direct attention towards the community's sociolinguistic reality and language use in the community space as well as in school. Indigenous school education in an educational program that has no connection with the reality of Indigenous students can generate a weakening of a people's identity, making harder the struggle for survival. Therefore, mathematics education courses for Indigenous teachers have been anchored on issues related to Indigenous communities' aspirations and respect for cultural identity, to meet the needs of Indigenous peoples for building their own educational curriculum, according to their reality and consistent with the new demands that post-contact situations imposed (Correa, 2002).

Among studies with a focus on cultural practices of Indigenous groups, Indigenous languages have a key role in knowledge constitution. Ribeiro and Ferreira (2004) show that the Xerente people have an organization that is based on a dual logical thinking process. Numbers expressed in that Indigenous language have a dual construction because the number one is not a complete entity. A unity, for this community, occurs in the encounter between one half and the part that is

lacking: “The whole number, reflecting the knowledge that comprises it, consists of the junction of two halves, which form an ethnomathematical dual system” Ribeiro and Ferreira (2004, p. 152). As this conception has no possible translation from the Xerente language into Portuguese, the authors underscore the need for vitalizing language to maintain the Xerente culture.

The case above exemplifies the fact that the encounter between Indigenous and non-Indigenous mathematics have generated tensions of a political and symbolic nature in relation to the uses of Indigenous languages and Portuguese. Such tensions have resulted in the development of new numerical terms, particularly in producing mathematical literacy materials in Indigenous languages, as a form of affirmation and maintenance of an ethnic identity as discussed by Mendes (2004, 2011). Following this trend, Indigenous schools are conceived of as intercultural spaces that can be conceptualized as “border schools”; that is, public spaces in which teaching and learning situations are related to the political and cultural identity of each Indigenous people. More generally, it can be argued that discussions of Indigenous school education in Brazil have questioned the relationship between society, culture, and school. Thus, intercultural and multilingual mathematics education draws on the social life of these groups in order to establish new meanings and functions for the school contexts.

4.5 Concluding Remarks

Since the 1980s, there has been a favorable advance of state policies towards the participation of Indigenous peoples regarding the recognition of their right to an appropriate education, according to their worldviews, cultures, and languages. In contrast to the colonial view of assimilation of Indigenous people through evangelization and monolingual/monocultural education, the advance towards the acknowledgement and respect of Indigenous cultures has been closely linked to the struggle of Indigenous organizations. In Brazil, Colombia, and Peru there are different routes for the implementation and development of educational models in the context of Indigenous peoples, which depend on the autonomy and dialogue that they establish with the state. In Peru, there is a diversified bilingual intercultural education provided by the government, with the participation of the Indigenous peoples. Education and professional development for bilingual and intercultural teachers are offered in pedagogic institutes and some universities. In Colombia, the communities are developing an entire educational system, following the principles of the *Educacion Propia* approach. In Brazil there is a differentiated, intercultural, and bilingual proposal for Indigenous schooling with emphasis on the initial education of Indigenous teachers in undergraduate programs at universities.

To attend to the needs of Indigenous populations, the three countries have diversified curricula, finding in different interpretations of ethnomathematics the theoretical and methodological elements necessary to support mathematics education in situations of bilingualism involving meetings of different cultures. Nevertheless, the implementation and development of mathematics education for Indigenous

populations have generated tensions derived from the diverse worldviews, cultures and languages involved. Indeed, Indigenous peoples generally agree to establish a harmonious relationship with nature, as opposed to those who see nature as an object of exploitation. American Indigenous cultures seek the good life of all beings, including humans. Also, cultural practices associated with mathematics are present in the field of daily life and social relations and are interwoven with spirituality and cosmologies. Such ways of understanding themselves and the environment usually clash with dominant views of school mathematics belonging to the main culture, where school mathematics is seen as a knowledge that stands on its own, decontextualized of its origin and use. All this brings to the fore the epistemological debate about what counts as mathematical knowledge in the domain of schooling, as well as the criteria to select what deserves to be addressed in Indigenous education.

The production, dissemination, and use of bilingual educational materials in mathematics may lead to solving linguistic, social, and epistemological issues. In fact, creating neologisms and determining loanwords suitable for the intended objectives of mathematics teaching requires an in-depth study of the linguistic structures of Indigenous languages. It also demands the active participation of the community and institutional support to ensure the use of the terminologies proposed. A factor of complexity is the fact that these languages are predominantly oral, with all that this implies for the understanding of the symbolic language of traditional school mathematics, particularly when symbolic expressions of mathematical relations do not match the syntactic structure of the corresponding oral expressions in Indigenous languages.

Research on the mathematics education of Latin American Indigenous peoples is recent compared to the advances in other similar situations (e.g., Meaney, Trinick, & Fairhall, 2012). Research on the systematically low levels of achievement of Indigenous students in mathematics alerts us to the urgency of considering educational approaches that build on Indigenous traditional knowledge, ensuring basic conditions to enable a *pertinent* and *quality* mathematics education. It is also important to reconsider the relevance of applying standardized tests to Indigenous peoples or the weighting of their results to the policies to be implemented, since the exercise of citizenship is differentiated in these peoples. Not everyone wants to enter into the schemes of economic production that mainstream society builds, with its standardization in school mathematics. Multilingualism in Latin American schools is engaged in a broader political project for respect and protection of cultural diversity and Indigenous heritage.

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