Chapter 1
An Ethnomathematics Overview: An Introduction

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Abstract After three decades since the emergence of the ethnomathematics as a program, many investigators and educators in many countries are not comfortable about the role of ethnomathematics in mathematics education. This particular pedagogical action underscores the importance of doing the ethnomathematical work first in order to come to a good understanding of the mathematical aspects of culture by having a clear purpose in regards to educational activities. Both the implantation and implementation of ethnomathematical perspectives in classrooms must be preceded by investigations of the mathematical ideas, procedures, and practices developed by the members of diverse cultural groups. Ethnomathematics helps to establish a meta-awareness of the role of mathematical knowledge in the society and cultural context of mathematics. Hence, ethnomathematics is a reciprocal program as it is possible to think of traditional academic mathematics and its role within its host cultural group. This reciprocity is a vital aspect of ethnomathematics.

Keywords Challenges · Cultural features · Ethnomathematics · Mathematics education · Opportunities

1.1 Preliminary Thoughts…

Over time, there has been an increased interest in how we, as researchers in ethnomathematics, incorporate new ideas and technologies in novel and creative ways and how these interactions are increasingly affecting our thinking and learning processes. Our own culture and society considerably influences the way in which

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we understand mathematical ideas, procedures, and practices. In this regard, we need to make an effort to open our eyes to *alternative* narratives, understandings, histories, and technological sophistication in relation to local non-western cultures and their mathematics.

Hence, the core of ethnomathematics research increasingly demonstrates how mathematics is made of many historically rich, diverse, and distinct traditions. The members of distinct cultural groups have developed mathematical concepts that are rooted in the universal human endowments of curiosity, ability, and transcendence. They characterize our very humanness. Awareness and appreciation of cultural diversity that can be seen in clothing, methods of discourse, religious views, morals, and our own unique worldview combine to allow us to understand each aspect of our daily life.

This context allowed D'Ambrosio (1985) to state that all people have developed unique, often distinct ways of mathematical knowledge that frequently were incorporated into cultural systems as diverse people interacted, immigrated and created new contexts. This is most obvious in ways that diverse groups order, quantify, use numbers, incorporate geometric forms and relationships, measure, and classify objects. Consequently, mathematical thinking is influenced by a wide diversity of human environments, which include language, religion, morals, economics, social, and political activities.

For example, language plays a central role in ethnomathematics research. The research related to the use of local languages empowers the knowledge of the *others*. Language implies a logical order and a cognitive structure that in turn carries implicit features of the worldview of a culture. It is through the knowledge of the language as well as its signs and meanings that we are able to understand and delve into the logic of differentiated groups. Thus, it is essential that investigators familiarize themselves with local languages in order to access distinct forms of expressions associated with mathematical knowledge of members of other cultures.

Within this context, Meaney et al. (2008) state that, "specific cultural practices such as ethnomathematical ones are embedded within the language of the culture" (p. 53). Along with language, the members of distinct cultural groups have come to develop logical processes related to quantification, measurement, and modelling in order to understand and explain their social, cultural, and historical contexts (Rosa and Orey 2010).

These processes enable the members of each cultural group to develop their own way to *mathematize*[1] their reality in order to examine how mathematical ideas and practices are processed and used in daily activities. These tools allow for the identification and integration of specific mathematical ideas, notions, procedures, and practices by schematizing, formulating, and visualizing a problem in different ways, discovering relations, patterns, and regularities, and transferring a real

[1]Mathematization is a process in which members of a distinct cultural group develop specific mathematical tools that can help them to organize, analyze, comprehend, understand, and solve concrete problems located in the context of their real-life situations (Rosa and Orey 2010).

world-situation into mathematical ideas through the mathematization process (Rosa and Orey 2012).

Inclusion of a diversity of ideas brought by people from diverse cultural contexts gives confidence and dignity to students, while allowing them to perceive a variety of perspectives in order to provide a base in which they are able to learn mathematics (Rosa and Orey 2015). Equally important is the search for alternative methodological approaches needed to reach this goal. On this matter, as traditional Western science-based mathematical practices were accepted worldwide, it is even more vital that we record historical, diverse, and alternate forms of mathematical ideas, notions, and procedures before many of these local practices are lost to us. In this way, students can see how mathematics has developed and realize how individuals help the overall evolution of mathematical knowledge.

Therefore, the development of mathematical ideas, procedures, and practices serves as a vehicle to transfer meanings and values from the culturally constituted to that of the constituted academic world. The communication of these ideas is represented best in the moderator process as the effect of culture on the mathematics concepts developed by the members of distinct cultural groups. When considering this process, it is worth noting that from an emic perspective, culture may not be seen as a construct apart from, and causing the development of, mathematical practices. We depict culture as causing the development of mathematical ideas, procedures, and practices in order to develop a framework that individuals can easily implement to compare mathematical practices developed by different cultures and isolate the cultural causes of the distinction of these practices.

In this regard, emic researchers view culture as inseparable from the individual, as an inherent quality (Geertz 1973). Thus, the emic approach focuses on the meaning of objects such as mathematical artifacts in the lives of the individual has also applied values theory to explain how people organize information in their own environment. An etic approach understands the mathematical phenomenon more cross culturally rather than cultural specific meanings. Studying culture according to pre-established etic procedures impedes the discovery of cultural diversity, whereas *emic* analysis broadens this view (Headland et al. 1990).

According to this context, Rosa and Orey (2011) argue that ethnomathematics attempts to establish relations between the mathematical ideas and procedures embedded in local practices (emic) and academic conceptual frameworks (etic). The goal of ethnomathematics research is about the acquisition of both emic and etic approaches because an emic approach is essential for an intuitive and empathic understanding of a culture, and it is essential for conducting effective ethnographic fieldwork while an etic approach is essential for cross-cultural comparisons, and forms an essential component of ethnology since such comparisons necessarily demand standard units and categories. Both etic and emic approaches refer to similar constructs but from different perspectives, that is, *between-cultures* versus *within-cultures*. The notion of values, or at least some variants of it, is a central component to most views of culture.

1.2 Cultural Features of Ethnomathematics

Ethnomathematics is a research program incorporating history, anthropology, pedagogy, linguistics, and philosophy of mathematics with pedagogical implications that focus on the techniques of explaining, understanding and coping with different sociocultural environments. According to D'Ambrosio (1985), the etymology of ethnomathematics, the prefix *ethno* refers to sociocultural contexts and, therefore, includes language, jargon, and codes of behavior, myths, and symbols. The derivation of *mathema* means to explain, to know, to understand, and to perform activities such as ciphering, measuring, classifying, ordering, inferring, and modelling. The suffix *tics* is derived from *techné* and has the same root as art and technique. In this case, *ethno* relates to the members of distinct cultural groups who identified themselves by their cultural traditions, codes, symbols, myths, and specific ways of reasoning and inferring.

It is the application of mathematical ideas, procedures, and practices developed and applied by members of a specific cultural group in distinct contexts, which are often used currently in present day contexts (D'Ambrosio 1985). The main objective of this program is to offer an innovative theoretical basis composed by philosophical, political, and epistemological dimensions of the development of mathematical knowledge as well as the comprehension of human behavior by making sense of the mathematical ideas and procedures practiced by humanity. This means that the study of the history of mathematics attempts to identify the cultural and mathematical contributions of different cultures across the world.

Much of what we call *modern mathematics* came about as diverse European groups sought to resolve unique problems related to colonization, commerce, art, religion, exploration, colonization and communications, the construction of railroads, census data, space travel, and other problem-solving techniques that arose from particular communities. For example, the Mayans invented the number zero and the positional value that are often attributed to the Hindus around the 9th century (Rosa and Orey 2005). These concepts were transmitted to the Arabs from the Hindus by means of exchanges and commercial activities. And the most common form of quantification is based on a Hindu-Arabic numeral system, which has resulted from a historical relationship between two distinct cultural groups that developed their own mathematical knowledge bases.

While making use of *modern mathematics* and science, ethnomathematics also embraces the mathematical ideas, thoughts, notions, and practices as developed by all cultures across time and space. From this perspective, a body of anthropological research has come to focus on both intuitive mathematical thinking and the cognitive processes largely developed in minority[2] cultural groups (Barton 1996). It is a

[2]One of the main characteristics people of minority groups have in common is that they often face discrimination, marginalization and exclusion from society. International human rights laws, which focus on the principle of equality, guarantee the educational right to all people. However, people of many minority groups are likely to be denied their right to education. In this context, the

program, which seeks to study how diverse groups of people understand, comprehend, articulate, process, and use mathematical ideas, procedures, and practices in order to solve problems related to their daily lives.

These basic principles of ethnomathematics define its philosophical and ideological postures, which are the roots of a *holistic theory* whose focus consists essentially of a critical analysis of the generation (creativity) and production of mathematical knowledge and its intellectual processes, as well as its institutionalization (academics) and diffusion through educational process (D'Ambrosio 2006). This *holistic* context includes diverse perspectives, patterns of thought, and histories, the study of the *systems*[3] taken from reality in order to help students to reflect, understand, and comprehend extant relations among all of the components of the system (Rosa and Orey 2010).

Cultural variables have strongly influenced how students come to understand their world and interpret both their own and others people's experiences (D'Ambrosio 1995). In attempting to create and integrate mathematical materials related to different cultures and that draw on students' own experiences in an instructional mathematics curriculum, it is possible to apply ethnomathematical strategies in teaching and learning mathematics. These strategies include, but are not limited to the historical development of mathematics in different cultures that:

> (…) use mathematics (e.g. an African-American biologist, an Asian-American athlete). Mathematical applications can be made in cultural contexts (e.g. using fractions in food recipes from different cultures). Social issues can be addressed via mathematics applications (e.g. use statistics to analyze demographic data) (Scott 1992, pp. 3–4).

Similarly, it is important to show how ethnomathematics describes the ideas and procedures that are implicit in the procedures and practices developed locally by members of distinct cultural groups because their mathematical thinking has been influenced by the vast diversity of human characteristics such as languages, religions, morals, and economical-social-political activities. In concert with these factors, throughout history, D'Ambrosio (2006) argues that humanity has developed logical processes related to universal needs regarding quantification, measurement, modelling, and explanation, all shaped and operating within different social and historical contexts in order to favor respect for solidarity and cooperation with the *others* in school practices.

(Footnote 2 continued)

majority of children who are members of non-traditional, marginalized or out-of-school populations and/or are also deprived of access to formal education that is relevant and responsive to their specific context and needs (UNICEF 2009). For example, globally speaking, there are some educational institutions in which a particular ethnic, racial or cultural group is a majority, thus, the experiences of students of a minority group such as Indigenous, English Language Learners or Special Education are not reflected in the mainstream cultural and educational materials of the broader national sense.

[3]Systems are sets composed of elements taken from reality. The analysis of the interrelationship among these elements seeks to develop reflection, understanding, and comprehension of phenomenon that are part of reality (Rosa and Orey 2016).

The main goal of ethnomathematics is building up a civilization free from truculence, arrogance, intolerance, discrimination, inequity, bigotry, and hatred of the others. In this regard, Western scientific arrogance is a disrespect of and outright refusal to acknowledge cultural identities by scientists and mathematicians that puts all processes of understanding and comprehension of many non-Western cultural systems at risk. These particularities should not be ignored and they should be respected when individuals attend school because this aspect gives confidence and dignity to students when their previous knowledge is acknowledged (D'Ambrosio 1985).

According to this context, Rosa and Orey (2015) state that ethnomathematics program can be considered as a creative insubordination movement in mathematics education because it caused the disruption of the existing order in academic mathematics by developing the study of ideas, procedures, and mathematical practices that are found in various and specific cultural contexts outside of mainstream science and academia. In this regard, this program broke the norms and bureaucratic rules of academic mathematics in order to recognize different ways and value diverse modes of producing mathematics in other cultures. The introduction of ethnomathematics by D'Ambrosio has played a large part in creating an environment that was receptive to the social turn (Lerman 2000, as cited in Alangui and Rosa 2016), which allowed mathematics educators to ask questions, discuss, and create views that challenge conventional notions about the nature of mathematics.

Since ethnomathematics is associated with the pursuit of peace, the challenge that many communities and school systems face today is in determining how to shape a new open, modern, international culture, which integrates and respects new and alternative ideas, and where diverse ideas coexist in balance with those of western science. This also includes an increased cultural, ethnic, and racial diversity. In this respect, D'Ambrosio (2009) states that:

> Education is a practice present in every culturally identified group. The major aims of education are to convey to new generations the shared knowledge and behavior and supporting values of the group, and, at the same time, to stimulate and enhance creativity and progress (p. 242).

Indeed, the most creative, dynamic, and productive societies develop these features accordingly (Florida 2004). The inclusion of moral consequences into mathematical-scientific thinking, ideas, procedures, and experiences as we explore the mathematics found in different cultural contexts is vital. Thereby, Rosa and Orey (2016) argue that it is important to acknowledge contributions that members from diverse cultural groups make to mathematical understanding, the recognition and identification of diverse mathematical practices in varied contexts, and the link between academic mathematics and student experiences should all become central ingredients to a complete study of mathematics. This is one of the most important objectives of an ethnomathematics perspective in the mathematics curriculum development.

This perspective is crucial in giving students a sense of cultural ownership of mathematics, rather than a mere gesture toward inclusiveness (Rosa and Orey 2010). An essential aspect of this program includes an ongoing critical analysis of

the generation of mathematical knowledge as well as the intellectual processes of this production that seeks to explain, understand, and comprehend mathematical procedures, techniques and abilities through a deeper investigation and critical analyses of students' own cultures (D'Ambrosio 2016).

For example, in Brazil, the use of designs found in *Bakairi* body painting in indigenous schools has facilitated the comprehension of spatial relations such as form, texture, and symmetry, which enables the construction and systematization of students' geometrical knowledge (Rosa 2005). In this regard, ethnomathematics rescues the ancestral knowledge of the environment in order to generate models related to the environmental balance such as the patterns used for sowing or fishing. Therefore, ethnomathematics attends to the sociological and anthropological dynamics of the differentiated groups since it contributes to the raising of awareness about the elements of the socio-environmental context that is part of the identity of the peoples.

This approach allows students to experience mathematical language and learn geometric concepts through the study of cultural artifacts (Rosa 2005) that can be considered as the "physical or expressions of a specific culture and they include but are not limited to food, clothing, tools, art, and architecture" (Rosa and Orey 2012, p. 194). Therefore, cultural artifacts are viewed as inventions and dependent entities that exist a priori waiting to be discovered. Since mathematics is considered a social and cultural product, these artifacts are embedded in and embody different worldviews (Alangui and Rosa 2016).

Consequently, it is important to uncover tacit mathematical knowledge implied in the creation of cultural artifacts, which reveal the development of daily activities since these objects are "created by the members of cultural groups, which inherently give cultural clues and information about the culture of its creators and users" (Rosa and Orey 2012, p. 194). The use of cultural artifacts from diverse groups in educational settings raises students' self-confidence, enhances and stimulates creativity, creates a sense of connection, and promotes cultural dignity (D'Ambrosio 2006).

It is necessary to connect mathematics with students' own communities. Ethnomathematics studies multifaceted strategies and processes applied in these cultural artifacts in order to reveal techniques and identify cognitive processes that are in unremitting dynamism with the nature of mathematics. Studies have shown sophisticated mathematical ideas and practices that include, for example, geometric principles in craftwork, architectural concepts, and practices in the activities and artifacts of many indigenous, local, and vernacular cultures (Eglash et al. 2006; Orey 2000; Urton 1997).

Ethnomathematics reveals the importance of mathematical ideas and practices in developing local cultures because "decorative and symmetrical patterns displayed on these cultural artifacts are also expressions of beliefs, values, taboos, and religion of the identifiable people whose culture they represent" (Rosa and Orey 2012, p. 195). Therefore, it is important to highlight that the conduction of ethnomathematical investigations makes possible to describe how mathematics has been used to create cultural artifacts (Barton 1996). Mathematical concepts related to a variety of mathematical procedures used in cultural artifacts form part of the numeric

relations found in universal actions of measuring, calculation, games, divination, navigation, astronomy, and modelling (Eglash et al. 2006).

This program takes into consideration the diverse processes that help in the construction and development of scientific and mathematical knowledge that includes collectivity, and the overall sense of and value for creative and new inventions and ideas. Accordingly, Rosa and Orey (2015) argue that ethnomathematics is a body of knowledge often built up by the members of distinct cultural groups over time and across generations of living who are in close contact with their own historical, social, cultural, and natural environment.

From this perspective, it is necessary to focus on both the intuitive mathematical thinking and the cognitive process that are largely developed in local cultures in order to study how students have come to understand, comprehend, articulate, process, and ultimately use mathematical ideas, concepts, and practices that they use to solve problems faced in their own contexts.

Ethnomathematics allows us to understand mathematics as a social science that contributes to the sociocultural development of communities, to the generation and enrichment of knowledge, and to the development of dialogue between academia and society. Likewise, it can enhance the identity traits of peoples by its incorporation into curricular innovation through its didactic and pedagogical action. This approach helps to enrich cultural autonomy and idiosyncrasy in order to promote respect for diversity since mathematics is perceived as a social phenomenon and as a human activity.

1.3 Discussing the Role of Ethnomathematics in Mathematics Education

The world's economy is globalized, yet traditional academic mathematics curricula neglects, indeed often rejects, the truly diverse contributions made by members of colonized and non-dominant cultures. Consequently, the role of ethnomathematics in mathematics education is primeval in recognizing the emergence of perceptions of space, time, and techniques of observing, comparing, classifying, ordering, measuring, quantifying, inferring, and modelling that are different styles of abstract thinking in the school curricula.

Ethnomathematics as a line of study and research of mathematics education, which investigates the roots of mathematical ideas and practices, starting from the way individuals behave in different cultural groups. It is a contemporary pedagogical trend in education that offers more inclusive, new and greatly expanded definitions of a given group's particular mathematical-scientific contributions. It attempts to identify mathematical practices that begin in the knowledge of the *others* as well as in their own rationality and terms.

This program promotes the integration of socially vulnerable sectors of society and encourages sustainable academic practices. It also recognizes that members of

distinct cultures and different groups develop unique mathematical techniques, methods, and explanations that allow them to develop alternative understandings and social transformations in order to contribute to the achievement of social justice, peace, and dignity for all.

Pedagogically, ethnomathematics enables school mathematics to be seen as the "process of inducting young people into mathematical aspects of their culture" (Gilmer 1990, p. 4). An ethnomathematics perspective has reshaped cultural identity in a positive way by requiring the inclusion of a greater representation of practices and problems of a student's own community. The application of ethnomathematics as pedagogical action restores a sense of enjoyment or engagement and can enhance creativity in doing of mathematics (Rosa and Orey 2015). An ethnomathematics program helps both educators and students alike to understand mathematics in the context of ideas, procedures, and practices used in the day-to-day life. It further encourages an understanding of professional practitioners, workers, and academic or school mathematics. Such depth is accomplished by taking into account historical evolution and the recognition of natural, social and cultural factors that shape human development (D'Ambrosio 2006).

One of the most relevant reasons for teaching mathematics involves the consideration of mathematics as an expression of human development, culture, and thought, which is an integral part of the cultural heritage of humankind (D'Ambrosio 1995). Therefore, it is necessary to start by using sociocultural contexts, realities, and the many interests and needs of students and not mere enforcement of a rigid set of external values or often-decontextualized curricular activities. An ethnomathematics perspective in mathematics education enables educators to rethink about the nature of mathematics in order to acknowledge that diverse people, despite their formal schooling experiences, actually come to measure, classify, order, organize, infer, model, and reason with numbers, algebra, and visuospatially. These mathematical activities occurs in everyday living, which are important aspects of diverse modes of teaching and learning of mathematics.

This pedagogical approach helps us to identify mathematical elements of students' daily, which can help to improve students' self-perception and motivation towards mathematics. It is important that educators are concerned about respecting students' cultural background. In order to do so, they must establish respectful dialogues with students (Shirley and Palhares 2016). The importance of integrating an ethnomathematics perspective into the mathematics curriculum is related to its social impact in relation to the changes in the students' attitudes towards to their own cultural backgrounds. For this reason, the role of educators has become even more central in this highly multiethnic society increasingly integrated to a globalized world.

Mathematical ideas, procedures, and practices developed by the members of specific groups that occur in daily life strengthen their own cultural identity in relation to other cultures, which allows them to reflect on the role of mathematics in determining cultural otherness. These ideas strengthen cultural autonomy in different groups because they address the challenges posed by UNESCO (2012) in respect to the attention to diversity, to the avoidance of exclusion and isolation, to

help students understand others' cultural contributions; and finally to show mathematics as a human activity.

When the focus of a study is the pedagogy of mathematics, the attention has been centered both around legitimizing the students' knowledge through the use of culturally relevant activities, grown from experiences built in their own ways and around the study of the possibilities of how to work with the learning of the ones outside the school and the ones inside the school. This means that "Curricular activities developed according to principles of culturally relevant pedagogy focus on the role of mathematics in sociocultural contexts. These activities involve ideas and procedures associated with ethnomathematical perspectives to solve problems" (Rosa and Gavarrete 2016).

Indeed, with a discussion of ethnomathematics helps educators to establish cultural models of beliefs, thought and behavior, in the sense of contemplating not only the potential of the pedagogic work that takes into account the knowledge of the students, but also a learning the school, which is more meaningful and empowering. It is important to understand how to make mathematics meaningful for students by using cultural artifacts found in distinct cultures. Therefore, it is necessary to develop contextualized mathematical activities in order to improve mathematical performance of the students by applying culturally relevant pedagogy into the mathematics curriculum.

The introduction of abilities and competencies into the mathematics curriculum is part of a worldwide trend. A focus on abilities and competencies emphasizes the individuals and tends to remove mathematics from its context. Ethnomathematics, on the other hand, emphasizes the communal and tends to connect mathematics with its own contexts. An ethnomathematical aspect may therefore provide a necessary balance to the new curriculum. If these two components are to be brought together, then we need to conceive ethnomathematics as an overarching aspect of this curriculum by humanizing mathematics. However, we are unsure exactly what this might mean, but perhaps ethnomathematics can be considered as a philosophical approach to the mathematics curriculum, or a context for it, or perhaps an affective or attitudinal response to the educations demands of the students.

It is necessary to propose a discussion about cultural relevance into the mathematics curriculum in order to help educators to acknowledge the relationship between cultural and school mathematical knowledge (Rosa and Gavarrete 2016). This approach fosters a critical and reflective attitude about the universality and contextualization of mathematical knowledge, since pedagogical work with ethnomathematics promotes educators' creativity when developing a mathematics curriculum that is connected to the social and cultural environments of the students.

Recent trends in mathematics education offer some hope for changing the role of mathematics that respects distinct and diverse contexts. In particular, the study of ethnomathematics can help educators to connect school mathematics to the students and their communities because culture influences the development of students' mathematical knowledge. Various educational initiatives brought to light the continuing need to develop mathematics lessons that are culturally relevant for students. Therefore, it is necessary to reiterate the importance of promoting

sociocultural approaches in the mathematics curriculum to combat curricular *decontextualization*[4] resulting from its monocultural view (Rosa and Gavarrete 2016).

This pedagogical action can be achieved by the application of *innovative approaches*[5] to ethnomathematics such as the trivium curriculum and ethnomodelling, which need more investigations to address the pedagogical purposes of the ethnomathematics program:

(1) The Trivium curriculum is composed of *literacy*, *matheracy*, and *technoracy* that allows for the development of school activities based on an ethnomathematics foundation. Literacy is the capacity students have to process information present in their daily lives; matheracy is the capacity students have to interpret and analyze signs and codes in order to propose models to find solutions for problems faced daily; and technoracy is the capacity students have to use and combine different instruments in order to help them to solve these problems (Rosa and Orey 2016).
(2) In the ethnomodelling approach, the use of ethnomathematics assumptions and the application of tools and techniques of mathematical modelling allow us to perceive reality by using different lenses, which gives us insight into mathematics performed in a holistic way. Ethnomodelling is a research paradigm related to critical-reflective dimensions of learning that allows learners the opportunity to develop a sense of purpose and their own potential by using mathematics to examine and solve problems they themselves choose and deem important (Rosa and Orey 2016).

Lastly, it is important to emphasize the in an increasingly *glocalized*[6] and interdependent world, it is fundamental that educators are given experiences that allow them to understand that the diversity of ideas and thoughts that come into contact either through communications, business, education, and science are greatly influenced by the way in which individuals who belong to different cultural groups learn mathematics. This pedagogical approach is not often reflected in the traditional mathematics classroom, yet high equitable expectations along with personalized connections in mathematics instruction are essential for success for all students.

In this way, the pedagogical innovation proposals raised from the ethnomathematics program can encompass the incorporation of sociocultural components in teacher training programs, which envisions mathematics as a human activity in all cultures as well as a social phenomenon, thus, contributing to a functional vision of

[4]Decontextualization is a consciously or subconsciously process of examining or interpreting mathematical ideas, procedures, and practices separated from the sociocultural context in which they are embedded.

[5]Other innovative approaches of ethnomathematics are: social justice, civil rights, indigenous education, professional contexts, game playing, urban and rural contexts, ethnotransdisciplinarity, ethnopedagogy, ethnomethodology, and ethnocomputing (Rosa and Orey 2016).

[6]*Glocalization* is the acceleration and intensification of interaction and integration among members of distinct cultural groups (Rosa and Orey 2016).

the notion of mathematical ideas and procedures (D'Ambrosio 2006) and, thereby, allowing the value of mathematical practices to be strengthened (Bishop 1988).

Accordingly, it is necessary to debate about issues regarding mathematics education and mathematical knowledge developed by the members of a specific cultural group. However, the discussions surrounding these issues do not imply that ethnomathematics is only an instrument to improve mathematical education because it also has a role in helping us to clarify the nature of mathematical knowledge and of knowledge in general. In so doing, we recommend to shift ethnomathematical research from theoretical issues toward educational and practical affairs.

1.4 Acknowledging Some Opportunities and Challenges…

After three decades since the emergence of the ethnomathematics as a program, some investigators, philosophers, and educators are still not comfortable about the role of ethnomathematics in mathematics education. Furthermore, they must be sure about some ethnomathematical features that are unrelated to the mathematics classrooms because:

1. Ethnomathematics is not a cultural content, thus, it is necessary to question: Which culture(s) should be in the mathematics curriculum? How would we know whether or not the educators and students make the link between culture and mathematics?
2. Ethnomathematics is not an imperative to take an account of the sociocultural contexts in schools, which has been known for many years and discussed in many different ways. Hence, how is it possible to develop an ethnomathematical program in the context of mathematical education that involves the characteristics of the whole school system?
3. Ethnomathematics should not be confused with ethnic-mathematics since its ethnic component is the *ethno*-graphic study of mathematical ideas, procedures, and practices developed by the members of distinct cultural groups and it is based on gathering empirical data on the form of mathematics practiced in diverse cultures. How can we know the extent of the ethnographic studies? What should we look for in the data?
4. Ethnomathematics cannot be considered as a discipline because it is not just a process of teaching a set of frozen mathematical theories. It proposes a lively and dynamic pedagogical action that deal with environmental, social, political, cultural, an economic contexts, which have important mathematics components. How can an ethnomathematical attitude help develop a critical and reflective understanding of the mathematics curriculum?

This kind of investigations and pedagogical actions underscore the importance of doing the ethnomathematical work first in order to come to a good understanding of the mathematical aspects of culture by having a clear purpose to the educational

activities. For this reason, the implantation and implementation an ethnomathematical perspective in classrooms must be preceded by a full investigation on the mathematical ideas, procedures, and practices developed by the members of the diverse cultural groups. Consequently, the ethnomathematical perspective must be clearly situated within the existing school curriculum and is intended to enhance the learning of mathematics.

It is necessary to understand the pedagogical action of ethnomathematics in schools. Classroom investigations using an ethnomathematics perspective is important because they are where D'Ambrosio's (1985) vision must be implemented. If starting with the students' own realities does not work, for whatever reason, it is necessary to think about how further investigations can help us to understand about the problems in using this approach. There are many arguments, but it is important to focus on the reasons to implement this program in the classrooms: (a) to be an effective path to traditional mathematics, (b) to be a way to develop intercultural classrooms, and (c) to be a way to transform the relationship between mathematics and society. Meanwhile, whatever the reason is, it is necessary to communicate this purpose in order to obtain the *buy-in* from the students. The critical education ideas of Freire (1973) are one way to develop this approach.

The suggestion of starting with the student's community sociocultural reality is another way to develop this approach, but they may refuse to study their own reality because it is oppressive. They do not identify this context as mathematics, and they may already have a grounded mathematical conception. Perhaps, in this case, educators should start with students' existing mathematical conceptions, even though if they are traditional, provided that what follows is their critical and reflective examination. The consequence of this approach for teacher education is significant. It means that educators must know more about mathematics and additional pedagogical skills in order to help students to undertake a critical and reflective examination of these mathematical conceptions. In this way, ethnomathematics is a tool to generate social awareness and promote processes of emancipation or empowerment of communities for justice and peace.

As a consequence, ethnomathematics becomes a high order task in this pedagogical action. The consequence of these ideas is that ethnomathematical work in the schools is not a simplistic presentation of cultural examples, nor situating mathematics in cultural contexts. Rather, it requires considerable background work, complete understanding, and pedagogical sophistication. This is a complex task; it takes time, and is difficult to access all of it is possibilities. According to Shirley (2015), one possible way to avoid this problem in order to bring the goals of ethnomathematics even more directly to students, is to encourage them to study problems taken from their own individual cultures, heritage, and personal interests. Perhaps, the importance of an ethnomathematical perspective in the schools is that it alerts us to the way in which cultural information can be used in the classrooms.

In this environment, ethnomathematics is considered as a way to contextualize mathematical ideas since it is related to the techniques developed as a study of mathematical procedures practiced by the members of distinct cultural groups. The idea of mathematics in cultural practices involves designing tasks that are

contextualized in the cultural heritage based on different ways of knowing in order to help us to reflect on certain mathematical notions as well as on the nature of mathematical knowledge. However, how this pedagogical work is realized in the classrooms may be problematic in regards to misconceptions related to ethnomathematics as a program. Under this circumstance, a modified mathematics curriculum is necessary because it admits a wider possibility for mathematical thinking and investigation that is based on diverse cultural practices. Yet, the challenge is how to enlist this cultural strength in schools.

It is recommended that investigators conduct studies that help us to understand know how ethnomathematics can contribute to the development of contextualized activities in classrooms. Thus, it is important to recognize how investigators identify ethnomathematical forms of mathematics, but there is no acknowledgement of the pedagogical actions linked to the educational environment. Centered on this possibility and questioned whether it is possible to infer the causes for the difficulties of the implementation of an ethnomathematical perspective into the mathematics curriculum, it is necessary to identify if educators are locating the problem outside the schools. The answers may be responded in many ways, one of which may come from the teacher's point of view of trying to observe and understand students' own reality.

However, in order to achieve this goal, it is necessary to promote a change in teacher education programs and bring prospective teachers to understand sociocultural realities in which they are professionally involved. This is because reflections on mathematics, culture, education, and society as well as on the relations maintained among them can be oriented towards inclusive pedagogical practices in which learning mathematics addresses deeper notions of equity (Gavarrete 2015). Therefore, the idea of incorporating the pedagogical action of ethnomathematics in educational programs should be reinforced because it poses new challenges for research in mathematics education. In this context, ethnomathematics constitutes a prospective vision of an innovative research paradigm and at the same time contributes to determining the role of this program in mathematics education.

For example, in mathematics education, if the focus is the pedagogy of mathematics, the attention must be centered both around legitimizing the students' knowledge, grown from experiences built in their own ways and around the study of the pedagogical possibilities of how to work with the learning process that occurs outside and inside of the school environments. A discussion of the educational aspects of ethnomathematics helps educators to establish cultural models of beliefs, thought and behavior, in the sense of contemplating the potential of the pedagogical work that takes into account the tacit knowledge of the students as well as the development of mathematical learning process that is more meaningful and empowering. Making the practical from the theoretical happen in classrooms is one of the fundamental principles of the pedagogical action of the ethnomathematics as a program.

This debate alerts us that there is a need to for continued dialogue and development of ethnomathematical curricular activities in order to rescue their cultural heritage and support learning as well as linguistic and social inclusion in schools. Ethnomathematics is a response to this important social justice issue. However, it is necessary that educators understand: (a) how they can help students in their fight against social injustices, (b) how teacher education can be part of the fight for social justice, and (c) how to prevent a domination of Western mathematics in the school curricula. Hence, it is necessary to consider the danger of assimilationist experiences by the students. In this context, whatever may happens, the members of each cultural group need to be in control of their own willingness to further develop this approach.

In continuing this theoretical debate, and what is often difficult for educators, is how to connect to what Freire (1985) would consider most fundamental, the community, to what has become almost universal, the formalized academic mathematics. Hence, another principle of ethnomathematics is to stretch the limits of what is perceived as mathematics and its related thinking in order to link it to the *greater* mathematical knowledge. In this case, ethnomathematics reminds us to look at the larger mathematical ideas and conceptions not just to search for isolated procedures and practices.

In closing, ethnomathematics helps us to establish a meta-awareness of the role of mathematical knowledge in the society and cultural context in which it manifests itself. In this respect, ethnomathematics is also reciprocal because it is possible to think of conventional mathematics and its role within its host cultural group. Indeed, this reciprocity is a vital aspect of ethnomathematics.

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