REFLECTING ON ETHNOMATHEMATICS AS PEDAGOGICAL ACTION IN THE MATHEMATICS CURRICULUM

REFLETINDO SOBRE A ETNOMATEMÁTICA COMO UMA AÇÃO PEDAGÓGICA PARA O CURRÍCULO MATEMÁTICO

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ABSTRACT

The history of research in ethnomathematics has been dominated by the study of the fundamental differences in ways of doing mathematics among various cultures. Understanding these differences allows students and teachers to connect culture and mathematics by providing a transformational and holistic environment in which diversity is seen as good, valuable, and necessary to living in a contemporary world. The use of mathematics in everyday life varies according to each different culture and its needs. Ethnomathematics, which is the study of mathematics within its diverse cultural contexts, is used to express relationships between culture and mathematics. Thus, ethnomathematics is primarily concerned with connections that exist between the symbols, representations, and the imagery used to solve problems. The development of ethnomathematics as a program has challenged traditional concepts of Euro-Western centered mono-representational systems of mathematics transforming it into a multi-representational system that represents mathematics as human endeavor. Hence, an ethnomathematics-based curriculum is grounded in the incorporation of mathematical ideas and activity that echo a diversity of cultures, particularly, those that experienced oppression or exclusion from society. Ethnomathematics is a pedagogical action that starts with teachers and students who learn to think flexibly about how they use mathematics in everyday and academic contexts.

Keywords: Ethnomathematics; Pedagogical Action, Curricular Implications; Sociocultural Contexts; Ethnomathematics Curriculum.

RESUMO

A história da pesquisa em etnomatemática tem sido dominada pelo estudo das diferenças fundamentais nas maneiras de fazer matemática entre várias culturas. O entendimento dessas diferenças permite que os alunos e professores conectem a cultura e a matemática para providenciar um ambiente holístico e de transformação no qual a diversidade é vista como boa, valiosa e necessária para a convivência no mundo contemporâneo. A utilização da matemática na vida cotidiana varia de acordo com as necessidades de cada cultura diferente. A etnomatemática, que é o estudo da matemática

em seus contextos culturais, é utilizada para expressar as relações entre a cultura e a matemática. Assim, a etnomatemática está preocupada principalmente com as conexões que existem entre os símbolos, as representações e as imagens utilizadas para a resolução de problemas. O desenvolvimento da etnomatemática como um programa tem desafiado os conceitos tradicionais euro-ocidentais centrados nos sistemas mono-representacionais da matemática, transformando-os em sistemas multi-representacionais que representam a matemática como uma atividade humana. Assim, um currículo baseado na etnomatemática está fundamentado na incorporação de ideias matemáticas e atividades que ecoam a diversidade de culturas, particularmente, aquelas que experimentaram a opressão ou a exclusão da sociedade. A etnomatemática é uma ação pedagógica que começa com os professores e os alunos que aprendem a pensar com flexibilidade sobre como utilizam a matemática nos contextos cotidiano e acadêmico.

Palavras-chave: Etnomatemática; Ação Pedagógica; Implicações Curriculares; Contextos Socioculturais; Currículo Etnomatemático.

1. Introduction

Classrooms with students from a variety of different linguistic, social, and cultural traditions use a diversity of mathematical ideas, procedures, and practices. The dynamics of cultural integration develops a relationship between formal and informal mathematics and language, which is an important factor that influences the performance of students in mathematics since it is related to their own cultural backgrounds. Most teachers believe that the gaps in the performance of students is partly due to the influence of language, as opposed to the many diverse cultural factors, on standardized mathematics assessments (Rosa, 2013). In order to address these issues, the mathematics curriculum cannot be considered just as the:

> (…) strategy of education systems to pursue goals created, negotiated, and accepted by society. It is usually organized in three strands: objectives, contents, and methods. This Cartesian organization implies accepting social aims of education systems, then identifying contents that may help to reach the goals, and developing methods to transmit those contents (D'Ambrosio & D'Ambrosio, 2013, p. 20).

This context sets the conditions for the development of a different educational project that must guide the objectives of the curriculum by placing students at the center of the teaching and learning process in order to recognize that social and cultural factors influence their mathematics performance. Thus, students also need a modified curriculum that improves their achievement in mathematics due to the influence of their linguistic background in relation to the curricular activities they perform in classrooms (Rosa, 2013). The current mathematics curriculum fails to "prepare students to read the world with mathematics and to understand their role as agents of change" (Tanase & Lucey, 2015, p. 107).

Many educators operate on the assumption that all students should receive the same mathematical content at the same time in the same way. Some mathematicians believe that there is only one right way to solve a mathematical problem. This often happens when, in the context of highly diverse communities, teachers often come from mainstream and middle class contexts, which are markedly different from those of other

types of learners and students. More often than not, schooling, including the learning of mathematics, has become a vehicle for the loss of self-esteem, or of power of the student (Rosa, 2000). How diverse people, despite their formal schooling experiences, actually come to learn, measure, classify, order and organize, infer, and model. These, from the ethnomathematics paradigm, are important aspects of diverse modes of teaching and learning of mathematics.

Many public school populations mirror the highly diverse and multicultural communities that they serve. Mathematics classrooms are most certainly part of this environment, and students must be encouraged to solve problems by applying multiple strategies to assist other students to learn new ideas and processes, and to understand mathematical concepts by the application of real-life problem solving scenarios (Rosa & Orey, 2013). In this environment, effective teachers must learn to appreciate the diverse methods of learning and thinking, modify instruction, and plan accordingly.

In this context, teachers must use diversity in order to build an inclusive classroom environment where student culture and background is respected, teachers learn to push students to come up with as many different algorithms, strategies, and thinking processes as possible for discussing or solving mathematical problems. Making use of how a variety of perspectives and different ways are used to create understanding mathematical content is as important as the actual answer. Diverse learning environments allow students to practice communicating and working with other people that are different from those that they are accustomed to learning and working with.

This kind of mathematics classroom is a place that embodies an inclusive and democratic setting in which all students are active and engaged. While learning to work with different people, they learn to work and navigate the dominant culture. All students need to learn about their own cultures and assess personal assumptions that influence and affect their interaction with individuals that are different from themselves. In this case, critical thinking skills and the ability to work cooperatively are necessary approaches to develop an inclusive mathematics environment rooted on culturally relevant activities, which are related to a holistic curriculum that empowers all learners.

However, currently, "the curriculum rarely encourages students to link mathematics and history, mathematics and politics, mathematics and language-mathematics and people" (Peterson, 2006). Methods of curricular reform in mathematics may be described as a progression from adding single pieces of cultural information and daily life phenomena to transforming the curriculum so that it equally values, indeed incorporates sociocultural perspectives in its pedagogical action.

2. Ethnomathematics as Diverse Ways of Knowing

The field of ethnomathematics links students' diverse ways of knowing and learning in culturally embedded contexts with academic mathematics. It explores academic and culturally rich ways to provide inclusive developmental programs for the diverse populations served at educational institutions. Ethnomathematics is a program that includes curricular relevance and builds curricula around the local interests and culture of the students. Teaching mathematics through cultural relevance and personal experiences helps students to know more about reality, culture, society, environmental issues, and themselves by providing them with mathematical content that enable them to

successfully master academic mathematics (Rosa & Orey, 2013). An ethnomathematics approach to the mathematics curriculum is a pedagogical vehicle for achieving such a goal.

An important change in mathematical instruction needs to take place in order to accommodate continuous and ongoing changes in the demographics of students in mathematics classrooms. It is necessary to integrate a culturally relevant pedagogy into the existing mathematics curriculum. This perspective is an essential component of culturally relevant education because it proposes that teachers contextualize mathematics learning by relating mathematical content to the real-life experiences of learners (Torres-Velásquez, & Lobo, 2004). It is important to highlight the importance of building connections between mathematics and students' personal lives and cultures. In accordance to this approach, when practical or culturally based problems are examined in a proper social context, the practical mathematics of social groups is not trivial because they reflect themes that are linked to the daily lives of students. Culturally relevant mathematical pedagogy should focus on the role of mathematics in a sociocultural context that involves the ideas and concepts associated with ethnomathematics, using an ethnomathematical perspective for solving problems (Rosa & Orey, 2008).

Mathematics was for a long time regarded as a neutral and culturally-free discipline removed from social values (Bishop et al., 1993; D'Ambrosio, 1990), and it was always taught in schools as a culturally free subject that involved learning supposedly universally accepted facts, concepts, and contents. Western or academic mathematics consists of a body of knowledge of facts, algorithms, axioms, and theorems. Frequently, mathematics is referred to as a universal language. However, when people speak of universals, it is important to recognize that often something thought of as universal is merely universal to those who share the same cultural and historical background. According to this context, many educators operate under the assumption that mathematics is acultural, that it is a discipline without cultural significance fail to see the connection between mathematics and culture (D'Ambrosio, 2001). Because mathematics in any culture has been based upon certain values and needs, students' cultural and linguistic references can interfere in the learning of mathematical concepts in the classrooms.

For example, the results of study conducted by Rosa (2013), most teachers believe that the cultural background of students does not influence their performance on standardized assessments. In so doing, the data also revealed that these teachers do not seem to be aware of the impact of the cultural backgrounds of students on their performance on curricular activities. In their opinion, culture does not play an important role in the mathematical academic success of the students because mathematics is more about their attitude towards mathematics than the influence that their cultural background has on the mathematics teaching-learning process. It is important that teachers use culturally specific contexts in teaching and learning mathematics by exposing students to a variety of cultural contexts.

The pervasive view of mathematics as Eurocentric and value-free misrepresents the evolution of modern mathematics (Joseph, 2000). This perception is also reinforced by students' experiences of the way mathematics is taught in schools. Teachers' view of mathematics is transmitted to the students in their instruction and this fact helps to shape

students' views about the nature of mathematics (Brown et al., 1990). Even though the universality of mathematical truths is not in question, it is only in the last two decades that the view of mathematics as culture free has been challenged. In this context, "there is no sense in regarding mathematics learning as abstract and culture free" (Bishop et al., 1993, p. 1). Then, the learning process cannot be decontextualized because it cannot be free of societal influence.

The contextualization of mathematics has been described as the identification of mathematical practices developed in different cultural groups (Orey, 2000). If mathematics is considered a cultural construct, then it is a product of cultural development (Zaslavsky, 1996). In other words, this claim of mathematics as a cultural construct contradicts the claims that modern mathematics is universal, objective, and culturally neutral. This leads to the development and inquiries of culturally relevant pedagogy of mathematics (Nasir et al., 2008). Frequently teachers are unaware of the norms that govern their behavior until students do not follow these rules, because they are unfamiliar with the expectations of the teachers' culture (Rosa, 2000).

The mission of the ethnomathematics program is to acknowledge that there are different ways of doing mathematics by considering the appropriation of the academic mathematical knowledge developed by different sectors of the society as well as by considering different modes in which different cultures negotiate their mathematical practices (D'Ambrosio, 2001). In this conception, ethnomathematics is a program that investigates the ways in which the members of distinct cultural groups comprehend, articulate, and apply concepts and practices that can be identified as mathematical practices.

Moreover, ethnomathematics may be described as a way in which the members from a particular culture use mathematical ideas and procedures for dealing with quantitative, relational, and spatial aspects of their lives (Barton, 1996). This way of viewing mathematics validates and affirms all members' experiences of mathematics because it demonstrates that mathematical thinking is inherent to their lives. Further evidence of this assertion is offered by Orey (2000), who stated that the "paradigm that diverse cultures use or work within evolves out of unique interactions between their language, culture, and environment" (p. 248).

Similarly, mathematical thinking is developed in different cultures in accordance to common phenomena and problems that are encountered in diverse cultural contexts. Therefore, in order to solve specific problems, *ad hoc*[1] solutions are created, generalized methods are developed from those solutions created to solve similar problems, and theories are developed from these generalized methods (D'Ambrosio, 2001). The tendency has been to consider these *ad hoc* mathematical practices as non-systematic and non-theoretical. In contrast, the study of ethnomathematics underlies a structure of inquiry in *ad hoc* mathematical practices by considering how these practices and problem-solving techniques can be developed into methods and theories.

Since different types of problems are common in different cultures, the kinds of solutions, methods, and theories that are developed may differ from culture to culture. In this regard, it is necessary to recognize that situations that are considered as problems

[1]Ad hoc is a Latin expression that means *for this purpose*. It generally means a solution designed for a specific problem or task, non-generalizable, and which cannot be adapted to other purposes.

in a specific culture may have no meaning in other cultures (D'Ambrosio, 1993). Ethnomathematics refers to mathematical ideas and procedures embedded in cultural practices developed in traditional and non-traditional societies. It recognizes that members of all cultures develop unique methods and sophisticated explanations to understand, comprehend, and transform their own realities (D'Ambrosio & Rosa, 2008). It also recognizes that the accumulated methods of these cultures are engaged in a constant, dynamic, and natural process of evolution and growth through the process of *cultural dynamism*[2].

Ethnomathematics is referred to here as the study of how members of various cultural groups develop techniques and procedures that help them to explain, understand and comprehend their own world in response to problems, struggles, and endeavors of human survival (D'Ambrosio, 1990). This includes material needs, arts, and spirituality through the development of *cultural artifacts*[3], which are objects created by members of a specific cultural group that inherently give cultural clues about the culture of its creator and users. This perspective "provides an important opportunity for educators to link current events and the importance of these artifacts in the context of ethnomathematics, history, and culture" (Rosa & Orey, 2008, p. 33). Cultural artifacts such as language, myths, and literature influence the representational system of different cultures and civilizations, and are often related to the use of mathematics.

Another presupposition of ethnomathematics is that it validates all forms of mathematical explaining and understanding formulated and accumulated by the members of distinct cultural groups (D'Ambrosio, 1993). This knowledge is regarded as part of an evolutionary process of cultural dynamism as the members of each cultural group come into contact with each other one (Zaslavsky, 1996). A study of the different ways in which peoples resolve problems and the practical algorithms upon which they base these mathematical perspectives become relevant for any real comprehension of the concepts and the practices in the mathematics that they have developed over time (D'Ambrosio, 2006). This approach is related to diverse forms of mathematics that vary because of being embedded in cultural activities which purpose is other than doing mathematics. In this regard, "ethnomathematics might be characterized as a tool to act in the world" (Orey, 2000, p. 250) and as such, it provides insights into the sociocultural role of academic mathematics in society.

3. The Role of Mathematics in Sociocultural Contexts

Traditionally, the learning of mathematics has been associated with the schooling process because people thought that mathematical concepts and skills were only acquired when people attended school. However, the analysis of students' mathematical knowledge has led educators and researchers to conclude that mathematical knowledge is also acquired outside of the structured systems of mathematics learning such as schools (Bandeira & Lucena, 2004; Knijnik, 1993; Rosa & Orey, 2013). It is necessary

[2]Cultural dynamism refers to the exchange of systems of knowledge that facilitate members of distinct cultures to exploit or adapt to the world around them. Thus, this cultural dynamics facilitates the incorporation of human invention, which is related to changing the world to create new abilities and institutionalizing these changes that serve as the basis for developing more competencies.

[3]*Cultural artifacts* are objects created by the members of distinct cultural groups, which inherently give cultural clues and information about the culture of its creators and users (D'Ambrosio, 1993). They are also the physical manifestations or expressions of a specific culture and they include but are not limited to food, clothing, tools, art, and architecture (Rosa & Orey, 2012).

to conduct studies that focus on school mathematics and the influence of cultural factors on the process of teaching and learning academic mathematics. The results of studies shown below identified cultural mathematics and its acquisition in traditional and non-traditional cultural settings. For example, Lean (1994) studied several indigenous counting systems in Polynesian and Melanesian countries in the Oceania region. These findings show that every distinct language has a unique counting system.

Similarly, fourteen years earlier, Saxe (1982) reported on the development of counting among Oksapmin students of Papua New Guinea and studied the use of this unique system by using body parts. Subsequently, it was found that the introduction of money had a negative effect on Oksapmin students' counting systems, which helped them to develop new ways of counting and doing mathematics. The results of this study show the development of specific mathematical ideas and practices related to the students' culture such as number systems and classification that were used to develop appropriate curricula that suited the cultural and educational needs of these students. An ethnomathematical perspective encourages the study of diverse number systems, including the symbols and the representational systems of different cultural groups. The representational system of a culture often depends upon the unique types of mathematical knowledge that each culture develops over time.

Counting systems are a part of language and that language is a part of culture (Ellerton & Clarkson, 1996), which means that students "also needed to involve the consideration of language usage for ideas that are important in school curriculum" (Owens et al., 2015, p. 39). In regards to the importance of language in cultural contexts, Trinick, McMurchy-Pilkington, and Taplin (2014) explored the linguistic and pedagogical tensions and at times conflicting ideologies that have influenced the lexication of mathematics terminology as well as the selection of ethnomathematical activities during the process of linguistic modernization of the Māori language in New Zealand. In this context, the:

> (…) state was compelled to respond to the community demands, and implement policies to support the revitalisation of the language and traditional practices. These policies included state funding of Māori language immersion schooling, and funding to support the implementation of state mandated mathematics curriculum (Trinick, McMurchy-Pilkington, & Taplin, 2014, p. 65).

The results of the study conducted by Rosa (2013) show that a deep understanding of both culture and its connection to academic mathematics is an important source of knowledge for teachers to help them to modify and transform their pedagogical and leadership practices in order to facilitate successful learning opportunities for all students. Thus, they must know their students, their cultural roots, linguistic backgrounds, previous experiences, and their students' perceptions about the world. This also includes knowing immigrant students' linguistic backgrounds and cultural values that may influence performance on standardized high-stakes assessments. Knowing students' cultural and linguistic background is essential for providing successful learning opportunities for all learners. Therefore, understanding students' cultural and linguistic differences help teachers (re)structure curricular activities to provide successful learning for all students through the application of different strategies and practices that best fit their specific cultural and educational needs.

Accordingly, mathematical knowledge results from sociocultural interactions in which relevant ideas, facts, procedures, concepts, principles, practices, skills, and abilities are acquired in different cultural contexts (Dossey, 1992). Hence, the nature of mathematics perceived by students is a result of intricate interactions of cognitive, cultural, and social factors that exist in the context of schooling. Thus, mathematics learning involves a notion of socialization and enculturation, which is rooted on the beliefs and values of the members of distinct cultural groups (Schoenfeld, 1992). Then, it is possible to envision that mathematics education is a socialization process rather than as an instructional mechanism (Rosa & Orey, 2007).

Therefore, mathematics cannot be considered as a universal formal domain of knowledge because it can be considered an assemblage of culturally constructed symbolic representations and procedures that facilitates the manipulation of these representations (Stigler & Barness, 1988). Students develop representations and procedures into their cognitive systems, a process that occurs in the context of socially constructed activities (Rosa & Orey, 2008). In other words, the mathematical skills students learn in schools are not logically constructed based on abstract cognitive structures, but rather forged out of a combination of previously acquired knowledge, abilities, and cultural inputs. Therefore, mathematics arose out of the needs of organized society since it cannot be divorced from the activities and practices developed by people in a contemporary society (D'Ambrosio, 1990).

Many people have come to develop mathematical practices out-of-school related to the understanding of numbers before they come to school. In this regard, the results of the study conducted by Carraher (1991) shows that young street vendors in the Northeast of Brazil use different algorithms from those applied in school computations. These results also show that these vendors were successful in correctly solving problems related to street contexts, but they were not so successful in solving traditional and academic computation problems in classrooms. However, some mathematical ideas and procedures were acquired without schooling; academic mathematics played an important role in accelerating the learning of these concepts, in particular, inverse proportion and word problems (Nunes & Bryant, 1997).

In this context, local mathematics is "an organized, systematic, mathematics education activity carried on outside the framework of the formal system" (Bishop, 1993, p. 15). Thus, there is a contrast between mathematical knowledge acquired academically and locally. For example, Bandeira and Lucena (2004) investigated mathematical ideas and practices developed by the members of a community of vegetable farmers in the Northeast region of Brazil. They studied the mathematical concepts that farmers use to harvest, produce, and commercialize vegetables. The results of this study show us that specific mathematical knowledge produced by farmers differ from the mathematical knowledge acquired in academic settings.

Mathematics used outside of the school may be considered as a process of modeling rather than a mere process of manipulation of numbers and procedures. The application of ethnomathematics based techniques and the tools of modeling allow us to see a different reality and give us insight into mathematics done in a holistic way. In this regard, the pedagogical approach that connects the cultural aspects of mathematics with its academic aspects is *ethnomodeling*, which is a process of translation and elaboration of problems and questions taken from systems that are part of the students' reality.

Ethnomodeling is considered an application of ethnomathematics that adds a cultural perspective to the modeling process by studying mathematical phenomena within a culture, which are social and culturally bound constructs (Rosa & Orey, 2010). In this regard, the application of "ethnomathematical techniques and the tools of mathematical modeling allows us to see a different reality and give us insight into science done in a different way" (Orey, 2000, p. 250).

In order to solve problems, students need to understand alternative mathematical systems in order to be able to understand more about the role that mathematics plays in a societal context (Rosa & Orey, 2007). This aspect promotes a better understanding of mathematical systems with mathematical modeling, which is a process of translation and elaboration of problems and questions taken from systems that are part of the students' reality. Systems are part of reality integrally considered. It is a set of items taken from students' reality. The study of these systems consider the study of all its components and the relationship between them (D'Ambrosio, 1993).

According to this context, mathematical modeling is a pedagogical strategy used to motivate students to work on mathematics content and helps them to construct bridges between the mathematics of school and the mathematical concepts they use in their own reality. D'Ambrosio (2002) commented about an ethnomathematical example that naturally comes across as having a mathematical modeling methodology. In the 1989-1990 school year, a group of Brazilian teachers studied the cultivation of vines brought to Southern Brazil by Italian immigrants in the early twentieth century. This investigation was conducted because the cultivation of wines is linked with the culture of the people in that region in Brazil. This wine case study is an example of the connection between ethnomathematics and mathematical modeling through ethnomodeling (Rosa & Orey, 2010).

According to Rosa (2000), educators and teachers should search for problems taken from students' reality that translate their deepened understanding of real-life situations through the application of culturally relevant activities. This process enables students to take a sociocultural, political, environmental, and economical position in relation to the system under study. The main objective of this pedagogical approach is to rehearse the established mathematical context that allows students to see the world as consisting of opportunities to employ mathematical knowledge that help them to make sense of any given situation.

4. A Proposed Ethnomathematics Curriculum

Classrooms and learning environments cannot be isolated from the communities in which they are embedded. Classrooms are part of a community with defined cultural practices. Thus, classrooms might be considered environments that facilitate pedagogical practices, which are developed by using an ethnomathematical approach (Borba, 1993). When students come to school, they bring with them values, norms, and concepts that they have acquired in their sociocultural context. Some of these are mathematical in nature (Bishop, 1994). However, the mathematical concepts of the school curriculum are presented in a way that may not be related to the students' cultural backgrounds. It has been hypothesized that low attainment in mathematics could be due to lack of cultural consonance in the school curricula (Bakalevu, 1998).

Moreover, the cultural aspects of mathematics in the curriculum have long-term benefits for learners because these aspects contribute to the recognition of mathematics as part of daily life, which helps students to enhance the ability to make meaningful connections and deepen their understanding of mathematics (Zaslavsky, 1996). In this regard, the pedagogical work towards an ethnomathematics perspective allows for a broader analysis of the school context in which pedagogical practices transcend the classroom environment because these practices embrace the sociocultural context of the students (Chieus, 2004). Therefore, pedagogical elements necessary to develop the mathematics curriculum can be found in the school community (Damazio, 2004). This means that the field of ethnomathematics presents some possibilities for educational initiatives that help to reach this goal.

It is important to recognize that ethnomathematics is a research program that guides educational pedagogical practices (D'Ambrosio, 1990). However, it is necessary to point out that the incorporation of the objectives of the ethnomathematics program as pedagogical practices in the school curricula, its operationalization, and its transmission in the educational field is a research field of study that is still developing its own identity in the pedagogical arena (Monteiro, Orey, & Domite, 2004). There is a need to examine the embeddedness of mathematics in culture, drawing from a body of literature that takes on the cultural nature of knowledge production into the mathematics curriculum (Rosa, 2013). Mathematics as part of the school curricula must reinforce and value the cultural knowledge of students rather than ignore or negate it. This mathematics curriculum must be grounded in a constructivist approach to learning and seek to change the way mathematics teachers construct their learning environments by producing teachers who are able to facilitate a mathematics learning environment grounded in real life experiences and to support students in the social construction of mathematics.

The trend towards ethnomathematical approaches to the mathematics curriculum reflects a comprehensive development in mathematics education. Ethnomathematical approaches are intended to make school mathematics more relevant and meaningful to students and to promote the overall quality of education. It is necessary to plead for a more culturally relevant view of mathematics to be incorporated into the school curricula (Adam, 2002). For example, Powell and Frankenstein (1997) proposed the elaboration of a mathematics curriculum based on students' knowledge, which allows teachers to have more freedom and creativity to choose academic mathematical topics to be covered in the lessons. This curriculum proposes the recognition of the relation between cultural practices and school mathematics, thus, it is important to recommend that:

> (…) mathematics instruction start from the points of cultural familiarity, brought out in the curriculum in a deep way connected with the entire context of intellectual activities of the particular culture. But we also recommend that all students learn about … the "current academic math" culture (Mukhopadhyay, Powell, & Frankenstein, 2009, p. 77).

According to this assertation, Powell and Frankenstein (1997) suggested that through dialogue with students, teachers could apply mathematical themes that help them to elaborate the mathematics curriculum. In their point of view, teachers can engage students in the critical analysis of the dominant culture as well as the analysis of their own culture through an ethnomathematical perspective.

It is necessary to investigate the conceptions, traditions, and mathematical practices of the members of a particular cultural group with the intention of incorporating them into the mathematics curriculum (Ferreira, 1997). The development of a mathematics curriculum that involves a relationship between academic mathematics and ethnomathematical knowledge contributes to the process of social change (Knijnik, 1993). Two decades later, Rosa and Orey (2014) stated that a culturally relevant mathematics curriculum based on an ethnomathematical perspective infuses the students' cultural backgrounds in the learning environment in a holistic manner. In this curriculum, mathematics needs to be taught in a meaningful context in which students are given opportunities to relate their learning experiences to previous knowledge they have previously acquired (Adam et al., 2003).

In this regard, it is particularly important that teachers acknowledge the previous experiences, cultural backgrounds, and linguistic experiences of minority students such as immigrant students in the process of learning of mathematics. For example, the results of the study conducted by Rosa (2013) showed that teachers possess some knowledge about the diversity of their students. However, they need to learn more about the linguistic and cultural backgrounds of their immigrant students in order to value cultural perspectives and languages these students bring to schools. If teachers know about their students' languages and cultural backgrounds, the better they are able to interpret their behavior and attempts to develop a symmetrical communication. According to Haberman (1994), high expectations are critical for students' achievement and should permeate the school and classroom climates regardless of the students' cultural, linguistic, or socioeconomic backgrounds.

In this curriculum, teachers come to develop a sociocultural response to students' needs by making connections between their cultural background and mathematics in a way that "mathematics is conceived as a cultural product, which has developed as a result of various activities" (Bishop, 1988, p. 182). In this context, it is necessary to highlight that some mathematics educational reform policies indicate that learners should be getting an education connected to their cultures. However, schools rarely allow educators to bring and explore the interconnections between mathematics and culture in deep pedagogically informed ways. Connections are often done superficially because of a teachers' inexperience in ways of connecting to deep ideas. In addition, the curriculum in schools lacks the motivation or support to work with content and specific strategies that enable the making of the profound connections explicit necessary for this to occur (Madusise, 2015).

Conversely, curricular activities using an ethnomathematical perspective in the traditional curriculum provide examples that draw on the students' own experiences that are common in their own cultural environments. This:

> (…) perspective into the curriculum should also address cultural issues when elaborating and communicating expectations about the students' mathematics attainment in order to guarantee the effectiveness and unprejudiced methods that distinguish achievements between individuals from different cultural groups (D'Ambrosio & Rosa, 2008, p. 97).

This means that ethnomathematics uses these cultural experiences as vehicles to make mathematics learning more meaningful and to provide students with the insights of mathematical knowledge as embedded in their sociocultural environments (Rosa & Orey, 2008).

Another possibility sees an ethnomathematics-based curriculum as an integration of the mathematical concepts and practices originating in the students' culture with those of conventional and formal academic mathematics (Lipka, 1998). In this approach, the *ethnocurriculum* takes aspects of the students' culture and uses it explicitly to integrate these experiences into the conventional mathematics curriculum. In such a classroom environment, students build on what they know as well as on the experiences they have from their cultural environments (González et al., 2005). These experiences are then used neither as motivation nor as an introduction, but instead as part of understanding of how mathematical ideas are developed and how they are built into systems, formulated, and applied in various ways within the culture.

A mathematics curriculum conceived in an ethnomathematical perspective helps to develop mathematical concepts and practices that originate in students' culture by linking them to academic mathematics. The understanding of conventional mathematics then feeds back and contributes to a broader understanding of culturally based mathematical principles. The work of Lipka (2002) in Alaska is a prime example of this type of approach to the mathematics curriculum because its nature motivates students to recognize mathematics as part of their everyday life. This approach helps them to enhance their ability to make meaningful mathematical connections by deepening their understanding of all forms of mathematics. For example, Duarte (2004) investigated the uniqueness of mathematical knowledge produced by workers in the home construction industry through a study of mathematical ideas and practices that they develop in construction sites. The reflection on the mathematical knowledge possessed by the members of this working class was used to modify pedagogical actions in classrooms.

The objective of developing an ethnomathematical curriculum model for classrooms is to assist students to become aware of how people mathematize and think mathematically in their own cultural contexts, to use this awareness to learn academic mathematics, and to increase the ability to mathematize in distinct contexts (Duarte, 2004). This curriculum leads to the development of a sequence of instructional cultural activities enabling students to become aware of potential practices in mathematics in their culture so that they are able to understand the nature, development, and origins of academic mathematics (Rosa & Orey, 2007). Students also come to value and appreciate their own mathematical knowledge, which allows them to understand and experience cultural activities from a mathematical point of view, thereby allowing them to make links between school mathematics and their real world and daily life (Knijnik, 1993; Rosa & Orey, 2003).

This context allows students to understand the nature of mathematics as they become aware of the mathematics in their own culture. With awareness, students perceive mathematics as a human activity rather than just a set of symbols, numbers, and figures presented only in the school. One possible bridge is to understand how both teachers and students realize connections between academic mathematics and the real world. This includes examples teachers can use in their instruction and the characteristics of informal and academic mathematics they choose to explore in classroom activities. In

this regard, Rosa and Orey (2003) affirmed that when students understand the nature of mathematics, they acquire the tools to better comprehend the relevance of mathematics in the various aspects of their everyday lives.

Mathematics curriculum, when based upon principles of ethnomathematics, brings a broader understanding about the importance of mathematics to pedagogical activities developed in the mathematics classrooms. This curriculum offers students, especially minority students, the motivation to perceive mathematics as an important cultural tool that facilitates their mathematical learning. The establishment of cultural connections to mathematics is a fundamental aspect in the development of new strategies to the process of teaching and learning this curricular content because it allows students to perceive mathematics as a significant part of their own cultural identity (Rosa & Orey, 2003).

A decade later, Rosa (2013) conducted a study in order to determine: *what were the perceptions of high school teachers in relation to the association between mathematics and culture?* In order to answer this question it is necessary to discuss that teachers and mathematicians do not agree on the nature of mathematics, debating whether or not it is bound by culture (internalists) or culture-free (externalists) (Dossey, 1992). For example, internalists such as D'Ambrosio (1990) believe mathematics is a cultural product, developed as a result of various activities such as counting, locating, measuring, designing, and playing while externalists such as Kline (1980) believe that mathematics activity is culture free. Thus, they do not believe in the connection between mathematics and culture. The results of this study show that the majority of the teachers possess an externalist view of mathematics, which means that they perceive mathematics as culture-free. Thus, they do not believe that there is a relationship between mathematics and culture.

This curriculum focuses on mathematics as a process rather than as a collection of facts, and it is based on the idea that mathematics is a human creation that emerges as people attempt to understand their world. Therefore, mathematics can be seen as a process and as a human activity, rather than just as a set of academic content (D'Ambrosio, 2000). This implies that an *ethnocurriculum* is not just about the application of relevant contexts in learning and teaching mathematics, but is also about generating academic mathematics from cultural ideas (Gerdes, 1993). Thus, academic mathematics becomes better understood, appreciated, and made more meaningful to its learners.

In this curriculum, teachers must analyze the role of what Borba (1990) referred to as students' *ethnoknowledge* in the mathematics classroom. Ethnoknowledge is acquired by students in the pedagogical action process of learning mathematics in a culturally relevant educational system. In this process, the discussion between teachers and students about the efficiency and relevance of mathematics in different contexts should permeate instructional activities. The ethnoknowledge that students develop must be compared to their academic mathematical knowledge. In this process, the role of teachers is to help students to develop a critical view of the world by using mathematics.

Teachers also need to develop a different approach to mathematics instruction that empowers students to understand mathematical power more critically by considering the effects of culture on mathematical knowledge and work with students to uncover the distorted and hidden history of the mathematical knowledge. According to Rosa (2000), this methodology is essential in developing the curricular practice of ethnomathematics

and a culturally relevant pedagogy: through the investigation of the cultural aspects of mathematics and an elaboration upon mathematics curricula that considers the contributions of people from other cultures, students' knowledge of mathematics becomes enabled and enriched.

5. Implications of an Ethnomathematics Perspective in the Curriculum

These implications both incorporate and integrate the many diverse possibilities of knowing, understanding, and representing information for teachers and students. This is especially important when instruction and learning take place in an environment that both encourages multicultural viewpoints and allows for the inclusion of knowledge that is culturally relevant to students. If teachers are provided with professional development opportunities that helps them develop a learning environment that is relevant to and reflective of students' social, cultural, and linguistic experiences, then they are increasingly able to act as guiders, mediators, facilitators, consultants, instructors, and advocates for students; helping to effectively connect their community-based knowledge to classroom learning experiences.

One implication concerns a teachers' individual preparation in pedagogical strategies and methodologies that can effectively help them to serve the students. This preparation needs to help teachers learn to confront the notion that "academic mathematics is a set of institutionalized, largely elitist, and mostly non-utilitarian practices that are linked to the culture of power in ways that lessen the school achievement and life chance outcomes of urban youth" (Brantlinger, 2007, p. 349). However, to make a decision about how we might modify pedagogies in response to the needs of our students, equal support must be given to teachers so they gain increased and effective research-based instructional practices in their curricular and pedagogical work. The consensus and research related to best practices shows us that curriculum, assessments, and instruction need to be meaningful and relevant to all students as well as appropriate to their linguistic and cultural backgrounds.

These best practices and strategies range from the simple use of visual representations such as a vocabulary scaffolding, graphic organizers, and differentiating instruction to the use of the cultural background of the students in the development of the pedagogical action in schools. An implementation of these pedagogical practices aims mainly to help students in developing their sociocultural identity and encourages them to strive for academic excellence and outstanding participation in society. Although professional development may help teachers to improve their pedagogical skills and teaching practices, the lack of consistency in the implementation of the teaching and learning strategies in their schools does not contribute to an effective outcome of those strategies.

Critical reflections on the social, cultural, and political dimensions of mathematics offers an important perspective for changes in a dynamic and modern society because it recognizes that all cultures and all people develop unique methods and explanations that allow them to understand, act, model, and transform their own reality. In this regard, ethnomathematics is the study of mathematical ideas developed by different sociocultural groups and offers a contextualization of the curriculum that contributes to the elaboration of pedagogical practices in multicultural classrooms.

Another important implication of this perspective is that ethnomathematics as a pedagogical action demonstrates that the content is contextualized and grounded in the needs and expectations of the community that utilizes it. Along this line, the goal of ethnomathematics is to contribute both to the comprehension of cultures and mathematics, but mainly to the relationship between these two understandings. Educating students mathematically consists of much more than just teaching them mathematical concepts. Because it requires a fundamental awareness of the values that underlie mathematics and a deeper recognition of the complexity of educating students about these values, this kind of teaching is arguably much more difficult to accomplish, and the problems and issues are more challenging.

In designing and selecting classroom activities that incorporate an ethnomathematics perspective in the curriculum, the main implication for teachers is that they have to be given the support to consider the social, linguistic and cultural backgrounds of their students. With the increased growth of a diverse student population in schools, the mathematics curriculum needs to reflect on the intrinsic and sociocultural learning of all students. Hence, it is important that teachers are prepared to address students' linguistic and cultural backgrounds in their classrooms. According to D'Ambrosio and Rosa (2008), this inclusion improves students' academic achievement, helps move classrooms towards an equitable learning environment, helps students to form positive beliefs about mathematics, integrates mathematics with other disciplines, and promotes mathematical understanding.

6. Final Considerations

The challenges of this new century and the increased accountability it demands requires a different kind of teaching strategy that both supports and enables teachers to serve their students more effectively. Therefore, mathematics teachers need to be encouraged to develop their teaching work and engage in reflection, which is essential to improving their own teaching practice. Similarly, researchers have recognized that reflecting on or pondering an ideal, issue, perception, belief, or problem leads educators to an enhanced educational practice. Since professional reflection constitutes a valued strategy for enhancing one's professional practice, it is paramount that teachers be allowed the time to create opportunities that reflect upon their own teaching practices in order to understand, critique, and modify it. In addition, a deep understanding of both culture and its connection to mathematics is an important source of knowledge for educators and curriculum leaders to reflect upon in order to modify and transform their teaching practices. In this regard, if educators are to be allowed and supported to develop strategies that facilitate successful learning opportunities, they must know the cultural roots, linguistic backgrounds, previous experiences, and their students' perceptions about the world.

Ethnomathematics presents an alternative view towards the teaching and learning of mathematics. Allowing students to appreciate and understand more than one representation helps us to both appreciate and understand mathematics as a potential for resolving conflict, and solving problems. Acknowledging how culture affects how we think and learn mathematics, builds one concrete example for understanding between humans. Ethnomathematics teaches us that both students and teachers can learn to appreciate, model, and value the diversity in the classroom. To understand both the influence that culture has on mathematics and how this influence results in diverse ways

in which mathematics is used and communicated (D'Ambrosio, 2001) increases understanding between diverse groups of students.

A comprehensive view of mathematics curriculum is implicit in an ethnomathematical perspective. Students possess potential for understanding and communication through a variety of mathematical signs and systems within cultural context. This allows them to gain new perspectives on human potential and on the organization of the mathematics curriculum. To our mind, mathematics can be better learned and taught if it includes aspects of the culture, natural language, and visual representations that are culturally relevant to learners and teachers alike. Thus, for students to reach their full mathematical potential, instruction should be provided in ways that promote the acquisition of increasingly complex mathematical knowledge, language skills and abilities in a sociocultural climate that fosters collaboration and positive interactions among students and teachers. Important features of such settings include both high expectations and an exposure to an academically rich mathematics curriculum, materials, resources, and approaches that are culturally and linguistically relevant to student needs in order to enhance their mathematical learning and achievement in addition to using effective methods and materials.

An ethnomathematical perspective to a curriculum helps students come to better understand, appreciate, and value alternative viewpoints, cultural diversity, natural language, mathematics, and visual representations, which form a unique system for meaning making. In this context, reorienting teaching and learning to include ethnomathematics can engage and excite students about learning and encourages them to see themselves as being able to do mathematics by valuing their own cultural experiences, which serves as an essential component of understanding and celebrating the differences between diverse cultural groups (Rosa, 2013). This perspective also encourages teachers to recognize that there is mathematics in everything, not just the mathematics found in required school curriculum and its required textbooks. How diverse people, despite their formal schooling experiences, actually come to learn, measure, classify, order and organize, infer, and model are all important aspects of the diverse modes of teaching and learning of mathematics.

In conclusion, teachers who understand students' linguistic and cultural differences continually strive for a variety in instructional, curriculum, and assessment tools and techniques that can lead to an improvement in the learning of mathematics, and a rich personal practice. Teachers, when supported and empowered to do so, can play a key role in encouraging and supporting best pedagogical practices for themselves and students in their classrooms. It is our hope that this article adds to the existing body of the literature in relation to the development of a curriculum based on an ethnomathematical perspective and provides useful information for the adoption of pedagogical actions that use the sociocultural background of students.

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