Ethnomodelling as a Creative Insubordination Approach in Mathematics Education

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Abstract
The application of modelling methods usually makes sense to researchers and educators (global, outsiders) when they understand that these techniques exam mathematical patterns developed by the members of distinct cultural groups (local, insiders). What is less evident is how these professionals attempt to make sense of the underlying cultural frameworks within which diverse mathematical ideas, procedures, and practices are embedded. Currently, an important dilemma in mathematics education is its overwhelming bias against a local orientation in its research paradigm. Thus, a search for innovative methodologies such as ethnomodelling is necessary to record historical forms of mathematical ideas, procedures, and practices developed for use in diverse cultural contexts. It is important to highlight that ethnomodelling is not an attempt to replace globalized academic mathematics, yet, at the same time, it is necessary to acknowledge the existence of local mathematical knowledge in mathematics curriculum. In this context, the insubordination triggered by ethnomodelling is creative and evokes a disturbance that causes a review of rules and regulations in the mathematical modelling process. This process increases the potential for continual growth in the debate about the nature of mathematics as it relates to culture since it proposes a dialogue between local and global approaches to the construction of mathematical knowledge.

Keywords: Ethnomodelling, Local Approach, Global Approach, Glocal Approach, Creative Insubordination.

Introduction
The acknowledgement of the relation between culture and mathematics can be interpreted as a reaction to cultural imperialism that imposed its version of mathematical knowledge on colonized communities around the world with the expansion of the great navigations from the fifteenth century (D’Ambrosio, 1990). In order to keep up with modern Western developmental models, other cultures have been forced to adapt to these paradigms or perish. In this regard, mathematics perpetuates to some extent imperialist goals, thus, it is perceived as a secret weapon that maintains the imposition and domination of Western cultural values on local cultures (Bishop, 1990).
School mathematics has also been criticized because it helps to reinforce a Western/Eurocentric approach in the prevailing curriculum as well as for helping to globalize particular kinds of mathematical technologies and ideologies (D’Ambrosio & D’Ambrosio, 2013) that supports the maintenance of cultural imperialism. However, the development of non-prescribed strategies to solve problems in diverse societal domains is an alternative method as well as an important tool for identifying innovative problem-solving techniques and mathematical ideas, procedures, and practices in ethnomodelling research.

The reaction to this cultural imperialism can be also related to the development of the concepts of *creative insubordination* (Crowson & Morris, 1982), *responsible subversion* (Hutchinson, 1990), and *positive deviation* (Zeitlin et al.; 1990). These concepts are equivalent as they “relate to the flexibility of rules and regulations in order to achieve the welfare of the members of distinct cultural groups” (Rosa & Orey, 2015a, p. 133). In this paper, we apply these three terms interchangeably because the amplitude of their concepts embraces innovative solutions in the pedagogical action of mathematical through ethnomodelling, which helps to confront the belief that persists in contemporary society that mathematics is a culturally neutral knowledge.

The historical and contemporary relations between culture and mathematics illustrate that mathematics is not culture-free. Accordingly, the culturally specific nature of mathematics should be acknowledged in order to describe mathematical ideas and procedures practiced among the members of distinct cultural groups such as tribal societies, labor groups, professional groups, social classes, and children of a certain age group (D’Ambrosio, 1985).

Consequently, it is important to search for alternative methodological approaches as Western mathematical practices are accepted worldwide in order to record historical forms of mathematical ideas, notions, procedures, and practices that occur in different cultural contexts. Hence, the members of distinct cultural groups apply innovative mathematical solutions to the challenges faced by society, which are identified and refined from the ideas, procedures, and practices they develop from generation to generation.

One alternative methodological approach is *ethnomodelling* that may be considered as the practical application of ethnomathematics that adds cultural perspectives to the modelling process (Rosa & Orey, 2012). The “application of ethnomathematical techniques and the tools of mathematical modelling allow us to see a different reality
and give us insight into science done in a different way” (Orey, 2000, p. 250). The pedagogical approach that connects the cultural aspects of mathematics to mathematical modelling is ethnomodelling (Rosa & Orey, 2010).

As a creative insubordination process, ethnomodelling seeks to change the “outside existing paradigms and conflicts with prevailing values and norms” (Marzano et al., 2005, p. 113) since it stands for the development of mathematical ideas, procedures, and practices that have its roots within distinct cultures. In this context, ethnomodelling binds contemporary views of ethnomathematics and, simultaneously, recognizes the need for a culturally based view on the modelling concepts and processes. Studying the unique cultural differences in mathematics encourages the development of new perspectives on the scientific questioning methods.

Research on culturally bound modelling ideas may address the issue of mathematics education in non-Western societies by bringing the local cultural aspects into mathematical teaching and learning processes (Eglash, 1999). This approach reveals responsible aspects of subversion in the ethnomodelling process that are identified with an ongoing movement that challenges the status quo of academic mathematical knowledge by aiming at to alter the system in creative ways (Lyman et al., 2005) in order to better serve the needs of the students. Essentially, it involves looking at issues from perspectives outside of existing educational systems and pedagogical models. Similarly, ethnomodelling can be considered as insubordinate and creative educational approaches because it disrupts the existing order in the academic mathematics, as it does not follow the linear modelling approach prevalent in schools. It develops the study of ideas, procedures, and mathematical practices that are found in distinct cultural contexts. Hence, ethnomodelling attempts to break bureaucratic rules of academic mathematics in order to recognize different techniques and value diverse modes of producing mathematical knowledge in diverse cultural groups (Rosa & Orey, 2015a).

This context allows ethnomodelling to challenge the prevailing traditional mathematical ways of thinking, thus, this positive deviance approach involves thoughts and/or actions that differ from the imposed norms and regulations (Dehler & Welsh, 1998). In the anthropological and sociological point of view, this act of responsible subversion examines how individuals solve problems in spite of or in opposition to the formal system or the commonly accepted rules (Hutchinson, 1990). Historically, mathematical knowledge takes different forms in different cultures as well as Western worldviews on
the ideas of modelling begin to shift in order to acknowledge that this process is culturally bound.

**Local (Emic), Global (Etic) and Glocal (Dialogical) Aspects of Ethnomodelling**

When researchers investigate the members of distinct cultural groups, they may be able to find distinctive characteristics of mathematical ideas and procedures that we might label as ethnomodelling. However, an outsiders’ (global, etic) understanding of objectivated cultural traits is always an interpretation that may misinterpret mathematical practices developed by the members of these groups. This happens because members of specific cultural groups often have their own unique interpretation of their cultural traits, including the mathematical knowledge passed from one generation to another. This is the *local* (emic\(^1\)) approach opposed to an outsider’s interpretation of these cultural traits, which is the *global* (etic) approach. According to this context, there are three approaches (global, local, and glocal) to be considered in order to investigate and study the mathematical ideas, procedures, and practices developed by members of distinct cultural groups.

**a) Global (Etic) Approach**

Global or etic approaches can best be defined as an *external* or *outsider’s* view on the beliefs, customs, scientific and mathematical knowledge developed by members of distinct cultural groups. The ongoing globalization process we are all part of, deals with cultural convergences that perceive mathematical knowledge in terms of increasing homogenization or sameness. It, either willingly or not, denies and ignores the diversity of cultures across social, cultural, political, economic, environmental, and geographic boundaries; often viewing western/academic forms of mathematics as correct, universal and monolithic and that can only emanate from the Euro/academic tradition. This process has inculcated an ethnocentric fear of, or at very least disinterest and disrespect for the many mathematical differences regarding symptoms of *cultural alterity*\(^2\). This approach is considered as *culturally universal* (Sue & Sue, 2003).

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\(^1\)The terms emic and etic were originally introduced by Pike (1954) who drew on an analogy with the linguistic terminology *phonetics* and *phonemics*. *Phonetics* are the general aspects of all possible vocal sounds production in languages. *Phonemics* are sounds locally significant that are used in a particular language. Just like in the study of a language’s sound system, it is possible to apply at least two approaches in the investigation of distinct cultures, which are the point of view of either the *insiders* or the *outsiders*. In this context, researchers can conduct investigations in mathematics education from the *emic* and *etic* approaches.

\(^2\)Cultural alterity is the process by which societies and cultures may exclude particular group of people because of their otherness. Thus, this term has embedded in it a negative connotation because of practices like stereotyping that allow people to use social markers to construct identity (Wexler, 2004).
b) Local (Emic) Approach

Local or emic approaches can best be defined as the insiders’ view about their own customs, beliefs, and scientific and mathematical knowledge traditions; and encompasses the skills, abilities, competencies, experiences, and insights developed by the members of distinct cultural groups as they use it in their daily lives and perhaps to maintain or improve their livelihood. Focusing on the local entails a more conceptual and dynamic interaction that developed and adapted continuously to gradually changing environments and passed down from generation to generation and closely interwoven with people’s cultural values. It is also the *cultural and social capital*\(^3\) of the members of these groups; that is it is their main asset used to invest in the struggle for survival, to solve problems faced daily, and to achieve control of their own lives. Local knowledge influences conceptions of the greater world, but it is important to understand how it changes in different times and places in relation to the broader political, social, economic, environmental, and cultural contexts (Yifeng, 2009). This approach is considered as *culturally specific* (Sue & Sue, 2003).

c) Glocal (Dialogical) Approach

A glocal approach can best be considered as the dialogical relation between globalization (etic) and localization (emic). This approach involves blending, mixing, and adapting two or more distinct knowledge systems or cultures and is known as *glocalization*\(^4\) (Robertson, 1995). In order to be meaningful, glocalization must include at least one component that addresses the local culture, system of values, or knowledge systems (Khondker, 2004). Glocalization describes the relationship between the local and the global as interdependent and mutually constitutive approaches and “challenges notions of cultural imperialism because the term suggests a negotiation process that appears to start from the inside out, i.e., a process that begins with a high regard for the local” (Maynard, 2003, p. 57). The main objective of this positive deviance procedure

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\(^3\)Social capital is the sum of the resources, actual or virtual, that accrue to an individual or a group by virtue of possessing a durable network of more or less institutionalized relationships of mutual acquaintance and recognition. Cultural capital includes non-economic resources that enable social mobility such as knowledge, skills, and education. Both concepts remind us that social networks and culture have value (Bourdieu & Wacquant, 1992).

\(^4\)Glocalization is a term coined by Robertson (1992) that merges the concepts of globalization and localization.
that departs from established norms or rules is to modify these regulations by applying innovation, creativity, and adaptability (Walker, 2005).

Because glocalization arises from culture and through interactions, adapts to the changes in culture, the dialogical approach is an active force of the ethnomodelling process. Indeed, our notion of contextualization is not an exclusionary view; rather it is an attempt to harness positive aspects of globalization of mathematical knowledge in a sustainable way. In this regard, well-conceived contextualized mathematical practices do not promote any forms of hegemony apart from the emphasis on dialogical relationships between sometimes opposing, or contradictory, and complementary approaches.

It is important to highlight here that in our point of view, the glocal approach is a reaction to globalization, or a reinforcement of cultural identity at the local community level. This means that, in ethnomodeling processes, mathematical knowledge might consider the worldwide connections, but also with the specific conditions of the local knowledge. This insubordination aspect of mathematics education is creative because it involves adapting rules in order to change, challenge, or even subvert the regulation of the implementation processes of the norms.

Dialogical approaches (glocalization) of ethnomodelling help us become more mindful of forms of the hegemony prevalent in mathematics through the application of dialogical approaches in ethnomodelling. Thus, it is necessary to incorporate cultural-based forms of knowledge and the notion of dialogical approaches and the continuous changes that arise in the process of teaching and learning mathematics.

It is necessary to state here that we are not enforcing another form of dualism, which is globalization (etic) versus localization (emic). Indeed, our intention is to contest the narrow view of globalization that allow for new or alternative traditions and developments of mathematical ideas, procedures, and practices. This is important in order to demonstrate that global approaches are not necessarily exclusive constructs, rather they coexist with localization

**Ethnomodelling as a Glocalization Process**

The debate between local (emic) and global (etic) mathematical knowledge traditions has a long tradition in conducting investigations. Some researchers have made important distinctions between the culturally specific and the culturally universal (Headland, Pike, & Harris, 1990). Unfortunate misunderstandings have arisen with the
assumption that this distinction implies dichotomous approaches to cultures (Pike, 1967), and in this case, diverse mathematical thinking or traditions.

A local or emic approach seeks to understand a particular phenomenon from the point of view of the members of distinct cultural groups (Pelto & Pelto, 1978) since they are the sole judges of the validity of emic descriptions on their own mathematical terms and contexts. Emic approaches focuses on studying sociocultural aspects of mathematical phenomena from within a specific cultural context and understanding, as the people from within that culture understand it (Gudykunst, 1997).

A global or etic approach seeks to understand particular phenomena by means of analytical tools and concepts drawn from the outsiders’ worldviews (Pelto & Pelto, 1978). The etic approach analyzes human behavior and knowledge with focus on universals because they can be compared across cultures using common definitions and metrics (Berry, 1969). It relies upon extrinsic concepts and categories that have meaning for researchers and educators who are the sole judges of the validity of etic accounts.

In general, local refers to taking the insider’s viewpoint whereas global means taking the outsider’s viewpoint. In this context, in a global approach, mathematical phenomena is cross-culturally understood rather than comprehended by culturally specific meanings and contexts. While local and global are often thought to create a conflicting dichotomy, they are, in reality, complementary viewpoints (Rosa & Orey, 2015b). Thus, rather than posing a dilemma, the use of both approaches deepens our understanding regarding cultural understandings and comprehensions.

However, cultural bias, is an unfortunate consequence, and occurs when researchers come to assume that a local (emic) construct is actually a global (etic) construct. For example, this result wrongly imposes the culturally-universal mathematical knowledge to culturally-specific mathematical ideas, procedures, and practices emically developed by the members of distinct cultural groups. The study of cultures according to pre-established etic procedures impedes the discovery of cultural diversity whereas emic analysis truly broadens this view (Headland, Pike & Harris, 1990). In this context, an emic analysis focuses on the behaviors and the knowledge unique to cultures or in diverse ways in which etic activities are carried out in a specific cultural settings.

Moreover, it is often presupposed that this methodological dichotomy corresponds to the opposition between the development of mathematical knowledge of the members of distinct cultural groups and their external experiences. In this context, the etic approach is equated with the objective explanation of sociocultural and mathematical phenomena.
from external points of view, while emic approaches are identified with the sympathetic comprehension of subjective experiences from the internal point of view (Harris, 1980). Local and global mathematical knowledge traditions should not be studied in isolation from one another but as mutually constitutive parts of a single expression. Ethnomodelling provides a lens through which it is possible to perceive both homogeneity and heterogeneity of mathematical ideas, procedures, and practices by allowing members of distinct cultural groups to increase their understanding of specific responses to global forces. Glocalization takes place when local (emic) and the global (etic) mathematical knowledge encounter each other, and refers to the mixing of cultural traits\(^5\) developed in distinct cultures that have created cultural patterns that where not previously known by outsiders. It is the interpenetration of the local with global mathematical knowledge that can result in unique outcomes in different cultural groups. It can be perceived as the local globalization or interchangeably as global localization (Robertson, 1995). Thus, the ethnomodelling process values the fusion of various cultural inputs into new and unique products regarding to mathematical practices. The exclusive view of globalization cannot help us realize the disempowerment and the loss of mathematical traditions or the limitations of a hegemonic worldview. On the other hand, an extreme advocacy of localization cannot empower students to apply multiple referents to their mathematical creativity. Therefore, this dialogical process (glocalization) provides us with opportunities to challenge both forms of hegemony, thereby, opening for multiple opportunities through the interplay of mathematical ideas and actions in context. It helps researchers and educators to examine the limitations and advantages of knowledge systems arising from different worldviews, thereby developing an honest and more contextualized version in their pedagogy (Rosa & Orey, 2015a).

Ethnomodelling considers the techniques and strategies rooted in local (emic) and glocal (etic) mathematical knowledge systems. Throughout history, humanity has developed tools that enable members of distinct cultural groups to explain, understand, and comprehend the world around them. Hence, transcendence was responsible for the creation of the cultural traits.

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\(^5\)A cultural trait is a socially learned system of beliefs, values, traditions, symbols, and meanings that the members of a specific cultural group acquire throughout history. It identify and coalesce a cultural group because traits express the cohesiveness of the members of the group. It is a deposit of knowledge, experiences, actions, attitudes, hierarchies, religion, notions of time, roles, spatial relations, concepts of the universe, and artifacts developed by the members of distinct cultural groups in the course of generations through individual and group strivings (Samovar & Porter, 2000).
development of the tools, techniques, codes and communication skills, which helped humanity to expand the perception of the past, present, and future (D’Ambrosio, 2015). In addition, mathematical facts are organized as techniques and strategies that evolve representations of reality (ethnomodels) explanations systems on the phenomena that occur in everyday life.

**Ethnomodels as Representations of Local, Global, and Glocal Knowledge**

By using ethnomodels, humanity tries to understand the world by means of explanations that are organized as procedures, techniques, methods, and theories, as it aims to explain and consider daily realities and phenomena. These strategies are historically organized in every culture as knowledge systems (D’Ambrosio, 2015).

Researchers and educators, if not blinded by their prior worldview, should come out with an informed sense of the diversity of mathematical ideas, procedures, and practices that are modeled since they should be able to tell outsiders (global, etic) what matters to insiders (local, emic) and vice versa (Rosa & Orey, 2011).

Ethnomodelling tends to privilege the organization and presentation of mathematical ideas, notions, and procedures developed by members of distinct cultural groups by encouraging the elaboration of local, global, and glocal ethnomodels by the people who actually do it. Thus, the: 

(…) elaboration of models that represent these systems are representations that help the members of these groups to understand and comprehend the world by using small units of information, named *ethnomodels*, which link their cultural heritage with the development of the mathematical practice. This approach helps the organization of the pedagogical action that occurs in classrooms through the use of the local aspects of these mathematical practices (Rosa and Orey, 2015a, p. 140).

Local (emic) ethnomodels reflect the information and observations that have come to represent the target population’s own vocabulary, scientific and mathematical knowledge, conceptual categories, language of expression, and cultural belief system. It deals with the diversity of mathematical knowledge and traditions that makes a difference from the *insiders’* point of view. These ethnomodels are grounded in what matters in the world of the people being modeled (Rosa & Orey, 2013).

These ethnomodels attempt to investigate and understand phenomena and their structural interrelationships through the eyes of the members of a specific cultural group. The primary goal of these ethnomodels is to develop a descriptive idiographic orientation that describes the effort to understand the meaning of contingent, unique,
and often-subjective mathematical phenomena since it emphasizes the uniqueness of mathematical practices developed by the members of distinct cultural groups. Global (etic) ethnomodels reflect the information collected in terms of the conceptual systems and categories of the researchers. It attempts to identify lawful relations and causal explanations that are valid across different cultures. These ethnomodels are built on the outsiders’ view of the world of the people being modeled (Rosa & Orey, 2013). The analysis of global ethnomodels is comparative since it examines many different cultures by using standardized methods and categories. Thus, etic knowledge is essential for cross-cultural comparisons that demand standardized units and categories, which are the essential components of ethnology. Glocal forms of ethnomodeling can capture the melding processes of interpretation. While rooted within the discursive arena of local mathematical ideas, procedures, and practices, these ethnomodels also includes uses of global mathematical knowledge. Rather than presenting local and the global perspectives as opposite sides of a single sociocultural spectrum, glocalized ethnomodels recognize the ways in which both local and glocal mathematical knowledges act upon one another.

It highlights both the structural constraints and the individual and collective agencies by referring to real world endeavors that may (re)contextualize global mathematical phenomena with respect to local cultural traditions. Thus, it critically transcends the binary oppositions of the emic and the etic mathematical knowledges and acknowledges the co-presence of sameness and differences, and the intensified interpenetration of the local and the global (Giulianotti & Robertson 2007) in the process of the elaboration of glocal ethnomodels. Thus, in the elaboration of ethnomodels, if researchers wish to make statements about universal (global, etic) aspects of mathematical knowledge, these statements need to be phrased in abstract ways as well as based on attributes of mathematical patterns found across many cultures. Conversely, if researchers wish to highlight the meaning of these generalizations in specific (local, emic) ways, then it is necessary to refer to a more precisely specified mathematical knowledge.

In this context, it is important to acknowledge the interplay of globalization and localization and the fact that we are microcosmic reflections of how globalization works on a local community level (Mendis, 2007). Thus, glocal ethnomodels incorporate knowledge systems arising from local and global cultural practices through dialogical approaches.
An Ethnomodel of the Gable

Informants from a roofing contractor cultural group can easily describe the practices acquired for the construction of a roof gable, which is the most commonly used type of pitched roof construction. After choosing the type of tile such as red roofing tiles or shingles to begin the construction of the roof, it is necessary that roofing contractors calculate the slopes for the beams that form the triangles in the gable.

Gabled roofs often possess a ridge near or at the center and slopes in two directions. It is simple and common in design, economical to construct, and can be used on any type of structure, and in any type of climate. Roofing contractors use triangles because they are stable, rigid, and do not move. The main objective of the roof is to provide protection from climate because they must be strong enough to withstand high winds, and shed moisture, and often snow and ice quickly.

For example, Rosa (2014) states that in the case of many Brazilian roofs, roofers calculate the slope of the roof by applying a ratio between the height and the length of the gable, which they express as a percentage. In this context, the percentage of the slope (trim) for the roof to the tiles is at least 30% so that rainwater can quickly drain. According to this kind of mathematical knowledge they acquired through observation and experimentation, for each meter (100 cm) that runs horizontally, there is a vertical rise of 30 cm.

Thus, if the length of the gable is \( L = 8 \) meters, roofing contractors mentally perform the percentage calculation by using \( a = 4 \) meters, which is half of that measure. Then, they multiply it by the percentage of the slope of the roof. For example, 30% of 4 meters corresponds to the height of 1.20 m. Figure 1 shows the scheme of a gable used in most of the roof constructions in Brazil.

![Figure 1: Scheme of a gable used in roof constructions in Brazil](image-url)
This context allows researchers and investigators to describe this mathematical practice (emic, local) by using the Pythagorean Theorem (etic, global). However, it is important to understand the dialogical (glocal) relationship between these two approaches. For example, the informal calculation (emic knowledge) of the height (trim, flow) of the gable does not preclude the use of the Pythagorean Theorem (etic knowledge) by these professionals. This means that these professionals strive to compare, interpret and explain the type of mathematical knowledge they observe and that the members of this particular cultural group are experiencing.

The results of the study conducted by Rosa (2014) shows that the glocal observation of this mathematical practice tries to understand it from the perspective of the internal dynamics of the Brazilian roofers (local) while providing cross-cultural comparisons in order to comprehend it from the point of view of individuals from different cultural backgrounds (global). Thus, this approach is necessary to comprehend and explain this particular mathematical practice as a whole from a dialogical point of view.

**Glocal Characteristics of Translation**

Issues of cultural differences and translation strategies are examined in the context of ethnomodelling. Ethnomodelling investigators often use *translation* to describe the modelling process to translate emic knowledge systems (Rosa & Orey, 2013), which is a process that depends “on acts of translation between emic and etic perspectives” (Eglash et al., 2006, p. 347). Accordingly, ethnomodelling attempts to establish relations between emic mathematical ideas and procedures embedded in local mathematical practices (designs, patterns, and symmetry) to etic (global) conceptual frameworks (Rosa & Orey, 2011).

In this context, mathematical practices can be seen as arising from emic rather than etic origins. However, in some cases, the *translation* from emic to etic mathematical knowledge is direct and simple such as in examining diverse counting systems or calendars (Rosa & Orey, 2015b). In other cases, mathematical knowledge is *embedded* in processes such as iteration in beadwork and in Eulerian paths in sand drawings. As well, there is a need to be cautious in this process because it is easier to use numeric systems and counting procedures rather than to understand the embedded mathematical knowledge found and applied in architecture and crafts.

For example, results of a study conducted by Eglash at al. (2006) show that frequently local (emic) mathematical knowledge such as the application of the symmetry...
classifications from crystallography to local textile designs and patterns are merely analysed from an (global) etic approach. In this process, “translators need to understand the cultures towards which they are translating” (Séguinot, 1995, p. 56).

In this context, local mathematical knowledge as redefined within conceptual frameworks of glocalization are reinforced through translations that invite and introduce differences and allow or encourage members of distinct cultural groups to interact with each other. Thus, translation conceptualizes the relationship between the global knowledge and the local culture.

In mutual encounters of members of distinct cultural groups, the emerging otherness necessitates a translation, which is primarily concerned with giving it its due without subsuming it under pre-conceived notions. Such an attempt highlights the translatability, as an operational mode, that marks it from the underlying assumptions that guide both comparative and typologies of cultures (Iser, 1994).

In this regard, an important transfer takes place when two or more cultures meet and interact, as the language, scientific, and mathematical knowledge of one cultural group passes or is shared into the interpretative realm of another (Iser, 1994). In this process, the translation of mathematical ideas, procedures, and practices of the observed culture is understood and comprehended through glocal terms that are different in temporal and special frames and is transformed. This approach raises the issue of cultural and temporal situatedness and the effect it has on our lack of or ability to appreciate other cultures.

The dialogical approach (glocalization) of ethnomodelling explores the diverse forces shaping the products and processes of transcultural and translational mathematical phenomena. It also emphasizes the links and tensions between local (emic) and global (etic) approaches by looking for a more targeted study of mathematical ideas, procedures, and practices.

Ethnomodelling seeks to equip students with a sound critical, reflective, and methodological framework for analyzing the complex interactions within and across diverse communities of linguistic, cultural, historical, political, and social practices through the elaboration of ethnomodels. The corollary is a more complex relationship between local and global mathematical discourses as reflected in translation, which is a constant process of decolonization in its cultural reproduction open to cultural specifics inherent in different traditions.
An Ethnomodelling Curriculum

The concept of positive deviance is useful, offering researchers and educators a basis for decision making when expected actions collide with their perception of mathematics curriculum. It involves an intentional act of breaking the rules in order to serve the greater good of the students. Researchers and educators who are positive deviants must question and discuss opposing status quo of mathematical knowledge in order to enact meaningful changes into the mathematics curriculum.

One of the goals of ethnomodelling curriculum is to add cultural components to the modelling process. Thus, instead of being another research paradigm itself, ethnomodelling aims at encouraging the search for mathematical ideas, procedures, and mathematical practices that are culturally bound as well as to their examination and adoption into mathematics curriculum (Rosa & Orey, 2015c). Traditional mathematical modelling methodologies in school curricula do not fully take into account the implications of the cultural aspects of local systems.

Mathematical curriculum conceived in an ethnomodelling approach helps students to develop mathematical concepts and practices that originate in their own cultural traditions by linking them to formal academic mathematics. The understanding of conventional mathematics then feeds back and contributes to broader understandings of culturally based mathematical principles (Rosa, 2010).

Classrooms should not be isolated from the communities in which they are embedded, thus, they are part of a larger community with defined cultural practices. In this context, classrooms may be considered as learning environments that facilitate the application of pedagogical action developed through the application of an ethnomodelling curriculum, which allows for a broader analysis of the school context in which pedagogical actions transcend school environment since curricular practices embrace sociocultural contexts of the students.

An ethnomodeling-based curriculum can integrate mathematical ideas, procedures, and practices that originate in the cultural background of student’s with the conventional, formal, and traditional mathematical knowledge. In such classroom environments, students build on what they know as well as on the experiences they have from their cultural environments. These experiences are used as part of understanding how mathematical ideas are developed and how they are built into systems, formulated, and applied in various ways within the culture.
The objectives for developing an ethnomodelling curriculum include: a) to assist students to become aware of how people mathematize and think mathematically in their own culture, b) to use this awareness to learn about formal mathematics, and c) to increase the ability to mathematize mathematical practices in distinct cultural contexts. This curriculum applies cultural experiences as vehicles to make mathematics learning more meaningful and, more importantly, to provide students with the insights of mathematical knowledge as embedded in their own sociocultural environments (Rosa & Orey, 2008).

This curriculum leads to the development of cultural activities that enable students to become aware of the mathematical potential found in their own communities and cultural traditions so that they are better able to understand the nature, development, and origins of academic mathematics (Rosa & Orey, 2010). This implies that an ethnomodelling curriculum is not just about the application of relevant connections in learning mathematics, but it is also about generating formal mathematics from cultural ideas.

The comprehension of the acts of creative insubordination in the process of learning mathematics generated from ethnomodeling processes enable the development of teaching strategies that help researchers and educators to apply methodological decisions related to teaching practices (Rosa & Orey, 2015a). This approach helps to improve the mathematics performance of students by modifying, adapting, and flexibilizing curricular practices.

**Implications of an Ethnomodeling Curriculum**

One of the primary issues regarding the mathematics curriculum is concerned to the position of researchers and educators in relation to the *etic* (global) and *emic* (local) approaches. In this regard, pedagogical work on mathematical content developed in classrooms may be based on the researchers and educators’ own worldviews, which relates to culturally-universal (global, etic), culturally-specific (local, emic), or culturally-dialogical (glocal) approaches to mathematics education.

Both researchers and educators who operate from etic (global) positions have been taught to see mathematical ideas, procedures, and practices as occurring in the same way in every culture. They can learn, however, to base their beliefs in relation to Western versus non-Western mathematical traditions in which the members of distinct cultural groups construct, develop, acquire, accumulate, and diffuse the same kind of mathematical knowledge (Rosa & Orey, 2012).
Researchers and educators who take on an emic perspective believe that many factors come into play when mathematical ideas, procedures, and practices are developed in regards to the cultural backgrounds of the members of distinct cultural groups. These factors include diverse sociocultural values, morals, and lifestyle. For example, different cultures have developed different ways of doing mathematics in order to understand and comprehend their own cultural, social, political, economic, and natural environments. It is necessary to highlight that students operate from an emic approach. Since these professionals have come to believe that the cultural backgrounds and life experiences can greatly influence the overall development of mathematical knowledge of students, they then use of culturally specific strategies in the pedagogical work of teaching and learning mathematics. In this regard, they are come to see that current worldwide guidelines and standards for mathematical instruction are very much culturally bound (Rosa, 2010). According to this discussion, it is important that both researchers and educators understand that diverse experiences, lifestyles, cultural values, and overall worldviews influence the development of mathematical knowledge (Rosa & Orey, 2013).

Another issue to discuss here is to determine the belief systems related to researchers and educators in relation to cultural universality, especially that which focuses on similarities and minimization of cultural factors. As well their understanding of techniques and beliefs that focus on cultural differences. Characteristics of culturally dialogical approaches in ethnomodelling research provide conditions in regards to the development of intercultural competence, which is the “ability to communicate effectively in cross-cultural situations and to relate appropriately to a variety of cultural contexts” (Bennett & Bennett, 2004, p. 149). Similarly, intercultural competence is the ability to “develop targeted knowledge, skills and attitudes that lead to visible behaviour and communication that are both effective and appropriate in intercultural interactions” (Deardorff, 2006). Figure 1 shows intercultural competence in the ethnomodelling process.
The question is, then, whether it is necessary to understand cultural specificity (local, emic) against the background of universal theories and methods (global, etic) that can be susceptible to cultural differences and to the demands of cultural contextualizations. However, results from culturally specific investigations encourage more cross-cultural research that supports the development of emic perspectives (D’Ambrosio, 1990; Eglash et al, 2006; Rosa & Orey, 2010).

This context strengthens the notion that mathematics cannot be conceived as a universal language because its principles, concepts, and foundations are not the same everywhere (Rosa & Orey, 2007). Conversely, it is naïve to state that the members of distinct cultural groups do not share universal mathematics ideas, thus, some mathematical activities are widely practiced across cultures.

For example, many of the everyday activities members often perform daily involve a substantial amount of mathematical application. In this regard, counting, measuring, designing, locating, explaining, and playing are six universal activities that are practiced by the members of any cultural group. These universal activities provide fundamental

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**Figure 1: Intercultural competence in the ethnomodelling process**

![Diagram showing intercultural competence in the ethnomodelling process](source: Adapted from Deardorff (2006))
facets used to probe traditional daily living practices (Bishop, 1993). It is also important to highlight that these activities are intertwined with other aspects of the daily routine of these members.

On the other hand, there are cultural differences within these universal activities. Academic mathematics may look the same in many societies because there is a competitive social, economic, environmental, and political ethics that demand a competitive mathematics curriculum. In this regard, dominant cultures may have imposed their forms of mathematics on other societies since the beginning of the development of the mathematical knowledge.

In this regard, even though these activities are considered universal, it is important to recognize that they are merely universal to those individuals who share the same cultural characteristics and historical perspectives. On the other hand, it is equally naïve to believe that mathematical ideas and procedures do not reflect the cultural values and lifestyles of the members of cultural groups (Rosa, 2010).

By applying an innovative pedagogical approach to these opposing views, it may be helpful to understand the universality of mathematical ideas, procedures, and practices that could be relevant to researchers, educators, and the members of a specific cultural group (Rosa & Orey, 2015c). Hence, it is necessary that this approach takes into consideration the relationship between cultural norms, values, attitudes, and the manifestation of mathematical ideas, procedures, and practices developed in different knowledge fields as well as in the context of distinct cultures.

If researchers and educators become self-aware of themselves and their worldviews, cultural paradigm, and values, then they may be more open to apply aspects of ethnomathematics and modelling in their pedagogical practices through the application of ethnomodelling (Rosa, 2010). This may lead them to a clearer decisions in the application of local (emic), global (etic), and glocal (dialogical) approaches.

**Final Considerations**

The tragedy of the impending disappearance of local (emic) knowledge is most obvious to those who live it, but the implication for others can be detrimental as well when mathematical procedures and techniques, technologies, artifacts, and problem solving strategies are lost during the development of contemporary society. Defined in this manner, the usefulness of both emic and etic knowledge is evident and necessary.

The majority of mathematics researchers and educators have been enculturated to, more or less, one particular cultural worldview. They therefore need a means of
distinguishing between the answers they derive as enculturated individuals and the answers they derive as observers. Defining emics and etics in epistemological terms provides a reliable means of making that distinction. From this perspective, the two definitions of culture, emic and etic, can be considered as two sides of the same coin. By utilizing the research provided by both approaches, we gain a more complete understanding of the culture(s) of interest.

Thus, one possible reason for many failing educational systems around the world could be that both policy makers and curriculum developers have ignored emic approaches in relation to school curricula, especially when it suggests the recognition of other epistemologies and of holistic and integrated natures of the mathematical knowledge developed by the members of other cultural traditions. It has been hypothesized that low attainment in mathematics could be due to lack of cultural consonance in the mathematics curriculum (Rosa, 2010).

When students come to school, they bring with them the values, norms, procedures, techniques, and concepts that they have acquired in their own sociocultural environment and some of these elements are mathematical in nature. However, mathematical concepts of the school curriculum are presented in a way that may not be related to their cultural background. Moreover, the inclusion of cultural aspects in the mathematics curriculum has long-term benefits for mathematics learners (Rosa & Orey, 2010).

Current mathematics curriculum lacks a dialogical approach in regards to the preparation of students for a living in a dynamic and diverse society. The lack of awareness of emic knowledge and the alienating effects of Western educational norms indicates a need for an ethnomodelling curriculum. The mathematical knowledge created based on an emic approach is a form of intellectual decolonization, and provides us with a major contribution to mathematics education and in the development of contemporary society. Ethnomodelling becomes the “joining of a new field of inquiry, which might be called communal transformation” (Block, 2010, p. vii).

In this context, an ethnomodeling-based curriculum comes to provide a theoretical basis for the teaching and learning process because it combines key elements of emic knowledge with an etic approach. The main goal of ethnomodelling is the acquisition of both emic and etic knowledge by applying dialogical approach.

Similarly, it is possible to define glocalization “by the social actor’s fluid and critical engagement with, and reconstruction of, local and global phenomena” (Giulianotti & Robertson 2006, p. 173). When analyzing the diffusion of mathematical knowledge, it is
necessary to look at the local and global reconstructions together. In this regard, cultural aspects contribute to recognizing mathematics as part of daily life, enhancing the ability to make meaningful connections, and deepening the understanding of mathematics (Rosa, 2010).

In this context, creative insubordination is necessary to serve students’ learning (Ayers, 2001), which is the main concern of the educational system and, therefore, if rules and norms need to be bent to achieve this goal. Then, researchers and educators must address student’s cognitive and pedagogical needs into the mathematics curriculum through ethnomodelling.

References


