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A Cultural Approach to Mathematical Modelling: An Ethnomathematical Perspective

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Abstract

A major problem with mathematics education in contemporary society is its overwhelming bias towards a Western orientation in its topics and research paradigm. A search for new approaches and methodologies is necessary to record historical forms of mathematical ideas that occur in different cultural contexts, and to take advantage of the emerging globalization of business, science, religion, art, music and other aspects of culture. There is a need to apply a fundamentally different philosophy, modelling techniques, and an ethnomathematical perspective to mathematics curriculum. In this article, the authors propose to demonstrate how ethnomodelling is a methodology for teaching and learning of mathematics that challenges the prevailing way of thinking.

Keywords: cultural groups, ethnomathematics, ethnomodelling, modelling.

Initial Considerations

Throughout history, people have explored other cultures and shared knowledge often hidden within their traditions, practices, and customs. This exchange of cultural capital[1] has enriched and equalized all cultures. The Greek foundations of European civilization are themselves

[1]Cultural Capital is the knowledge, experiences, and connections that individuals have had through the course of their lives, which enables them to succeed more than individuals from a less experienced background. It also acts as a social relation within a system of exchange that includes the accumulated cultural knowledge that confers power and status to the individuals who possess it.

founded upon the Egyptian civilization (Powell & Frankenstein, 1997). One consequence of this is a widespread consensus towards the supremacy of Western scientific and logical systems at the exclusion of all other traditions.

In mathematics, as in other academic disciplines, the literature, methods of problem solving, and teaching materials are all based on the traditions of written sciences, and with very few exceptions, by Western academics. Most examples used in the teaching of mathematics are derived from European-based cultures. These same problem-solving methods mainly rely on the European view on mathematics. It goes without saying that culture and society considerably affect the way individuals understand concepts of any mathematical ideas and practices. It means that, this interaction may leave out a significant amount of knowledge in its cultural forms (D'Ambrosio, 1990).

Observing this, D'Ambrosio stated that the "culture of a group results from the fraction of reality that is reachable by the group" (D'Ambrosio, 2006, p. 5). However, the multiplicity of cultures, each one with a system of shared knowledge and a compatible set of behavior and values facilitates cultural dynamics by enabling an expanding familiarity with the rich diversity of humanity. This creates an important need for a field of research that studies the phenomena and applications of modelling in diverse cultural settings.

This kind of cultural perspective can be used in problem solving methods, numerous conceptual categories, structures and models that we use to represent and manipulate data translates as forms of cultural mathematical practices specifically the modelling processes referred to as *ethnomodelling* (Bassanezi, 2002, D'Ambrosio, 1993; D'Ambrosio, 2002; Rosa & Orey, 2006). It also recognizes how the foundations of ethnomodelling differs from the traditional modelling methodologies

Ethnomathematics and Modelling

Historically, models that arise from reality have been the first paths that have provided numerous abstractions of mathematical concepts. Ethnomathematics uses the manipulations of models taken from reality. Modelling as a strategy of mathematical education incorporates the codifications provided by others in place of a formal language of academic mathematics. According to this context, mathematical modelling is a methodology that is closer to an ethnomathematics program (Bassanezi, 2002; D'Ambrosio, 1993; Rosa & Orey, 2003) and it is defined as the intersection between cultural anthropology and institutional mathematics, and utilizes mathematical modelling to interpret, analyze, explain, and solve real world problems (D'Ambrosio, 1993; Rosa, 2000; Rosa & Orey, 2003).

Investigations in modelling have been found to be useful in the translation of ethnomathematical contexts by numerous scholars in Latin America (Bassanezi, 2002; Biembengut, 2000; D'Ambrosio, 1993; Ferreira, 2004; Orey & Rosa, 2007; Rios, 2000; Rosa & Orey, 2003). In order to document and study diverse mathematical practices and ideas found in many traditions, modelling has become an important tool used to describe and solve problems arising from cultural, economic, political, social, environmental contexts and brings with it numerous advantages to the learning of mathematics (Barbosa, 1997; Bassanezi, 2002; Bernardo & Morris, 1994; Biembengut & Hein, 2000; Cross & Moscardini, 1985; Hodgson & Harpster, 1997; Orey, 2000; Rosa, 2000; Rosa & Orey, 2003).

At the same time, outside of the community of ethnomathematics researchers, it is known that many scientists search for mathematical models that translate their deepening understanding of both real-world situations and diverse cultural contexts. This enables them to take social, economic, political, and environmental positions in relationship to the objects of the study (Bassanezi, 2002; D'Ambrosio, 1993; D'Ambrosio, 2002; Rosa & Orey, 2006). Ethnomodelling is a process of elaboration of problems and questions that have grown from a real situation (system). It forms an image, or sense of, an idealized version of *mathema*[2]. This perspective essentially forms a critical analysis for the generation and production of knowledge (creativity), and forms the intellectual process for its production, including the social mechanisms for the institutionalization of knowledge (academics), and its transmission (education). D'Ambrosio (2000) affirmed that "this process is modelling" (p. 142).

In this perspective, by analyzing their role in reality as a whole, this holistic context allows those engaged in the process of modelling to study systems of reality in which there is an equal effort made to create an understand of the components of the system as well as their interrelationships (Bassanezi, 2002, D'Ambrosio, 1993). By having started with a social or reality-based context, the use of modelling as a tool begins with the knowledge of the student by developing their capacity to assess the process of elaborating a mathematical model in its different applications and contexts (D'Ambrosio, 2000). This uses the reality and interests of the students, versus the traditional model of instruction, which makes use of external values and curriculum without context or meaning.

For example, Bassanezi (2002) has characterized this process as "ethno/modelling" (p. 208) and defines ethnomathematics as "the mathematics practiced and elaborated by different cultural groups and involves the mathematical practices that are present in diverse situations in the daily lives of members of these diverse groups" (p. 208). This interpretation is based on D'Ambrosio's (1990) trinomial: *Reality – Individual – Action* (Figure 1).

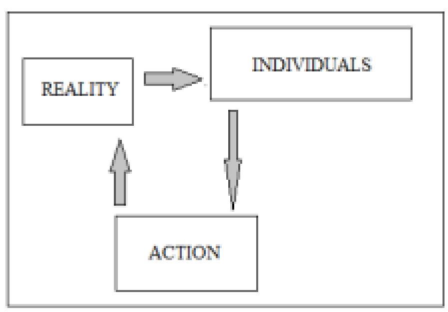

Figure 1: D'Ambrosio's trinomial

For example, D'Ambrosio (2006) affirmed that the "discourse above was about one individual. But there are many other individuals in varied contexts going through a similar

[2]According to D'Ambrosio (1990), mathema may be considered as the actions taken by people from distinct cultural groups to explain and understand the world around them. In other words, they have to manage and cope with their own reality in order to survive and transcend. Throughout the history of mankind, *technés (or tics)* of *mathema* have been developed in very different and diversified cultural environments, that is, in the diverse *ethnos.* Thus, in order to satisfy the drives towards survival and transcendence, human beings have developed and continue to develop, in every new experience and in diverse cultural environments, their own ethnomathematics.

process. For living individuals, the cycle is the same: ... → reality → individual → action → reality → individual → action → ...” (p. 5).

In this context, D’Ambrosio (2006) also states that the “individual agents permanently receive information and process it and perform an action. But although immersed in the same global reality, the mechanisms used to receive information of individual agents are different” (p. 5). In other words, it is crucial to highlight how individuals capture and process information in diverse ways and, consequently, their different actions. Thus, students learn to construct their own connections between both traditional and non-traditional learning settings, it becomes necessary to translate and/or interpret ethnomathematical knowledge into systemized mathematics.

Ethnomodelling

The etymology of the prefix *ethno* traces back to the Greek word *ethnos* relating to a *people*, a *nation* or a *cultural* group in the broadest sense. In the context of ethnomodelling, *ethno* does not refer to any specific race or people only, but also to interesting differences between cultural groups. These differences may include those based on racial oppression or nationality, but are mainly based on language, history, religion, customs, institutions, and on the subjective self-identification of a people. In so doing, *ethno* represents particularity and modelling universality and the combination of the specific and the universal leads to a mathematical activity that takes place within a culture.

The patron goddess of practical knowledge in ancient Greece was *Techné*, whose name forms the base for the words *technique* and *technology*. As well the Greek word for art is *techné* and the Greek word *tikein*, which means to create, is also derived from *techné*. Thus, *techné* is a form of practical knowledge that results in productive action. These mythic modes of knowledge are considered as practical knowledge that results in productive action.

This etymology reveals a deep connection between technology and the practices of living and creating. It represents relationships between humanity and the creation of all forms of technology, and how this might serve as a guide to scientists and educators to develop a moral and cultural standard for the teaching and learning mathematics. This is one of the most important purposes of ethnomodelling. Ethnomodelling binds contemporary views in ethnomathematics. It is an attempt at decolonizing previous ethnomathematics and related research by encouraging the voice of those once studies from the outside. It recognizes the need for a culturally-based view on modelling concepts and processes.

Studying the unique cultural differences in mathematics encourages the development of new perspectives on the scientific questioning methods. Research of culturally bound modelling ideas may address the problem of mathematics education in non-Western societies by bringing the local cultural aspects into mathematical teaching and learning processes (Eglash, 1999). This perspective is needed in mathematics education.

Therefore, ethnomodelling involves ways in which individuals or groups explain and draw on traditional or curricular mathematical ideas in the course of their problem-solving experiences. In so doing, it is important to not to idealize or label them as *correct* or *appropriate* ways of thinking, but rather to highlight the relationship between cultural groups and the deeply embedded mathematics in their daily activities (Rosa & Orey, 2010).

In this context, Rosa and Orey (2013) state that ethnomodelling is a “practical application of ethnomathematics which adds the cultural perspective and voice of the individual to modelling concepts” (p. 78). This cultural perspective broadens views of modeling because it recognizes it as a potential pedagogical bridge for students in their learning of mathematics (Bassanezi, 2002; D’Ambrosio, 2002). Hence, ethnomodelling brings an “inclusion of a diversity of ideas brought by students from other cultural groups can give confidence and dignity to students, while allowing them to see a variety of perspectives and provide a base for learning academic-Western mathematics” (Rosa & Orey, 2013, p. 78).

Ethnomodelling is a tool that responds to its surroundings and is culturally dependent (Bassanezi, 2002; D’Ambrosio, 2002; Rosa & Orey, 2006; Rosa & Orey, 2007). The goal of recognizing ethnomodelling is not to give mathematical ideas and practices of other cultures a Western stamp of approval, but to recognize that they are, and always have been just as valid in the development of mathematics and sciences.

Ethnomodelling studies the ideas of culturally different groups, whether technically advanced. It is necessary to understand how mathematical concepts are born, conceptualized, and adapted into the practices of a society (D’Ambrosio, 1993; Eglash, 1997; Huntington, 1993, Rosa & Orey, 2007). Ethnomodelling does not follow the linear modelling approach that is prevalent in modernity.

Previously, Bassanezi (2002) stated that the ethno/modelling process starts with the social context, reality, and interests of students and not by enforcing a set of external values and decontextualized activities without meaning for the students. This process is defined as the mathematics practiced and elaborated by different cultural groups, which involves the mathematical practices present in diverse situations in the daily lives of diverse group members.

For example, the introduction of the term *mathematization* by D’Ambrosio (1990) set the stage for emerging scholarship in ethnomodelling. This context allowed Rosa and Orey (2006) to state that “mathematization is a process in which individuals from different cultural groups come up with different mathematical tools that help them organize, analyze, comprehend, understand, and solve specific problems located in the context of their real-life situation” (Rosa & Orey 2013, p. 118).

This approach shows that people of different cultures have different views of relations between the nature of spirit and humankind, the individual and the group, the citizen and the state, as well as differing views on the relative importance of rights and responsibilities, liberty and authority, and equality and hierarchy. In addition to these categories, culture is expanded to include also how differing professional groups and age classes function (D’Ambrosio, 1985) as well as social classes and gender.

Culture is defined as the ideations[3], symbols, behaviors, values, knowledge and beliefs that are shared by a community (Banks & Banks, 1993). The essence of a culture is not its

[3]Ideation means to come up with a bright idea that may make a difference to society. A more innovative idea makes a bigger difference in society. Ideation involves both divergent thinking, starting with the known and moving outwards, and convergent thinking, starting with the known and moving inwards. In so doing, ideation is the process of generating innovative ideas and transforming them into valuable outcomes for the well-being of the members of all cultural groups.

artifacts, tools or other tangible cultural elements, but the way the members of the group interpret, use, and perceive them. An artifact may be used in different cultures in very different ways and for very different purposes. Mathematical ideas and practices are good examples of this fact.

Different cultures contribute to the development of mathematical concepts, ideas, and practices, and enrich them in the traditional fields of mathematics. As D'Ambrosio (1997) recognized, the ethnosciences, in this case ethnomathematics; means going back to basics which includes the goals of equity and dignity. Traditional Eurocentric conceptions of science have been imposed globally as the pattern of rational human behavior. Under the control of Western powers, the results of this globalization are far from being acceptable (D'Ambrosio, 1997). The study of ethnomodelling encourages the ethics of respect, solidarity and co-operation across cultures.

Final Considerations

This article outlines ongoing research related to cultural perspectives in mathematical modelling. Contemporary academic mathematics is predominantly Eurocentric and colonial in its spread across the globe. This Eurocentrism facilitates an ongoing divide that has hindered the mathematics coming from non-Western traditions. The motivation towards a cultural approach presents us with an assumption that makes use of cultural perspectives through ethnomathematics and uses mathematical modelling to bring local issues into global discussion, primarily using the voices and perspectives of those who do the math in the context under study.

The authors have suggested a mathematics education that is an active, participatory social product including a dialectic relationship between mathematics and society and is chiefly non-colonial in its approach. Moreover, when presented as a modern or westernized mathematics primarily dominated by the preferences of the West (European-North American), and or done by outsiders imposing their often-unintended bias, it is here that this Eurocentrism poses problems in mathematics education for non-Western cultures.

Ethnomodelling stands for mathematical ideas and practices, which have at its root culture. The immerging study of ethnomodelling is defined as the study of mathematical phenomena within a culture. Ethnomodelling differs from the traditional definition of modelling in that whereas the traditional view considers the foundations of mathematics education as constant and applicable everywhere. The study of ethnomodelling takes the position that mathematics education is a social construction and thus culturally bound, and seriously listens to the voice of those doing the mathematics.

In order to keep up with modern Western developmental models, other cultures have been forced to adapt or perish. Relying primarily on constructivist theories, the authors argue that universal theories of mathematics take different forms in different cultures, and that Western views on the abstract ideas of modelling are culturally bound. Ethnomodelling is considered a powerful tool used in the translation of a problem-situation of mathematical ideas and practices within a culture. These new-found ethnomathematical lenses lead to new findings in the development of an inclusive model of mathematics.

In an increasingly globalized world, educators must find ways in which we can consider accounting the cultural and philosophical background of a society. Ethnomodelling is just one way to do this. Different cultures have different perceptions of time and space, logic, problem solving methods, society, and values and translating this to our westernized paradigm of thinking is often difficult. Learning to listen to, and then come to a mutual understanding and appreciation of these differences enriches the curriculum and increases understanding between peoples.

The adoption of an ethnomodelling perspective in a mathematics curriculum recognizes the importance of and gives voice to local cultures in the development of mathematics. This pedagogical aspect produces student-researchers who are active participants in their own mathematics education as they learn that they themselves can contribute to the development of mathematics.

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