Ethnomodeling: An Ethnomathematical View on Mathematical Modeling

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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 an emerging globalization of business, science, religion, art, music and other aspects of culture (Orey & Rosa, 2007). There is a need to apply a fundamentally different philosophy, modeling techniques, and an ethnomathematical perspective to mathematics curriculum. In this chapter, the authors propose to demonstrate how, as a member of the family of ethnosciences, ethnomodeling is a methodology for teaching and learning of mathematics. Ethnomodeling challenges the prevailing way of thinking. 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 abstract ideas of modeling are culturally bound. In so doing, the study of ethnomodeling 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.

Keywords: Constructivism, Ethnomathematics, Ethnomodeling, Ethnosciences, Multiculturalism.

RESUMO

Um problema relevante que aflige a educação matemática em tempos atuais é o seu alinhamento estrito com modos ocidentais em seus tópicos e paradigmas de pesquisa. Para a busca de novas abordagens e metodologias cabe investigar formas históricas das ideias matemáticas que ocorrem em diferentes contextos culturais, e tendo em conta a globalização, considerar ciência, religião, arte, música e outros aspectos da cultura (Orey & Rosa, 2007). Há necessidade de ruptura com esse estado de coisas, tendo em vista uma filosofia fundamentalmente diferente, dentro de uma perspectiva etnomatemática do currículo. Neste texto, os autores propõem demonstrar como, um integrante da família das etnociências – ethnomodeling – constitui-se numa metodologia de ensino e aprendizagem da matemática. Mostrar-se-á que ela desafia o modo predominante de pensar. A ethnomodeling é considerada uma poderosa ferramenta utilizada na tradução de uma situação-problema, em termos de

ideias e práticas matemáticas, no âmbito de uma dada cultura. Nesse sentido, a proposta tem por finalidade a análise de um modelo inclusivo de educação matemática.

Palavras-chave: construtivismo, etnomatemática, ethnomodeling, etnociência, multiculturalismo

Introduction

Throughout history, people have explored other cultures and shared the knowledge often hidden behind traditions, practices, and customs. This exchange of cultural capital[1] has enriched and equalized all cultures. The Greek foundations of European civilization are themselves founded upon the Egyptian civilization (Powell and 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 many other academic disciplines, literature, methods of problem solving, and teaching materials are all based on the traditions of written sciences, with very few exceptions, by Western academics. Most examples used in the teaching of mathematics derive from non-Latino North American and European cultures. These same problem solving methods mainly rely on the European view on mathematics. It goes with out 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 has said, "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 modeling in diverse cultural settings. This kind of cultural perspective used in the problem solving methods, conceptual categories, structures and models used in representing data, and techniques translates cultural mathematical practices by using modeling processes is referred to as *ethnomodeling* (Bassanezzi, 2002, D'Ambrosio, 1993; Rosa & Orey, 2006). It also recognizes how the foundations of ethnomodeling differs from the traditional modeling methodologies.

In this chapter, the authors share their studies and analysis of ethnomodeling using both a constructivist and a multicultural paradigm.

Ethnomathematics and Modeling

Historically, models that arise from reality have been the first paths that have provided numerous abstractions of mathematical concepts. Ethnomathematics uses the manipulations

[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.

of models taken from reality and modeling as a strategy of mathematical education and incorporates the codifications provided by others in place of a formal language of academic mathematics. Mathematical modeling is a methodology that is closer to an ethnomathematics program (D'Ambrosio, 1993; Bassanezi, 2002; Monteiro, 2004; Rosa & Orey, 2003, 2006, 2007a) and is defined as the intersection between cultural anthropology and institutional mathematics, and utilizes mathematical modeling to interpret, analyze, explain, and solve real world problems (D'Ambrosio, 1993; Rosa, 2000; Rosa & Orey, 2003).
Investigations in modeling 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; Monteiro, 2004; Rios, 2000; Rosa & Orey, 2003, 2007a, 2007b). In order to document and study diverse mathematical practices and ideas found in many traditions, modeling has become an important tool used to describe and solve problems arising from cultural, economical, political, social, environmental contexts and brings with it numerous advantages to the learning of mathematics (Barbosa, 1997; Bassanezzi, 2002; Bernardo & Morris, 1994; Biembengut, 1999; Biembengut & Hein, 2000; Cross & Moscardini, 1985; Hodgson & Harpster, 1997; Orey, 2000; Rosa & Orey, 2003; Rosa, 2000).

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, economical, political, and environmental positions in relationship to the objects of the study (Bassanezzi, 2002; D'Ambrosio, 1993; Rosa & Orey, 2006).

Ethnomodeling is a process of elaboration of problems and questions that grow from a real situation (system), and forms an image or sense of an idealized version of the "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, the social mechanisms of institutionalization of knowledge (academics), and its transmission (education). D'Ambrosio (2000) affirmed that "this process is modeling" (p. 142). In this perspective, by analyzing their role in reality as a whole, this holistic context allows those engaged in the process of modeling 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 modeling 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, 2000a). 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. Bassanezi (2002) characterizes this process as "ethnomodeling" (p. 208), and defines ethnomathematics as "the mathematics practiced and elaborated by different cultural

[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, *technes (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.

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.

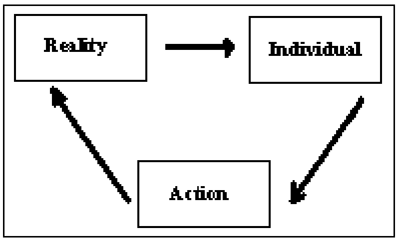

Figure 1:D'Ambrosio's Trinomial

D'Ambrosio (2006) affirmed that "The discourse above was about one individual. But there are many other individuals in reality, from the most varied species, going through a similar process. For living individuals, the cycle is the same: ... → reality → individual → action → reality → individual → action → ..." (p. 5). D'Ambrosio goes on to state that the "individual agents are permanently receiving information and processing it, and performing action. But although immersed in a same global reality, the mechanisms 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 as a consequence, their different actions.

According to this perspective, it is necessary to translate interpretations and contributions of ethnomathematical knowledge into systemized mathematics as students learn to construct their own connections between both traditional and non-traditional learning settings.

Ethnomodeling

The etymology of the prefix *ethno* traces back to the Greek word *ethnos* meaning "people", "nation" or "foreign people". In the context of ethnomodeling, though, *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 modeling universality and the combination of the particular and the universal leads to a mathematical activity that takes place within a culture.

The patron goddess of practical knowledge in ancient Greece was *Techne*, whose name originates from the words *technique* and *technology*. As well the Greek word for art is *techne* and the Greek word *tikein*, which means to create, is also derived from *techne*. *Techne* 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 the relationship between humanity and the creation of all forms of technology, and guides 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 ethnomodeling.

Ethnomodeling binds contemporary views in ethnomathematics. It recognizes the need for a culturally-based view on modeling 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 modeling 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.

Ethnomodeling is a tool that responds to its surroundings and is culturally dependent (D'Ambrosio, 2002; Bassanezzi, 2002; Rosa & Orey, 2006; Rosa & Orey, 2007a). The goal of recognizing ethnomodeling 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. Ethnomodeling studies the ideas of culturally different groups, whether or not technically advanced. It is necessary to understand how mathematical concepts are born, conceptualized, and adapted into the practices of a society (Huntington, 1993, D'Ambrosio, 1993; Eglash, 1997; Rosa & Orey, 2007b). Ethnomodeling does not follow the linear modeling approach, so prevalent in modernity.

People of different cultures have different views of relationships 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 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 ethnomodeling encourages the ethics of respect, solidarity and co-operation across cultures.

[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.

Ethnosciences

In past decades, the concept of *ethnosciences* has evoked worldwide debate and discussion. Most of debate and discussion has been in relation to ethnomathematics, and demonstrates the uncertainty of what is ethnosciences and includes many misconceptions.

The Theory of Ethnosciences

D'Ambrosio (1985) defined ethnosciences as the study of scientific and, technological phenomena in direct relation to social, economic, and cultural backgrounds. D'Ambrosio (1998) also stated that ethnosciences is described in terms of the development of sciences in general. In other words, knowledge is established as systems of explanations and ways of thinking and doing sciences that is accumulated through generations in distinct cultural environments. Bernard (1995) stated that, currently, the ethnosciences have been used by many different disciplines. There are studies in ethnoastronomy, ethnobiology, ethnochemistry, ethnomusicology, ethnogeography, ethnobotany, ethnopedology, ethnoforestry, ethnoveterinary medicine, and ethnoecology.

Ethnosciences teaches a respect for, and interest in how each community have developed their own unique ways, styles, and techniques of doing certain tasks and solving problems. This includes responses to how diverse peoples search, explain, understand, and learn. These are ways of doing and knowing and are called *systems* of knowledge (D'Ambrosio, 1998). They use inference, quantification, comparison, classification, representation, measuring, and modeling. Western sciences and mathematics are systems of knowledge, but other systems of knowledge with the same aims have also developed. As well, the ethnosciences include the study of people's perceptions of their surroundings as reflected in their use of language. It is also an organized examination of thought across cultures, modeled after the principles of linguistics. Ethnosciences may be considered a system that supports the teaching of modeling in different cultural settings. This includes a teaching process that takes into account the cultural origin of students. Both changing attitudes and promoting multicultural competence are equally important goals. These goals are just as important as the development of students´ proficiency in basic skills. In light of these assertions, ethnomodeling is part of ethnosciences because as a knowledge system that emerged and exists as work-based, local, traditional, vernacular, folk, or indigenous knowledge systems, it uses interdisciplinary sciences that link learning in regards to people with the many kinds of learning offered by the physical and social sciences.

Diverse knowledge systems have never come into existence or prospered under conditions of complete isolation. Nor are they static. People have always acquired new knowledge and new ways of learning through interactions across the social, cultural, and physical boundaries that exist in any cultural group or society. However, there are no absolute boundaries, since even those who are trained in the sciences of modern society, still have their own vernacular traditions of creation, accumulation, transmission, and diffusion of the knowledge. After 500 years of colonization and globalization of information, where thousands of scientists have been trained in Europe and North America and returned to their homelands (former colonies), a new sense of what is mathematics and science is emerging. Ethnomodeling is part of this new paradigm of sciences.

Constructivism

The sociology of knowledge and the theory of the social construction of reality, and its view in relation to how language and culture develop have shaped diverse ways in which people communicate, understand their world, and comprehend information. Schwandt (1994) offers an explanation as to how constructivism teaches how people learn to understand the world of meaning, and how people interpret their own reality in diverse ways. He affirmed that constructivists see that an inquirer must elucidate the process of meaning construction, often on their own terms and most certainly with in their own context first. Moreover, the inquirer has to clarify what meanings are embodied in language and actions of social actors, and how they are embodied.

According to Schwandt (1994), knowledge and truth are created, not just discovered by the mind. Simply put, learners actually create their own knowledge. The constructivist paradigm is a pluralistic one, that is, reality is expressible with a variety of symbol and language systems. It is also plastic in the sense that reality is stretched and shaped to fit purposeful acts of intentional human agents (Schwandt, 1994). The constructivist paradigm asserts that reality is manifested in different forms.

Schwandt (1994) argued that people may be using a constructivist approach if their minds are active in the construction of knowledge. Most people would agree that knowing is not a passive process because it is not a simple imprinting, or banking of sensory data. Knowing, therefore, is an active process in which minds work with impressions in order to abstract and conceptualize new forms of knowledge and experiences. Constructivism means that people find or discover knowledge as they construct or make it because they invent concepts, models, and schemes to make sense of their own experiences and, further, they continually test and modify these constructions in the light of the acquisition of new experiences. Palincsar (1998) stated that all cognitive science theories entail some form of constructivism to the extent that cognitive structures are typically viewed as individually constructed in the process of interpreting experiences in particular contexts.

In constructivist theory, knowledge is not simply transferred from one individual to another. Since knowledge is constructed, learners' previous experiences are built upon. Learning is therefore an adaptive and experiential process rather than transference of knowledge (Candy, 1991). In the perspective of using ethnomodeling, teaching is much more than the transference of knowledge because teaching becomes an activity that introduces the creation of knowledge (Freire, 1998). This approach in mathematics education is the antithesis of turning students into containers to be filled with information (Freire, 1970).

As learners encounter new situations, they look for similarities and differences between their own cognitive schemes. Contrasts such as these, are also called cognitive perturbations, and form the end-product of conflictive knowledge waiting to be resolved through reorganizing schemes of knowledge (Phillip, 1995).

In constructivist terms, learning depends on the way learners are guided to look at a particular situation and respects an individuals' autonomy by allowing them to draw upon their own conclusions (Biggs & Moore, 1993). Constructivism therefore gives recognition and values instructional strategies in which students are able to learn mathematics by personally and socially constructing their knowledge. Constructivist learning in mathematics includes methodologies such as self-reflective oriented learning activities such as exploratory and generative learning strategies such as ethnomodeling.

Sociology of Knowledge

Denzin and Lincoln (1994) stated that social constructivists turn their attention outward to the world of inter-subjectively shared social constructions of meaning and knowledge. They are interested in language and other social processes that generate meaning and knowledge. Berger and Luckmann (1966) introduced the problem of sociology of knowledge with allegories to average individuals in the street, philosophers, and sociologists. They stated that average individuals are not troubled about their own knowledge. What is real to them is real because they have taken their reality and knowledge for granted. Individuals might think that they posses freedom of will. On the other hand, philosophers are professionally obligated not to take anything for granted, and to obtain maximal clarity as to the ultimate status of what individuals in the street believe to be reality or knowledge. However, the sociologist had to ask whether the difference between the two realities of the common individuals and the philosopher may not be understood in relation to various differences between their two societies. Hence, the sociologist will need to ask how it is that the notion of freedom has come to be taken for granted in one society and not in another, how the reality of this notion is maintained in the one society and how, even more interestingly, this reality may once again be lost to an individual or to an entire collectivity.

The sociology of knowledge must deal with both empirical varieties of knowledge in human societies, and the processes through which any body of knowledge comes to be socially established as reality (Berger and Luckmann, 1966). The most central processes in Berger and Luckmann's view on the social construction of reality are externalization, objectivation, and internalization. In externalization, active individuals create the society with their own contribution. Objectivation is the process where the order of everyday life comes to be understood as ever-existing. The most important elements of objectivation are comprehension and the attachment of linguistic meaning. Thus, internalization or socialization is the process in which individuals adopt their social reality, as objective.

Reification is the process in which internalized human productions are understood as if they were something other than the human product. Externalization occurs in the processes where people are confronted with a new social situation and where they establish a personal relationship with the situation. In this perspective, Berger and Luckmann (1966) stated that externalized experiences are an anthropological necessity; human beings must ongoingly externalize themselves in meaningful activities.

The authors of this chapter believe that externalization and objectivation are moments in the continuing dialectical process that happens in social interactions because the externalized experiences attain the character of objectivity through the objectivation process. The internalization process fixates the objectivated social world into consciousness in the course of socialization. Within this context, society and the social reality as a whole can be seen as a dialect between the objective and the subjective, where people continuously recreate reality through their work and actions. For example, mathematical concepts and practices seem to be developed outside of school settings without specific academic instructions. This means that concepts, procedures, and practices may appear to arise through individuals' social interactions in everyday activities such as commerce and production of goods. Based on research with Brazilian vendors and American adults, Lave (1988) concluded that "mathematics used outside is a process of modeling rather a mere process of manipulation of numbers" (p.30). In the dialogue between society and social reality ethnomathematics plays an important role.

The Role of Social Constructivism in Educational Psychology

Events people take to be as experiences of the world do not dictate the terms by which they understand the world (Gergen, 1985). People's relations with the world do not always correspond to the actual world (Guerin, 1992). There are many cases where objective criteria for identifying behaviors, events, or entities are shown to be highly circumscribed by culture, history, and social context. The terms in which the world is understood are social artifacts, products of the historically situated interchanges among people (Gergen, 1985). In other words, the terms and concepts people use to understand and explain the world around them are also defined as social products (Guerin, 1992).

Conceptions of psychological processes differ markedly from one culture to another because they all consider the social origins that take for granted assumptions about the mind. The degree to which a given form of understanding prevails or is sustained across time is not fundamentally dependent on the empirical validity of the perspective in question, but on the vicissitudes of social processes such as communication, negotiation, conflict, and rhetoric. That is, whether knowledge is maintained or not may depend as much on social exchanges as on the nonsocial environment (Guerin, 1992).

Placing this idea in the context of social interaction, Gergen (1985) stated that because a social relationship changes, people's interpretations of phenomena also change, the rules for "what counts as what" are inherently ambiguous and continuously evolve. Diverse forms of negotiated understanding are of critical significance in social life, as they are integrally connected with many other activities in which people engage (Gergen, 1985). In other words, knowledge because it is constructed socially, cannot be separated from social life.

On the other hand, Chen (2002) argued that the constructivist perspective in education is based on cognitive constructivism and social constructivism. The cognitive constructivism is based on the theory of Jean Piaget, which is composed by "ages and stages" that predicts what children can and cannot understand at different ages, and a theory of development that describes how children develop cognitive abilities. Chen (2002) stated that Vygotsky shared many of Piaget's assumptions of how children learn, but he placed much more emphasis on the social context of learning. Vygotsky theorized how both teachers and more experienced students play very important roles in learning. According to Chen (2002), these two perspectives have some points in common, but she argued that Vygotsky's theory has much more room for an active and involved teacher.

Vygotsky (1986) affirmed that culture gives the student the cognitive tools needed for development. Psychological tools that mediate people's thoughts; feelings, behavior, and language are the most important ones because culture provides basic orientations that structure the behavioral environment of the people. This means that it is through language and culture that people construct, define, shape, and experience their own realities.

It is crucial to distinguish between scientific and spontaneous concepts. Scientific concepts are gained through systematically organized learning in an educational setting, whereas spontaneous concepts emerge from people's own reflections on everyday experience.

Scientific concepts, far from being assimilated in a ready-made form, actually undergo substantial development, which essentially depends on the existing level of a person's general ability to comprehend (Vygotsky, 1986). Spontaneous concepts are drawn up to the level of conscious application of abstract thinking; abstract concepts bearing the experience of society come down and make a connection with experience and begin to become natural (D'Ambrosio, 1990; Vygotsky, 1986).

Moreover, Daniels (1996) stated that everyday or spontaneous concepts are seen to bring the embedded richness and detailed patterns of signification of everyday thinking into the system and organized structure of scientific knowledge. According to Tharp & Gallimore (1992), even though Vygotsky's theory is about children's learning, his concepts are also applicable to adult learning because they merge with everyday referents and scientific concepts come to life in order to find a broad range of application. They claimed that in a neo-Vygotskian instructional approach, it is necessary to ensure that an interface (intersection) between the scientific concepts and spontaneous concepts is provided. It is on that interface that people achieve the highest order of meaning. And it is this very intersection that is of most value and interest to ethnomathematicians.

In accordance to Vygotsky (1978) learning does equate to development because properly organized learning results in mental development and sets in motion a variety of developmental processes that would be impossible apart from learning. Learning is a necessary and universal aspect of the process of developing culturally organized, specifically human, psychological functions, and awakens a variety of internal developmental processes that are able to operate only when individuals are interacting with other individuals in their environment in cooperative fashion (D'Ambrosio, 1990).

From the social constructivist perspective, separating individuals from social influence is not regarded as possible (Palincsar, 1998). The sociocultural contexts in which teaching and learning occur are considered critical to learning itself, and learning is viewed as culturally and contextually specific. Furthermore, cognition is not analyzed as separate from social, motivational, emotional, and identity processes, and the study of generalization is study of processes rather than study of personal or situational attributes.

What unifies different postmodern constructivist perspectives is the rejection of the view that the locus of knowledge is in the individual. Postmodern constructivist learning and understanding is regarded as socially inherent. Language, cultural activities, and tools that range from symbol systems to artifacts are regarded as integral to students' conceptual development (Palincsar, 1998). Fully developed constructivism may also furnish a means for understanding the process of sciences (Gergen, 1985). This fact strongly supports the idea of culturally sensitive learning connected with ethnomodeling.

Social Construction of Science

Science was once popularly thought to be some sort of an extreme or highly elite form of knowledge. Only a small fraction of people are able to understand or express their thoughts in a theoretical and scientific form while most of people are not able to understand the language of sciences itself.

However, Berger and Luckmann (1966) stated that the sociology of knowledge must concern itself with everything that passes for knowledge in society, and specified that ideas and theoretical thoughts are not that important in society. In their view, common-sense knowledge rather than ideas must be the central focus for sociology of knowledge. In accordance to this perspective, it is important to emphasize the importance of understanding the social construction of the theoretical format of scientific representation and analyze how this understanding has been shaped by a very limited segment of society.

Fish (1989) claimed that reality is the result of the social processes accepted as normal in a specific context. Knowledge claims are intelligible and debatable only within a particular context or community. According to Eglash (1997) the process of pushing the location of scientific thought towards a local culture, which is, holding that both failure and success in sciences are results of social construction of knowledge, is also called cultural construction. This may lead to a claim that people are capable of producing science that they then experience as something other than human product, which is accordance to Berger and Luckmann’s notion of objectivation and internalization processes.

Since most knowledge derives from experiences (Berger & Luckmann, 1966), one of the challenges of ethnomodeling is to translate this subjective, culturally bound, and usually hidden knowledge into mathematical modeling concepts. Some reasons why the current theory of pure modeling has become dominant are that the Western modeling is profoundly intertwined with modern academic mathematics. However, this fact should not be used to justify the supremacy of a Western view on mathematical modeling over other possible views because it only shows that a product of Western culture works well in a Western culture.

On the other hand, Carey (1989) stated that the resistance towards a cultural perspective of sciences derives from the "ever-present desire to maintain a distinction between hard science and soft scholarship" (p. 99). Sciences such as physics, chemistry, and economics are often seen as the crowning achievements of Western civilization, and in their practices it is assumed that truth may transcend opinion and personal bias.

Code (1991) affirmed that objectivity is commonly regarded as a defining feature of knowledge. The construction of knowledge is seen as an inter-subjective process, a dialectic relationship between the individual and society, as well as a dialogue between mathematics education and society. In other words, society is to some extent shaped by changes in mathematics education, which arises from society.

Multiculturalism

Safran (1994) studied the situation of cultural minorities within a dominant culture. Banks (1999) used the term *ethnically fair* in multicultural education settings. The authors use the term “ethnically fair” to mean something that is equally available to everybody regardless of race, gender, sexual orientation, language, religion, and cultural background.

A solid multiculturalist approach in mathematics and sciences education has both societal and scientific benefits. First, it meets a social demand, guaranteeing every student an equal chance to excellence and second, different approaches to scientific problems may also bring along novelties in science in form of new approaches to scientific problems. For example, McCarthy (1998) criticized the standard school curriculum in the United States for its Eurocentrism and Western bias. He also stressed that there is an urgent need to rethink the current privileges of Eurocentric ideas in a contemporary school curriculum as well as in overall scientific research.

Nieto (1992) also noted that one of the hindrances in multicultural education in the United States, as well as in many European countries, is that education has currently been canonized. The canon assumes that the most worthy knowledge is already in place in the curriculum. Banks (1999) explained canon as a standardized criterion used to define, select, and evaluate knowledge in the school curriculum within a nation. The problems with canonization in studies is that it is danger of creating a narrow-minded view on a subject, and a discontinuity between what students experience at home and what they experience at school (Rosa & Orey, 2007).
For example, Ladson-Billings (1995) pointed out that sociolinguistics have suggested that if a students' home language is incorporated into the classroom, they are more likely to experience academic success. Torres (1998) mentioned that the proponents of liberal multiculturalism argued that it increases fairness by representing the range and richness of different ethnicities. In addition, liberal multiculturalism increases tolerance by exposing students to multiple perspectives in the meaning of history.

Relying on the social constructivist theories in education, effective teaching also depends on how familiar the concepts are to the students and that how concepts are taught shapes the way the information is understood. According to Banks (1993a, 1999), this is named as the knowledge construction process, which is described as the procedures by which social, behavioral, and natural scientists create knowledge and how the implicit cultural assumptions, frames of references, perspectives and biases within a discipline influence the way knowledge is constructed within the discipline.

Multicultural education needs to be more broadly understood so that teachers from a wide range of disciplines may respond to it in appropriate ways and so that resistance to it may be minimized (Banks, 1993b). In another study, Banks (1993c) stated that a mainstream-centric curriculum is a major way in which racism and ethnocentrism are reinforced and perpetuated in schools and in then in society at large. In addition, it has negative consequences also for mainstream students, since it reinforces a false sense of superiority, giving them a misleading conception of their relationship with other racial and ethnic groups, and denying them the opportunity to benefit from the knowledge, perspectives, and frames of reference that may be gained from studying and experiencing other cultures and cultural groups.

A systematic study of ethnomodeling aims at developing skills to observe mathematical phenomena whose roots are in a distinct cultural setting. The results may then lead to new viewpoints into mathematics education, and may be used to improve cultural sensitivity in teaching mathematics.

New viewpoints greatly benefit Western science by promoting the competence of different social groups with different cultures and by creating ethnically fair sciences (D'Ambrosio, 1995). However, one major problem with this perspective is that almost all teaching material, problem solving methods and concepts are dominantly Eurocentric-Western in content. In her study, Fasheh (1982) noticed that these materials are nonsensical to non-Western students. This may cause problems for non-Western students who need to start with learning a whole new philosophy when studying mathematics.

For example, the non-western student needs to learn a whole new way of thinking, whereas a western student is already familiar with the logic system that underlies the school mathematics curriculum. As an antidote to this mechanistic view of schooling, Miller (2000) presented an attempt to rebuild society's educational system on a postmodern cultural foundation, which is democratic and student-centered rather than mechanical. He argued that the learning environment cannot be constrained by textbook and curricula established by anonymous bureaucrats. He also stated that teaching cannot be narrowed to be the service of standards that elite commissions impose on all learners.

On the other hand, Ellis (2000) emphasized that in learning communities, there are two aspects that need to be considered in respect to the term community. One is that in which learners get from the community; the other is that in which learners give to the community. In other words, this refers to dialectic composition. It is imperative to incorporate cultural knowledge and the idea of a dialectic composition, and continuous change into the teaching and learning mathematics. Because it arises from culture and adapts to the changes in culture, ethnomodeling is an active force of dialectic composition in the process of teaching and learning mathematics.

Final Considerations

This chapter sought to outline ongoing research related to cultural perspectives in mathematical modeling. Contemporary academic mathematics is predominantly Eurocentric. 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 accompanied assumption that makes use of cultural perspectives through ethnomathematics and uses mathematical modeling to bring local issues into global discussion.

A new social constructivist theory in mathematical modeling was proposed here. The authors have suggested a mathematics education that is an active, participatory social product including a dialectic relationship between mathematics and society. This claim is supported by social constructivist theories in sociology and educational psychology. Moreover, the authors have presented a modern or westernized mathematics as primarily dominated by the preferences of the West (European-North American), and that this Eurocentrism poses many problems in mathematics education in non-Western cultures.

Ethnomodeling stands for mathematical ideas and practices, which have its roots within a culture. The study of ethnomodeling is defined as the study of mathematical phenomena within a culture. Ethnomodeling differs from the traditional definition of modeling in that whereas the traditional view considers the foundations of mathematics education as constant and applicable everywhere. The study of ethnomodeling takes the position that mathematics education is a social construction and thus culturally bound.

In an increasingly globalized world, educators must take into account the cultural and philosophical background of a society. Different cultures have different perceptions of time and space, logic, problem solving methods, society, and values. Learning to understand and appreciate these differences enriches the curriculum and increases understanding between peoples. The adoption of an ethnomodeling perspective in a mathematics curriculum recognizes the importance of local cultures to 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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