CULTURAL ASSERTIONS AND CHALLENGES TOWARDS PEDAGOGICAL ACTION OF AN ETHNOMATHEMATICS PROGRAM

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We are two mathematics educators who work together doing research in *ethnomathematics and mathematical modeling* in Brazil and in the United States. One of us is from São Paulo state in Brazil and the other one is from California in the US We will use our different particular backgrounds to highlight distinctions that could be seen more generally This discussion is limited by our personal experiences – we make no apology for the assertions to which our experiences have led us.

We begin with a joint assumption, however, that those who study and use mathematics academically operate from a unique paradigm. That is, as mathematicians, we see the world from a certain point of view, and, most importantly, we operate from within a certain cultural perspective.

Modern western academic mathematics, the 'scientific way of thinking', has come to represent a grammar and language that originated when people began to work with *quantity*, *measure*, *shape*, and *modeling* in the Mediterranean Like many of the other cultural vehicles that have come to dominate the planet, the western mathematical way of thinking spread and grew along with these civilizations.

At the same time, this particular form of mathematics also came into contact with other ways of thinking and interpreting the world. The conquest and domination of the planet, along with and through the use of modern mathematics by European-North American colonizers, was not without its consequences. Arrogance coupled with a not so subtle sense of entitlement and a scientific cultural hegemony has spread faster than it has sought to understand or come to terms with the thousands of traditions and time honored forms of thinking, calculating, and problem solving. D'Ambrosio (2006) stated that as individuals become integrated into humankind as a whole, it is hoped that the respect for diversity will not be replaced by arrogance, envy, prepotency and great power and, as a result of this, people will be able to contribute to the preservation of a common inheritance.

Many people (including ourselves) have been attracted to western-academic mathematics for its elegant, yet powerful, sense of logic and form, as well as its scientific, cultural, and artistic qualities It goes without saying that the mathematics of the 21st century has allowed impressive scientific achievements to emerge in all parts of the planet, yet this came with incalculable costs to millions of people, their cultures and civilizations as European-North American ideas, morality, and science have come to dominate, control, and capture our imagination It has, as well, enabled some of the most horrific, social, scientific, ecological and cultural disasters in the history of the planet. The *Ethnomathematics Program* considers a concept of mathematics which includes a critical, moral, holistic, and global perspective.

D'Ambrosio's approach to ethnomathematics

We have chosen D'Ambrosio's approach to ethnomathematics as the philosophical basis for our work in ethnomathematics and school mathematics. However, other researchers and educators have used a diversity of approaches to demonstrate the dualistic concepts between both approaches in mathematics education. According to Gerdes (1997),

> [i]n this context, various concepts have been proposed to contrast with the "academic mathematics" / "school mathematics" (*i.e.*, the school mathematics of the transplanted, imported curriculum). (p. 337)

These concepts were *indigenous mathematics* (Gay and Cole; Lancy); *sociomathematics* (Zaslavsky); *informal mathematics* (Posner); *spontaneous mathematics* (D'Ambrosio); *oral mathematics* (Carraher, Carraher and Schliemann); *oppressed mathematics* (Gerdes); *hidden* or *frozen mathematics* (Gerdes); *folk mathematics* (Mellin-Olsen); *non-standard mathematics* (Carraher *et al.*; Gerdes; Harris); and *mathematics codified in know-how* (Ferreira) as cited in Gerdes (1997). In his study, Gerdes (1997) also stated that these

> concepts have been gradually united under the more general "common denominator" of D'Ambrosio's ethnomathematics (p 339)

In this context, we feel that D'Ambrosio's (1993) approach is broader in concepts, ideas, and objectives, as it considers mathematical modeling as a methodology that may be used as a tool in the ethnomathematics program We also consider this perspective to be a new trend for the pedagogical actions

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of the ethnomathematics program for its agenda for the 21st century.

Ethnomathematics

Ethnomathematics is the application of mathematical ideas and practices to problems that confronted people in the past or are encountered in present contemporary culture (D'Ambrosio, 2006) Much of what we call *modern* mathematics came about as diverse cultural groups sought to resolve unique problems such as exploration, colonization, communications, and construction of railroads, census data, space travel, and other problem-solving techniques that arose from specific communities. More than ten years ago, the National Academy of Sciences (1994) reported that cultural variables have strongly influenced how students consider themselves as human beings, how they came to understand the world, and interpret their own and others' experiences Simply put, culture affects the ways we acquire and use our own mathematical knowledge.

In attempting to create and integrate mathematical materials related to different cultures that draw on students' own experiences in an instructional mathematics curriculum, we believe that it is possible to apply multicultural or ethnomathematical strategies in teaching and learning mathematics. According to the report on the activities of Working Group 10 at ICME-7 in Canada, the president of the Subgroup 1, Preston (1992) stated that these strategies include, but are not limited to:

> [an] aspect of multicultural mathematics [being] the historical development of mathematics in different cultures (e g. the Mayan numeration system). Another aspect could be prominent people in different cultures that use mathematics (e.g an African-American biologist, an Asian-American athlete). Mathematical applications can be made in cultural contexts (e.g. using fractions in food recipes from different cultures). Social issues can be addressed via mathematics applications (e.g use statistics to analyze demographic data.) Multicultural mathematics materials can be integrated into the regular instructional program, and personalized activities can be done that are related to different cultures and draw on students own experiences. (p. 3)

Seen in the above context, Gilmer (1990) stated that "[ ] there is an urgent need to multiculturalize the mathematics curriculum" (p. 4). A growing body of literature on ethnomathematics has been stimulated by concerns for equity, equality, and excellence in a context of diversity. Many teachers worldwide have come to realize that students become motivated when they are involved in their own learning. This is especially true when dealing directly with issues of greatest concern to themselves (Freire, 1986).

The challenge that many societies face today is to determine how to shape a modernized, national culture integrating selected aspects of traditional culture that coexist in an often delicate balance with those of westernized globalization. An increased cultural, ethnic, and racial diversity provides both an opportunity and challenge to societies and institutions, with many questions related to schooling forming an integral part of this challenge.

Ethnomathematics as a program

The inclusion of moral consequences to mathematical-scientific thinking, mathematical ideas and experiences from different cultures around the world, the acknowledgment of contributions that individuals from diverse cultural groups make to mathematical understanding, the recognition and identification of diverse practices of a mathematical nature in varied cultural procedural contexts, and the link between academic mathematics and student experiences could become a central aspect to a complete study of mathematics This is one of the most important objectives of an ethnomathematics perspective in mathematics curriculum development. Within this context, D'Ambrosio (1990) describes ethnomathematics as:

> The prefix *ethno* is today accepted as a very broad term that refers to the social-cultural context, and therefore includes language, jargon, and codes of behavior, myths, and symbols The derivation of *mathema* is difficult, but tends to mean to explain, to know, to understand, and to do activities such as ciphering, measuring, classifying, ordering, inferring, and modeling. The suffix *tics* is derived from *techne*, and has the same root as art and technique. (p. 81)

In this case, *ethno* refers to groups that are identified by cultural traditions, codes, symbols, myths and specific ways used to reason and to infer Mathematics is therefore more than *counting*, *measuring*, *classifying*, *inferring*, and *modeling*. Ethnomathematics forms the intersection set between cultural anthropology and institutional mathematics and utilizes mathematical modeling to solve real-world problems, and translate them into modern mathematical language systems. According to Eglash (1997), mathematical modeling is a tool, which provides a translation from indigenous knowledge systems to academic mathematics

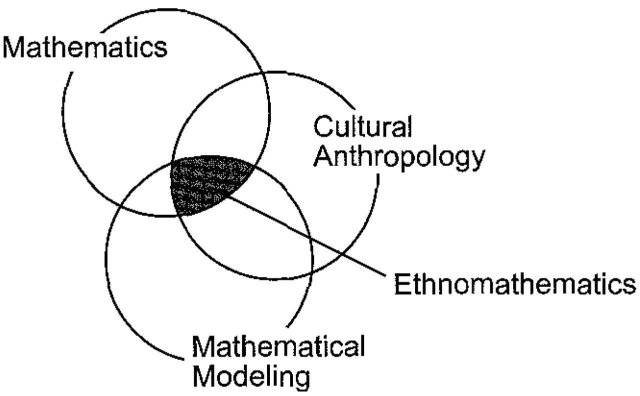

Figure 1: Ethnomathematics as an intersection of three disciplines.

An essential aspect of the program includes an ongoing critical analysis of the generation and production of mathematical knowledge and the intellectual processes of this production (D'Ambrosio, 1993; Rosa, 2000) This process also includes the social mechanisms of the institutionalization of knowledge (academics), and its transmission (education).

A general assertion

Ethnomathematics is a contemporary global pedagogical trend in education. This approach has allowed a number of mathematicians and educators to criticize (Greene, 2000; Ravitch, 2005) ethnomathematics and express fears that this trend may represent a pulling away from certain cultural norms, even though some social realities underlie the need for many multicultural efforts to reform curricula.

The world's economy is globalized; yet, formal mathematics curricula neglect, indeed often reject, the contributions made by the world's non-dominant cultures. Given these conditions, an ethnomathematical perspective in the curriculum may be seen as giving new, and expanded, often extremely complicated definitions of a given society's unique scientific contributions. This context allows school mathematics to be seen "as the process of inducting young people into mathematical aspects of their culture" (Gilmer, 1990, p. 4).

Ethnomathematics can reshape our greater cultural identity in a positive way by requiring the inclusion of a greater representation of the true mathematical practices and problems of a student's own community (D'Ambrosio, 2006; Zaslavsky, 1996). It helps both educators and students alike to understand the universality of mathematics, in the context of mathematical practices of day-to-day life, preliterate cultures, professional practitioners, workers, and academic or school mathematics. It can do this by taking into account the historical evolution, and the recognition of natural, social and cultural factors that shape human development (D'Ambrosio, 2006).

A brief summary of assertions

There are numerous favorable arguments related to the implementation of ethnomathematics as a program towards pedagogical action. It is possible to summarize these arguments in the following categories:

Education

The *Ethnomathematics Program* promotes the rights of all people, no matter their sexual orientation, gender, ethnicity, race, and socio-economic status. It does this in order to allow learners to understand the issues and problems of all the members of our increasingly globalized society (D'Ambrosio, 1990; Fasheh, 1982). The students will learn to make contributions and learn to appreciate the achievements of their own and other cultures (D'Ambrosio, 1990; Joseph, 1991).

Mathematics

The *Ethnomathematics Program* deals with both the *content* and the *process* of curriculum, classroom management, teacher expectations, professional development, and relationships among teachers, administrators, students, and the community (Borba, 1990; D'Ambrosio, 1985, 1990). This approach allows students to make connections with historical developments of mathematics ideas, practices, and the contributions made by diverse cultural groups and individuals

Ethnomathematics possesses important characteristics of being able to help develop the concept of mathematics. In other words, ethnomathematics may be seen as a transformational endeavor because it transforms what mathematics really is. Thus, a possible purpose of the analysis of an ethnomathematical perspective as an addition to the school curriculum could be tracing the developments or transformations of mathematical ideas and practices throughout history.

Ethnomathematics also develops the study of mathematical ideas and practices of socio-cultural groups, but how this is realized in the classroom is still problematic because much of ethnomathematical research and investigations identify ethnomathematical forms of mathematics but do not continue to develop the pedagogical actions for this program. Classroom research about ethnomathematics and its role is a crucial aspect of this perspective because this program should be implemented in classrooms (D'Ambrosio, 1993).

Ethnomathematics emphasizes the communal and tends to connect mathematics with its contexts. If these two components are to be brought together, then ethnomathematics may be conceived as an overarching aspect of the curriculum because mathematics may be humanized, that is, ethnomathematics may be viewed as a philosophical, contextual, affective, and attitudinal approach to the curriculum

From a perspective of using mathematical modeling towards pedagogical action for the ethnomathematics program, 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, 1986). Bassanezi (2002) characterizes this process as "ethnomodeling" (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)

Students

Students need to develop skills in critical thinking and analysis that can best be applied to all areas of life. These skills include vital issues involving health, environment, race, gender, and socioeconomic class (D'Ambrosio, 1990; Freire, 1970). Bassanezi (1994), Borba (1990) and D'Ambrosio (2006) agree that ongoing contact of students with diverse and different ways of thinking and practicing mathematics, will raise interest in learning the necessary and required content, by having students apply mathematical concepts to future professional contexts and by facilitating student performance.

In an *Ethnomathematics Program*, students develop abilities, increased creativity, and a sound set of research habits, as they learn the required mathematics. They develop the capacity to create a hypothesis (Bassanezi, 1994; Biembengut, 1999; D'Ambrosio, 1993). Ethnomathematics contributes to the development of student capacity by selecting data and the subsequent adaptation to their needs (Biembengut, 1999; Hodgson, 1995), by encouraging contact with biology, chemistry, physics, geography, history, and language (Bassanezi, 1994; Zaslavsky, 1993) and by developing work in groups, sharing tasks, learning how to appreciate both criticism and alternate opinions, respecting the decisions of others and of the group. By facilitating student interactions in a globalized society, students share global and interactive visions necessary to develop successful mathematical content (D'Ambrosio, 1993; Bassanezi, 1994; Freire, 1986; Gerdes, 1988a, 1988b). In our opinion, a major objective of ethnomathematics as a program can be to raise student self-confidence, to enhance creativity, and to promote cultural dignity (D'Ambrosio, 1990; Rosa, 2000). These factors are essential for students to learn all school subjects

Teachers and educators

As societies become increasingly urbanized, diverse and globalized, the application of an ethnomathematical perspective in the curriculum encourages further and ongoing intellectual and professional development of teachers. It also encourages long-term learning through a diversity of experiences. Teachers are characterized as facilitators, advisers, and mediators of the mathematics learning process. Bassanezi (1994), Biembengut, (1999), Hodgson, (1995), Orey (2000) and Rosa [1] have all shown that teachers and students can discover a process of understanding mathematics together if given proper support and encouragement. This alternative allows students to learn mathematics content through varied experiences that are related to the cultural, historical, and scientific evolution of mathematics.

School mathematics

Ethnomathematics turns perceived conceptual poverty into conceptual richness. This process can go wrong, for example when non-Western knowledge systems are idealized, or when educational processes trap students in old ways of thinking. However, the process is likely to be positive provided that ethnomathematics:

- looks forward, not backwards; that is, ethnomathematics as an expression of contemporary thought
- is not just a recording of historical ideas and practices
- assumes a sophisticated knowledge system because it is not just mathematical skills and drills.

When a mathematical system is actively used as a system based on theory that can solve real problems, this can be described as modeling. In such modeling activity, both conventional mathematics and the mathematical system of the cultural group are used. The point of this activity, as ethnomathematics, is not just to solve problems, nor just so that people understand alternative mathematical systems, but also it is so that people understand more about the role that mathematics plays in a societal context (Orey, 2000). There can be a better understanding of mathematical systems through the use of mathematical modeling.

According to D'Ambrosio (1993), mathematical modeling is a process of translation and elaboration of problems and questions growing from any real situation (system), which forms an image or sense of an idealized version of the system. By analyzing their role in the contextual reality as a whole, this holistic context allows those engaged in the modeling process to study the systems of reality in which there is an equal effort made by them to create an understanding of all components of the system as well as the interrelationships among them (D'Ambrosio, 2006).

In 2002, D'Ambrosio commented about an ethnomathematical example that naturally comes across as having a mathematical modeling methodology. For example, a group of Brazilian teachers (1989-1990) studied the cultivation of vines brought to Southern Brazil by Italian immigrants in the early twentieth century. They chose to investigate this theme because, in their opinion, the problem to be analyzed should be linked with the culture of the people in that region. Both Bassanezi (2002) and D'Ambrosio (2002) have cited this is an excellent example of the connection between ethnomathematics and modeling.

Teachers started their project by interviewing wine producers, doing ethnographical and historical research about their theme. One of the producers made wine and also was involved in the building of their own barrels. The barrel used to store the wine formed a truncated cone. The teachers realized that the process used by the producer to find the volume of the barrel was different from the process used in academic mathematics, but worked perfectly well, and had been used for centuries in Italy. The producer's process was based on techniques that were learned from his father and transmitted to the members of his family, by his ancestors, through generations long before arriving in Brazil. The teachers in this study used mathematical modeling techniques (academic mathematics) to model the process used by the producer (ethnomathematical practice).

Through modeling (Rosa, 2000; Rosa and Orey, 2003), it is possible to mix school mathematics and ethnomathematics. Hence, students practice academic mathematics while learning to model situations that are generated by ethnomathematics (D'Ambrosio, 1993). This is especially true when they are encouraged to solve problems that are related to their own communities. Mathematical modeling acts as a bridge between ethnomathematics and Western-academic mathematics, which will be required for the student's success in today's globalized technological society.

A general challenge

The traditional mathematics curriculum may not allow implementation by ethnomathematical perspectives. This challenge depends on how ethnomathematical aspects are selected from student experiences or from their own environment and community, because, as a paradigm, it is culturally rooted, and often there is no traditional *syllabus* or *assessment* standards. The selection of mathematical content is dependent on situations that are interesting to students themselves because motivation and creativity are key components in the teaching and learning process in mathematics. In this curriculum model, teachers must learn to be both flexible and knowledgeable in the content because they are the ones who select cases that are related to student cultural background and their environment

Seen in this context, part of the challenge is to adopt a methodology that deals with ethnomathematical perspectives in the mathematics curriculum. It is feasible to believe that a methodology that is adequate to this perspective is the use of mathematical modeling strategies. The selection of mathematical content can be directed to cover specific topics, standards or benchmarks in required mathematics content. However, many teachers are not trusted or allowed to work away from required texts and curriculum, nor are they sufficiently prepared or supported to be able to connect mathematical modeling and ethnomathematics, limiting the possibility for an ethnomathematical perspective to enter into classrooms

To work with this perspective it is necessary that a school and community have an open curriculum whereby the mathematics content that must be covered depends on the development of the class and how students become motivated. In this context, mathematical modeling becomes a methodology intrinsic to the *Ethnomathematics Program*. A careful look into the history of mathematics reveals that mathematical modeling is the root out of which much of modern mathematics has developed, often from a process of abstraction, which represents the real world. The determination of the time or location where the first ideas of mathematical modeling took place is probably not possible. Mathematics has expressed itself through modeling since the earliest times of recorded history.

The invention of the wheel for the Sumerians in 3000 BC may be one of the earliest mathematical models considered. When a tree trunk was first observed rolling down a slope, the idea to use objects to roll heavy loads was born. Loads were placed on logs (rolling objects) instead of carrying this same cargo on people's backs, eventually allowing the Egyptians to transport objects and build their architectural wonders. This invention also led to the development of new mathematical problems inherent to the solving and construction of impressive buildings and monuments. Another example of an early mathematical model was activity originating with the work of Eratosthenes (276-196 BC), who created a mathematical model that allowed him to measure accurately the circumference of the Earth. The development of modeling methodology can also be seen in the model of Newton's *Theory of Universal Gravitation* in the 17th century. Even though modeling has been used frequently since the beginning of humankind, the term mathematical modeling was only introduced in the 19th century by Lobachevsky (1792–1856) and Riemann (1826–1866), who created the proposed models for the non-Euclidean geometries.

A summary of the challenges to ethnomathematics

There are numerous unfavorable arguments related to the implementation of ethnomathematics as a program. It is possible to outline some of these challenges in the following categories:

Education

For several years it has been argued that traditional uses of the school curriculum do not foster a genuine disposition for realistic mathematics in students. Yet the same argument can be used against many attempts to make ethnomathematics useful to educators and students. Other concerns are related to the lack of enough time to develop content that enables teachers to execute pre-established pedagogical plans. Concerns related to the application of ethnomathematics as pedagogical action generally include:

- few, if any, textbooks and other pedagogical materials about ethnomathematics are in use in classrooms
- a scarcity of university ethnomathematics courses leaves teachers and researchers unprepared to argue this issue, and leaves the door open to further criticism of the field
- few, if any, assessment instruments are appropriate to this new curriculum model
- there is a real danger of ethnomathematics being taught as folkloristic introductions to academic mathematics
- much of the published ethnomathematics activities represent a shallow, superficial understanding of the field with a sense of "multicultural experiences" based only upon "exposure to diversity", and an inability to look at the deeper mathematics present

Students

Many students have difficulty with working in groups or in cooperative learning styles. Many teachers and parents are unsure about how their children should work without traditional classroom structures. Because of the traditional, often passive, aspect of schooling, many students and teachers have not developed the habit of formulating questions and mathematizing ideas and hypotheses, and have difficulty assimilating several subjects simultaneously (Burak, 1994), or seeing mathematics outside of the traditional classroom context

Teachers and educators

Many educators are reticent to de-emphasize their traditional authority in favor of group work (Burak, 1994). Other reasons may relate to issues of the lack of time for planning lessons (Burak, 1994). Many educators are not familiar with the interface between mathematics and other subjects, that is, the interdisciplinary nature of the mathematics curriculum, which is required when teachers work from this perspective. In a generally mathematics phobic culture, certainly the reverse is equally true. Many mathematics educators are not always prepared to employ practices that will enable underserved and underrepresented groups to learn, understand, and comprehend mathematics (Burak, 1994; Zaslavsky, 1996).

School mathematics

It has been extremely difficult to mix the goals and philosophy of ethnomathematics, academic benchmarks, standards, and goals related to passing of standardized exams that are based in traditional school mathematics (Rosa, 2000). Many teachers and educators feel that their students will not learn mathematics if they use an ethnomathematical approach in school curricula They believe that this perspective makes students' and teachers' accountability in standardized examinations problematic.

We believe that one way for ethnomathematics to be taken to classrooms is for ethnomathematicians to develop rigorous research linking ethnomathematics and modeling activities to the mandated mathematics curriculum. Such work is gradually being undertaken in places such as Brazil Like it or not, educators are less likely to use ethnomathematics if they cannot see at this time how this would allow them to succeed in improving overall student achievement

Challenges towards pedagogical action

The pedagogical action of the ethnomathematical program underscores the importance of doing the ethnomathematical work first Seeing in this context, coming to a good understanding of the mathematical aspects of culture and having a clear purpose to the educational activity are vital aspects of this perspective The consequence of these ideas is that ethnomathematical work in the schools is not a simplistic presentation of cultural examples or simply situating mathematics in cultural contexts. Rather it requires considerable background work, complete understanding, and pedagogical sophistication. This is a complex task, takes time, and is difficult. For example, it is convenient to state that teachers may interpret an ethnomathematical approach by starting with the students' outside socio-cultural-economic realities, but the students may refuse to study their own realities because they consider them to be oppressive In this case, they may not identify this contextualization as mathematics because they already have a grounded mathematical conception as previous knowledge In this case, one possibility is to start with the students' existing mathematical conceptions, even if they are traditional, because this is another way to develop the mathematical content followed by a critical examination of these conceptions The consequence of this educational aspect for teacher education is significant. It means that teachers must know more about mathematics and additional pedagogical skills in order to help students undertake a critical examination of the mathematical content.

Final considerations

An eventual inclusion of ethnomathematics in the school curriculum could happen simply because current trends in many urban schools (growing migration, immigration and the increasing complex, urban diversity of our populations) will demand it However, ethnomathematics can be considered negative when it restricts ethnic groups to stereotypes and leaves them unprepared to participate in greater academic endeavors It can be considered equally negative if it is seen to "water down" the necessary mathematics content in general. Ongoing work needs be undertaken by ethnomathematicians that shows that we can and do integrate rigorous mathematics such as modeling, into the curriculum.

As stated earlier, ethnomathematics seeks to recognize the contributions, values, rights, and the equality of opportunities of all cultural groups that compose any given society. Educators can begin to develop an ideal equality among students and build a foundation for promoting academic excellence for all their students by implementing ethnomathematics and modeling

Ethnomathematics may come to exert some influence on mathematics education if researchers develop rigorous activities that are linked to standards and curriculum that makes mathematics a living subject for both teachers and students. Traditional mathematics education aims at transmitting a certain amount of content and uses it in artificial situations presented as problems. The problems are artificially formulated, in such a way that they can only help memorization skills, at best. These techniques and problems are usually boring, uninteresting, obsolete, and unrelated to the modern reality of students. These characteristics of traditional mathematics education are responsible for downgrading of school satisfaction and achievement in many countries. Ethnomathematics, through modeling, may restore a sense of pleasure in the doing of mathematics

The use of calculators and computers must be integrated into the concept of ethnomathematics and a mathematical modeling curriculum (D'Ambrosio, 2006). The emphasis in ethnomathematics can be considered *conceptual* while the emphasis in modeling can be thought of as *performance*. And both, concepts and performance are aided in significant ways by advanced technology (Rosa, 2000).

In relation to the ongoing development and implementation of ethnomathematics and modeling, debate should continue as part of ongoing development and research that creates inclusive paths for the learning and teaching of mathematics in schools, communities, and societies. Sociological questions about the relationships between the institutionally dominant majority and minority cultures need to be reflected by ethnomathematics research in this, our increasingly interconnected and globalized world

Notes

[1] Rosa, M. (2000) *From reality to mathematical modeling: a proposal for using ethnomathematical knowledge*, unpublished Master's thesis, Sacramento, CA, California State University.

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If in our enthusiasm for providing active experience for young children we do no more than provide the springs and balances, the sand and water, with requests for recording of what happens in certain selected situations, then we run the danger of abdicating from mathematics altogether. We certainly encourage the same abdications if we think in terms of children 'discovering' relations in certain external situations Some of the most important mathematics relations stem from the earliest mental and emotional activity of the infant. We make sense of our environment by imposing these relations upon it. In developing our understanding and control of these relations in this way we further provide the possibility of a control of the environment. In order to develop the fullest resources of the human mind, it may be more important to think of creating mathematics rather than discovering it. In the creation of likes and unlikes we detect 'the mind at work creating works of the mind'. And this is mathematics.

(Dick Tahta and Bill Brookes (1966) 'The genesis of mathematical activity' in W. Brookes (ed.) *The development of mathematical activity in children: the place of the problem in this development*, Nelson, UK, Association of Teachers of Mathematics (ATM). Quotation placed on the ATM web-site in memory of Dick Tahta by Sue Johnston-Wilder, current Chair of ATM.)