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POP: A STUDY OF THE ETHNOMATHEMATICS OF GLOBALIZATION USING THE SACRED MAYAN MAT PATTERN

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Abstract: There exists a belief that mathematics produced by non-Western cultures is irrelevant for both the economic and technological development of our modern globalised world. From a global perspective, ethnomathematics can be considered an academic counterpoint to globalization, and offers a critical perspective of the internationalism of mathematical knowledge through attempts to connect mathematics and social justice. It is also possible to perceive ethnomathematics as a form of academic articulation between cultural globalization and the mathematical knowledge of diverse non-Western cultural groups. Through a study of the mathematical practices found in the sacred mat and geometric diamond patterns of the Maya, it is possible to use an ethnomathematical, anthropological, and global perspective, to demonstrate one way in which we might preserve a portion of the wisdom and knowledge of these unique and resilient peoples

Keywords: globalization; ethnomathematics; Mayan civilization; anthropology; mathematical knowledge; mat patterns; cultural groups; non-Western cultures, mathematical modelling

1. Introduction

Before the present era of globalization, the world's continents were separated by vast expanses of ocean and sea. Ancient peoples knew of the existence of others only through myth, legend, and the stories of conquerors or travellers. Most of humanity lived in isolated and self-sufficient cultural groups and lived and died in the same place (Toffler, 1980). Recently, the world's peoples have been linked together through extensive systems of communication, migration, trade, and production.

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2. Globalization

Globalization is an ongoing historical process that has, at its roots, the very first movement of peoples from their original homelands. Explorers, conquerors, migrants, adventurers, and merchants have always taken their own ideas, products, customs, and mathematical practices with them in their travels. The analysis of the great events of human history such as the conquests by Caesar, Alexander, Cortez; the adventures of Marco Polo, the Portuguese Naval School of Dom Enrique, and the navigation of Columbus, all occurred primarily for economic reasons. Imperialistic adventures determined the colonial social-cultural characteristics through the imposition of non-native customs on local and diverse indigenous peoples. This form of colonialism was practiced primarily by European nations and is often referred to as the *Europeanization* (Featherstone & Radaelli, 2003) of the world.

In order to maintain and govern their possessions, European colonizers required enormous amounts of capital and power, and settled most questions of cultural difference by force. This increased a certain amount of awareness of non-Western cultures by the colonizers, and has raised new questions for scholars about the nature of society, culture, language, and knowledge. For example, Recinos (1978) stated that "from the first years of the colonization, the Spanish missionaries were aware of the need to learn the languages of the Indians in order to communicate with them directly and to instruct them in the Christian doctrine" (p.30).

Emerging theories of social evolution allowed Europeans to organize this new knowledge in a way that justified the political and economic domination of others. Colonized people were considered less-evolved, thus giving the powerful sense of justification to the colonizers as they came to believe themselves more evolved. Nevertheless, an effective administration required some degree of understanding of other cultures.

Colonial powers built educational institutions based on their own educational paradigms and systems. Because of this, it is possible to identify the early processes of globalization and internationalization of scientific-mathematical knowledge through the very establishment of the school systems that were built and adapted in colonies on Asia, the Americas, and Africa. Worldwide, the concept of higher education generally takes on the system, titles, and structures of a medieval European design that was passed around the world through colonial expansion.

With Guttenberg's invention of the printing press in 1455, some European cultural groups were quickly empowered over others and began to expand their culture, values, thoughts and civilization. Initially, this process of globalization developed relatively slowly, however, with the onset of Industrial Revolution, and the subsequent rise of materialism and capitalism, globalization has rapidly expanded.

3. The Globalization of Mathematical Knowledge

We do not really know when an interest in the mathematical practices of other cultures was first expressed. The earliest observations of distinct mathematical practices probably occurred in tandem with the first travels to different regions of the world, made by those who came in contact with local cultures. They observed different customs that no doubt included different mathematically-related practices such as counting and measuring. Even though an absence of early records has hindered true understanding, observations of those practices allowed early scientists, philosophers, and mathematicians to apply many mathematical concepts and ideas that were brought back from their travels. The development of writing allowed historians of mathematics to piece together knowledge accumulated by early civilizations.

In the light of these facts, the globalization of mathematical, scientific, and technological knowledge brought accelerated technological *progress* to various parts of the world. For example, when in the 7th century the Arabs invaded Europe, they brought with them the mathematical knowledge that they acquired from India (thus the term Hindu-Arabic numeration system). They also influenced Medieval Europe by exchanging food, customs, culture, science and technology. In turn, when they conquered and colonized the peoples who lived there, Europeans introduced this system into the New World.

The mathematical discoveries made by the Hindus around the 9th century were transmitted to the Arab peoples through religious expansion and commercial activities, war, and conquest. At this time, the number system used by the Greeks and Romans was cumbersome and impractical for many uses and the adoption of the decimal number system used by the Hindus and brought to Europe by the Arabs made perfect sense. This improved ability to calculate allowed for growth in the western sciences.

The Hindus also took advantage of this same cultural interchange by learning important concepts of Greek mathematics by way of the Arabs. Despite this "Eastern" globalization, the earliest systematic use of a symbol for zero in a place value system was used by the Mayans centuries before the Hindus began to use a symbol for zero (Cajori, 1993; Diaz, 1995; Jr. Merick, 1969). It is very important to note that the Mayan number system was in use in Mesoamerica while the Europeans were still struggling with the Roman numeral system which suffered from serious defects because there was no zero and the numbers were entirely symbolic with no direct connection to the number of items represented.

In the Mayan number system the symbol for zero was used to indicate the absence of any units of the various orders of the modified base-twenty system. In this context, Ifrah (1998) stated "What is quite remarkable is that Mayan priests and astronomers used a numeral system with base 20 which possessed a true zero and gave a specific value to numerical signs according to their position in the written expression" (p. 308). Further evidence of this phenomenon resulted from Ifrah's study of Mayan achievement in mathematics:

> So we must pay homage to the generations of brilliant Mayan astronomer-priests who, without any Western influence at all, developed concepts as sophisticated as zero and positionality, and despite having only the most rudimentary equipment, made astronomical calculations of quite astounding precision
>
> (p. 322).

In the 11th century, the internationalization of scientific, technological, and mathematical knowledge was not only influenced by Western cultures, because the agents of globalization were located in other regions of both the known and unknown world (Sen, 2002). Powerful technological items such as paper, gunpowder, the magnetic compass, and the iron–chain suspension bridge were used in China, but other cultures around the world had little if any knowledge of these technologies (Sen, 2002).

In the 14th century, the Arab historian and philosopher Ibn Khaldun (1332–1406) examined social, psychological, economic, and environmental factors that affected the development, ascension and fall of different civilizations. In his study, Khaldun analyzed several economic policies and demonstrated the consequences for both local and distant communities (Oweiss, 1988). These facts accompanied a mathematical knowledge that strongly contributed to the defence of communities against the injustice and oppression of the ruling class.

At the end of 15th and the beginning of the 16th centuries, explorers provided descriptions of different aspects of the "exotic" cultures they encountered in Asia, Africa, and the Americas. Early chroniclers of the Americas reported observations and registered data collected in relation to the cultures they encountered in their explorations. Using a process that can be considered ethnomathematical in nature, Juan Diaz Freyle published, in 1556, the first book of arithmetic of the new world entitled *Sumario compendioso de las quentas de plata y oro que en los reinos del Pirú son necessarias a los mercaderes y todo genero de tratantes: Con algunas reglas tocantes al arithmética*[1]. In this book, Freyle described the arithmetic practiced by the indigenous people. It is important to observe that this book described the process of the indigenous people's assimilation of the conquering people's mathematical knowledge. This can be perceived as a transformation of the native mathematical system through a global and cultural dynamic perspective.

According to Grattan-Guinness (1997), when Europeans invaded and conquered the northern part of the Americas during the early 16th century, they "began to apply commercial arithmetic to the purchase of citizens in North America from local chiefs and kings, and the later sale of those still alive, to entrepreneurs and landowners across to the Americas" (p. 112). He also affirmed:

> They too made little effort to conserve the culture of either slaves or of the indigenous tribes. Nevertheless, the latter have managed to maintain a repertoire of mathematical theories, not only in arithmetic, geometry and astronomy but especially in connection with skills such as archery and in games of chance involving the throwing down of rods and sticks decorated in various ways
>
> (p. 113).

[1] Translation: *A Compendium Summary of the Accounts of Silver and Gold that in the Kingdoms of Peru are Necessary to Merchants and All Kinds of Dealers: With Some Rules Concerning Arithmetic*.

The ascension of the Portuguese, Spanish, French, Dutch, English, and Belgian Empires in 18th and 19th centuries contributed to increasing contact with the cultures they colonized. This context allowed for an increased development of global commerce, a greater spread of the growing capitalist economy, and the industrialization of Europe.

The newly industrialized countries continued their search for new lands as sources of supply, cheap manpower, and the raw materials to be manufactured at low costs. At the same time, millions of Europeans from the lower classes were encouraged to immigrate to the newly established colonies in promise of better lives. These cultural exchanges allowed for a continued accumulation of data and information of distinct cultural groups that were “found” and subjugated in the colonies.

In the 19th century, the first forms of what would become modern anthropology began to be systematized. According to some experts, as different cultures were studied during the ongoing processes of assimilation and colonization, the customs and mathematical practices of diverse cultural groups also became objects of study by many early European anthropological societies. In the 20th century, a growing and increasingly sensitive understanding of mathematical practices and ideas from diverse cultural groups became increasingly available through the growth of the fields of ethnology, culture, history, anthropology, linguistics, and the development of ethnomathematics. Insights from many theoretical studies signal the possibility of the sensitive internationalization of mathematical practices and ideas expressed in different cultural contexts.

4. The Perspective Offered by Ethnomathematics

Ethnomathematics recognizes that all cultures and all people develop unique methods and sophisticated explications to understand and to transform their own reality. It also recognizes that the accumulated methods of these cultures are engaged in a constant, dynamic, and natural process of evolution and growth in every society. In this context, culture is a complex whole that includes knowledge, beliefs, art, laws, morals, customs, and any other practices and habits assured by a member of a society. Lindsey, Robins, & Terrel (2003) define culture as “a group of people identified by their shared history, values, and patterns of behaviour” (p. 41). Lindsey et al (2003) also believe that “culture is a problem-solving resource we need to draw-on, not a problem to be solved” (110). Ethnomathematics looks at the mathematics of this problem-solving resource.

Another presupposition of ethnomathematics is that it validates all forms of mathematical explaining and understanding formulated and accumulated by different cultural groups (Rosa, 2000). This knowledge is regarded as part of an evolutionary process of change that is part of the same cultural dynamism present as each group comes into contact with each other in this new global reality. In this perspective, all cultures have, by necessity, evolved unique ways to *quantify, count, classify, measure, explain and model* the phenomena of their own daily occurrences (Borba, 1997). A study of the different ways in which people resolve problems and the practical algorithms on which they base these mathematical perspectives becomes relevant for any real comprehension of the concepts and the practices in the mathematics that they have developed over time. For example, when we speak of patterns and sequences, we know that humanity utilized different numeric and geometric patterns to make music, dance, or create basketry, ceramics, rugs, and fabric. Many times, these patterns possessed religious and spiritual aspects that sought to connect their own human perspective with the "divine" around them.

5. Ethnomathematics and Anthropology

One of the most important concepts of ethnomathematics is the association of the mathematics found in distinct cultural forms. Ethnomathematics as a program is much wider than traditional concepts of mathematics and ethnicity. In this case, D'Ambrosio (1990) refers to "ethno" as that related to distinct cultural groups identified by cultural traditions, codes, symbols, myths, and specific ways of reasoning and inferring.

The focus of ethnomathematics consists essentially of a serious and critical analysis of the generation and production of knowledge (creativity), intellectual processes in the production of this knowledge, the social mechanisms in the institutionalization of knowledge (academic ways), and the diffusion of knowledge (educational ways). In this holistic context, the study of the systems that form reality and look to reflect, understand, and comprehend extant relations among all of the components of the system require constant analysis of their reality. Rosa (2000) has defined ethnomathematics as the intersection of cultural anthropology, mathematics, and mathematical modelling which is used to translate diverse mathematical practices.

All as shown in Figure 1 individuals possess both anthropological and mathematical concepts; these concepts are rooted in the universal human endowments of curiosity, ability, transcendence, life, and death. They characterize our very humanness. Awareness and appreciation of cultural diversity that can be seen in our clothing, methods of discourse, our religious views, our morals, and our own unique world view allow us to understand each aspect of the daily life of humans.

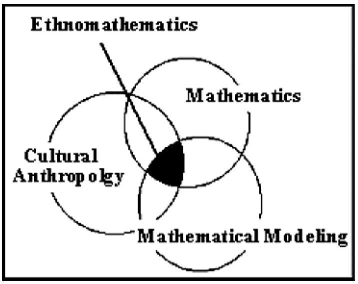


Figure 1. Ethnomathematics as an Intersection of Three Disciplines

The culture of each group represents a set of values and the unique way of seeing the world as it is transmitted from one generation to another. The principal focus of anthropology that is relevant to our work in this chapter includes such aspects of culture as language, economy, politics, religion, art, and our daily mathematical practices. Since, cultural anthropology gives us the tools to increase our understanding of the internal logic of a given society; an anthropological study of distinct cultural groups allows us to further our understanding of the internal logic and beliefs of different peoples.

6. Ethnomathematics in the Process of Globalization

Knowledge is generated and intellectually organized by individuals in response to their own social, cultural, and natural environment. This knowledge is socially organized and used to recognize and explain activity in the daily lives of people. According to D'Ambrosio (2002), observers, chroniclers, theoreticians, sages, and professionals expropriated this knowledge, and then classified, labelled, diffused, and transmitted it across generations.

There are structured forms of knowledge such as language, religion, the culinary arts, medicine, dress, values, sciences, and forms of mathematical thinking that are interrelated and respond to the way reality is perceived through the unique social, cultural, and local environment of an individual (D'Ambrosio, 2002). These forms of knowledge are structured differently because cultural dynamics increasingly plays a role in the broadening perception of reality which, as a consequence, modifies responses to these cultural structures that are in a dynamic state of change as shown in Table 1. Some individuals, groups, societies, or nations freeze these forms of knowledge (Gerdes, 1985). The frozen knowledge becomes accepted and energy is directed towards keeping these forms of knowledge static.

Table 1. Mathematical Practices as Diverse Cultural Forms of Knowledge

Mathematical Practices	are	Diverse Cultural Forms of Knowledge
• measurement	• general	• languages
• comparison	• product	• communication
• classification	• organized	• jargon
• quantification	• diffused	• mathematical ideas
• ordering	• transmitted formally and informally	• codes of behaviours
• selecting	• symbols	• myth
• cipering	• values	
• memorization of routines	• beliefs	
• counting		
• inference		
• modelling		

D'Ambrosio (1985) has stated that there are many different kinds of ethnomathematics. Each one of them responds to different cultural, social, and natural environments. One of these environments originated in the Mediterranean basin and gave origin to a form of ethnomathematics called "mathematics." Through the subsequent processes of conquest and colonization, and now a corporately forced globalization, this "mathematics" has been imposed across the world at large. It has been accepted because of its tremendous scientific success and its ability in dealing with space and time which accompanied the colonial world view of property ownership, production, labour, consumption, and subsequent capitalistic values. Mediterranean-based mathematics has come to be known as "Western" mathematics, is often referred to as "universal mathematics", but in reality it can be seen as a subset of our overall basic human endowment.

Ethnomathematics is the mathematics practiced by identifiable cultural groups (D'Ambrosio, 1990) such as national and tribal societies, labour groups, children of a certain age, and professionals. Borba (1997) agrees with this point of view and stated that "even the mathematics produced by professional mathematicians can be seen as a form of ethnomathematics because it was produced by an identifiable cultural group" (p. 40). Mtetwa (1992) found that "some people have misunderstood the term, using it exclusively to refer to mathematical forms created and practiced by and for a specific ethnic group" (p. 1). This interpretation of ethnomathematics does not represent the broader definition given by D'Ambrosio (1993) to this program.

Ethnomathematics includes, but is certainly not limited to academic or school mathematics, and the kinds of mathematics conceived and practiced by the professional scientific community (Orey & Rosa, 2003). Powell and Frankenstein, (1997) stated that it "is the informal and ad hoc aspects of ethnomathematics that broaden it to include more than academic mathematics" (p. 7). Western mathematics can and should be considered as a subgroup of ethnomathematics because there is a relationship between ethnomathematics and academic mathematics through mathematical modelling (Borba, 1997; D'Ambrosio, 1993; Orey & Rosa, 2003). In this perspective "school mathematics is an outgrowth and subset of ethnomathematics" (Mtetwa 1992, p. 3).

However, the distinction between western and non-western mathematics is weakened by a theory of knowledge that is supported by cultural dynamics which occurs through encounters among different cultural groups, and produces cycles of generation, organization, transmission, and the diffusion of knowledge. Traditional or academic mathematical practices are a form of ethnomathematics defined by the cultural background and patterns of individuals that practice them. They translate this knowledge in a form of academic language and incorporate it as mathematical practice in their daily lives. This cultural dynamics is defended and described by D'Ambrosio (2000).

In an increasingly globalised world, the subtlest weapon of the colonizer[2] has been the institution of "formal" education. By instituting the use of formal education, the colonizer removes the roots of the colonized and facilitates the cultural process of submission. In this case, one of the main functions of ethnomathematics is the *decolonization* of individuals and communities (Orey & Rosa, 2003). Because of this, ethnomathematics is frequently criticized as being political, since it seeks the liberation of the oppressed in the ongoing process of colonization and globalization. By doing this, ethnomathematics seeks to raise the self-confidence, to enhance creativity, and to promote cultural dignity of diverse cultural groups. These factors are essential to value an individual's cultural background.

D'Ambrosio (1999) gives a global dimension to ethnomathematics without being colonialist or imperialistic. According to his theory, ethnomathematics is international in its own rite. In his perspective, it is possible to internationalize and value different mathematical practices through mathematical modelling[3]. Modelling acts as a bridge between mathematical ideas and academic mathematics. This environment allows us to internationalize diverse mathematical practices by including mathematical modelling in the mathematics curriculum which will enable students to understand and function in a globalised world (Atweh & Clarkson, 2002). This process shows that mathematics is a cultural endeavour, and is rooted in tradition, and which considers all systems of mathematical ideas developed by every civilization as valid (Rosa, 2000).

Most notably, unlike much of modern sciences and mathematics, the program of ethnomathematics as defined by D'Ambrosio, emerged from the unique conditions of the Brazilian socio-political-economic reform movement in the late 20th century. For all these reasons, we believe that an ethnomathematics program cannot be viewed as a neo-colonial approach in mathematics education.

Both ethnomathematics and a new globalised mathematics must take care not to trivialize other cultures based on the misrepresentations of their scientific and mathematical ideas or structures. It is also important to uphold a balanced analysis that maintains a group's cultural integrity while accurately portraying its scientific, mathematical, and technological contributions. We have outlined here, one example of how this future scholarship might proceed.

7. The Great Architect

Many cultures share the belief that a "Great Architect" of the universe possessed certain mathematical characteristics. This "Great Architect" is, according to many Mediterranean traditions, God, Yahweh, Allah, and, according to the Mayan tradition, named *Tzakol* (Recinos, 1978). The knowledge of this "Great Architect"

[2] The colonizer can be any government, religion, individual, or corporation.
[3] Mathematical modelling is a tool that provides a translation of different mathematical practices into academic mathematics.

was learned and captured by many Mediterranean and ancient non-Western civilizations (D'Ambrosio, 2000). Since there is more than one religious practice, more than one system of values, more than one name for the "Great Architect", there is, perhaps more than one way of *explaining, knowing,* and *understanding* these diverse realities (D'Ambrosio, 2001).

A study of the mathematics of indigenous peoples who were "discovered" and colonized by Europeans allows us to introduce mathematical ideas of cultural groups who have been excluded from traditional mathematical discourse. It is in this context that an ethnomathematical perspective can be used to challenge what is often known as an ethnocentric view of diverse cultural systems. Complex social organizations are typically thought of as having advanced technology and thus, a more "complicated" mathematical system; yet, indigenous cultures such as the Mayans, developed equally complicated mathematics which had an equally conscious effect on the world around them.

8. The Mayan Civilization

Mayan civilization has survived for more than 3000 years in the region now called Central America. The Mayan people are best-known by their distinct architecture, the patterns they found in their observations about the universe, the development of mathematical relationships, and a symbolic and sacred system that they developed to represent these patterns. About 7 million Mayan people are dispersed in urban and rural communities in Southern México, Belize, Guatemala, Honduras and El Salvador. With centuries of persecution, cultural insulation, and disrespect of Mayan traditions, beliefs and religion, most Mayan people now live in crushing poverty.

9. The Mayan Process of Globalization

For indigenous Mayan people, the violent encounter with globalization began in 1524 with the arrival of the Spanish conqueror Pedro de Alvarado. With the invasion of the Americas by Europeans, the world of the Mayans, Incas, and Aztecs, like all the other Indigenous societies in the New World, came to an abrupt and extremely brutal end. On other hand, according to Ascher & Ascher (1981), the Incas did not destroy and replace the cultures they conquered, "An Inca deity was added to, not substituted for, the local gods… locally important people continued to be important…" (p. 5–6).

Although medieval Europe was in many ways less developed than the Mayans, the conquerors arrived with an enormous military advantage such as gunpowder, steel swords, and horses. At the same time, indigenous societies were weakened by diseases against which they had no immunity. It was the superior European technology and firearms that proved a vital factor to the success of the conquest of the Americas. They justified their "destructive acts on the basis of cultural superiority" (Ascher, 1991, p. 17). In a quest for riches, the European invaders defeated the Mayans. In so doing, they destroyed libraries that were possibly the greatest repositories of indigenous science in the Western Hemisphere. Some surviving texts were carried to safety by Mayan priests. Among them was the hieroglyphic source for the *Popol Vuh*, which is considered by some to be the "Mayan Bible", and the Dresden Codex, which reveals the sophistication of Mayan knowledge of astronomy and mathematics. Knowledge about the Mayan world in these texts is just a small fraction of knowledge that they accumulated during thousands of years (Coe, 1992).

When Mayan cities were decimated by disease, burned and sacked, their religion and culture were banned and forced underground. Within a short time; the Mayans had become slaves in their own homeland and were deprived of their land, their rights, and any kind of political or social representation. The once proud Mayan kingdoms were subjugated and colonized. Yet, despite this, they have continued to maintain much of their heritage, religion, mathematical knowledge, and languages.

However, the Mayans did not accept this fate lightly; a study of Mayan history shows that in every generation since the initial invasion by Spain, the Mayans have risen-up in rebellion (Wilkinson, 2002). The Mayan peoples have never forgotten their cultural identity. Despite centuries of oppression and prejudice, they continue to celebrate their own cultural and religious ceremonies, and maintain and speak their own languages. There is no doubt that Mayan culture has been weakened due to the processes of disease, slavery, colonization, conquest, and globalization. The early greed and ambition of colonizers has recently been replaced by the phenomenon of globalization, resulting in social deprivation and degradation for Mayan peoples. Yet, Mayan culture survives despite a brutal history of religious repression, racism, inequality, and exclusion (Wilkinson, 2002).

10. The Geometric Pattern of the Mayan Diamond

The Mayans made use of a series of sacred geometric-numeric patterns that they transmitted from generation to generation. The utilization of these patterns probably originated with a species of rattlesnake *Crótalus durissis* (Figure 2), found in the region (Nichols, 1975; Diaz, 1995; & Grattan-Guinness, 1997). Rattlesnake skins possess a unique diamond pattern (Figure 3); this particular species is called the "diamond backed rattle snake" in English. The contemplation of this form and geometric pattern inspired Mayan art, geometry, and architecture (Diaz, 1995, & Grattan-Guinness, 1997). The images of rattlesnakes are found in many aspects of Mayan culture. They symbolize the birth and life changes of the ancient Mayans because *Crótalus durissis* enlivens and crawls its way across time.

The significant and purely abstract, patterns found in geometric rattlesnake forms are found in fabrics and in façades of numerous ancient buildings, monuments and architectural structures though out the ancient Maya territories.

In Figure 4, it is possible to observe that the degrees of slope of Mayan pyramids are extremely steep and are difficult to climb comfortably. The easiest and most comfortable way to climb Mayan pyramid stairs is to climb the steps in a zigzag.

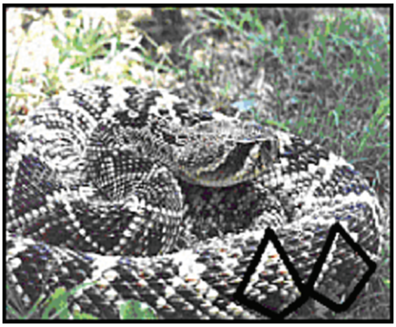


Figure 2. Crotálus durissus

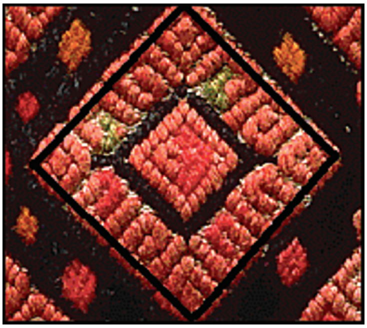


Figure 3. Rhombus representing the geometric from of the skin of the rattlesnake

Figure 4. EI Castillo in Chichen Itza

The trajectories formed by the movement of the priests ascending and descending of the pyramids have the same form and geometric patterns found in the rattlesnake skin (Diaz, 1995; Grattan-Guinness, 1997). In this case, Mayan priests ascended and descended pyramids in a criss-cross ritual that reproduced the diamond pattern of the rattlesnake.

11. The Sacred Mayan Mats

The word *Popul* present in the title in of the sacred book *Popul Vuh* contains the prefix *Pop (Ahpop)*, that is, the Maya Quiché word for *mat* (Recinos, 1978). The Gods that were represented in the monuments of numerous Mayan pyramids sat on top of *Pop* patterns built over sacred mat patterns. The monuments themselves were constructed over *mats* that had magic or mystical power and used number values to provide a spiritual foundation to accompany the physical buildings.

Diaz de Castillo (1983) affirmed that the priests and the Mayan nobility also sat on top of sacred *mats* for ceremonies and festivities. He also described that in the time of the conquest of the Mayans by the Spanish, important meetings were made between Spanish leaders and the Mayan nobility and priests. In these meetings, the Spanish leaders sat on sacred mats that were offered by the Mayan nobility. However, they covered the mats with cloth that contained values that neutralized any mystical power and blessing that emanated from the numbers presented in the geometric patterns in the mats (Figure 5).

These patterns were sculpted in stones and used in jewellery and cloth. They are still used in the clothing of 21st century Maya descendents (Figure 7).

Through much of their weaving, the present *magic* of the designs in the vestments are connected with ceremonies that were promoted by their ancestors.

In the universal diamond (Figure 6), the four fields represent the frontiers between space and time in the Mayan universe. The small diamonds that are in each field represent the cardinal points of this universe; the east is placed where the sun rises, the west is placed below and represents the end of the day, the north is placed on the left and the south on the right.

The Mayan spatial orientation of the four corners of their universe is not based on the cardinal points of the western compass (Morales, 1993). Frequently, the diamonds are placed so eastern and western fields are coloured blue to represent the Caribbean on the east and Pacific Ocean on the west. The centre of each large diamond is placed so that a small diamond represents the sun. Sometimes, a fine line is placed on the design that connects the east and west and represents the trajectory of the sun across the sky.

Figure 5. Different Geometric Patterns of the Mayan Sacred

Figure 6. The Universal Diamond

Figure 7. Huiple-Traditional Maya Dress

Figure 8. Wall of a Mayan Temple in Yucatan, Mexico

Many present-day Mayans weave and sew many of the same designs and motifs that have been popular since the classic period of Mayan culture between 3rd and 10th centuries (Deuss, 1981; Rowe, 1981). Many of the pictures found on ceramics, lintels, stela and murals also contain the same patterns and geometric forms that are utilized in the Mayan weavings (Figure 8).

The diamond shape was considered extremely important, indeed sacred because it represented the light reflected with brilliance in a polished diamond. This diamond shape brought a sense of order and light, and reminded them that all need to live in harmony.

The attraction of the diamond form was in concord with the sacred numbers of the Gods; it was divine power that implied the numbers of 1 to 9 (Nichols, 1975, Orey, 1982). This context allowed the Mayans to use these numbers which were based on the snakeskin and diamond patterns for a type of numerology because they could have had a sacred value and a specific significance (Coe, 1966, Coe & Kerr, 1988; Nichols, 1975, Orey, 1982).

12. Decoding Mayan Messages

According to Nichols (1975), the patterns X's or XX's[4] found on many Mayan mats (Pop) contained information. The numbers placed on these mats progressed sequentially and zigzagged diagonally as shown in Figure 9. The first number is positioned on the right vertice of the first square that composed the mat. For example, on a mat of 3 lines by 2 columns, the numbers are placed as in the diagram below:

The final numerical number of this matrix might be calculated in the following manner:

1. We add the corresponding numbers of each line of the matrix.

$$1+6=7$$

$$5+2=7$$

$$3+4=7$$

Consulting the table 2, the result 7 has the value: God in Divine Power.

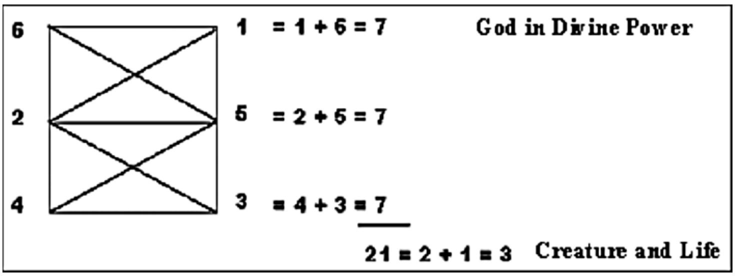


Figure 9. Decoding Mayan Messages

[4] According to Girard (1979), "when the King spreads his legs and lifts his arms over his head, he assumes a posture that can be called a cross and which is nothing more nor less than the representation" (p. 293) of the glyph of kin or glyph of the sun.

Table 2. The Sacred Significance of the Numbers

1.	God or Goddess
2.	The Creator: Parents
3.	Creature and Life
4.	Venus, called Kulkulkan
5.	Priest : The Hand of God
6.	Life and Death
7.	God in Divine Power
8.	Body and Soul
9.	The Nine Drinks

2. Adding all the results we get:

$$7 + 7 + 7 = 21$$

3. We then add the digits resulting in the ultimate value of: 2 + 1 = 3
4. According to the table 2, the number 3 corresponds to Creature and Life.

A possible interpretation of the message of this result can then be: *God utilizes His Divine Power to give life to all creatures in the world.*

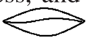
Objects found in some of the most important archaeological sites of Guatemala such as Tikal and Quirigua reveal that Mayan priests made certain decisions based on sacred mats because they contained significant sacred numbers that were based on *ultimate values* for each pattern. For example, to find a solution for a given situation, a priest needed to make a decision towards codifying a mat that contained the ultimate value 6 which signifies "Life and Death." In this perspective, the Mayan priests were charged with maintaining the spiritual, religious, scientific, and mathematical knowledge of Mayan civilization.

13. The Mayan Number System of the Divine Creation

According to Mayan theosophy, the creation of the world was closely associated with mathematical concepts. In accordance with this perspective, Girard (1979), states:

> The Quiché codex begins by referring to the creation of the universe. Divinity – pre-existent to its works – creates the cosmos, which extends through two superimposed, quadrangular planes – heaven and earth – their angles delimited and their dimensions established. Thereby is established the geometric pattern from which will derive the rules for cosmology, astronomy, the sequential order in which events occur, and the marking out and use the land, which for the Maya are all reckoned from that space-time scheme.
> (p. 28).

Diaz (1995) stated that the creation of the four corners of the Mayan universe was governed by the geometric pattern of the rhombus which represents the geometric pattern on the skin of the rattlesnake *Crótalus durissus.* In the creation of the Mayan universe, the god Tzakol's[5] used his supernatural intervention in the creation process by applying the sacred-symbolic power of the numbers as described in the book *Popol Vuh* (Recinos, 1978). This can be interpreted by the following mathematical pattern:

Number 0: "This is the first account, the first narrative. There was neither man, nor animal, birds, nor forests; there was only the sky. … Nothing existed." (Recinos, 1978, p. 81). It was like a seed phase because all was in suspense, all calm, in silence, all motionless, and the expanse of the sky was empty. Thus, the Mayans used a seed symbol  for zero.

Number 1: *Tzakol*, known as Huracán, is the first hypostasis of God. He planned the creation of the universe, the birth of life, and the creation of man (Recinos, 1978).

Number 2: The Creator brought the Great Mother (*Alom*) and the Great Father (*Qahalom*). *Alom* is the Great Mother and represents the essence of everything that is conceived. *Qahalom* is the Great Father who gives breath and life.

Number 3: Then came the three: *Caculhá Huracán* (the lightning), *Chipi-Caculhá* (the small flash) and *Raxa-Caculhá* (the green flash) that represent life and all creatures.

Number 4: Diaz (1995) states that the Venus Goddess, called *Kukulkan* is represented by number 4 because it corresponds to the four sides of the rhombus. His view is that the number 4 is "in the design on the skin of the *Crótalus*" (p. 8).

Number 5: The gods delegated their power to the priests. The priests were considered as the hands of the god because they gave to the Mayan people the gods' answers to their prayers. In Mayan ceremonies, the priests held ceremonial rods decorated with rhombuses in the centre and a snake head on top and they were "the mathematical insignias of the wise priests that ordered the construction of the Mayan temples" (Diaz, 1995, p. 8).

Number 6: In Mayan cosmology, bones are like seeds because everything that dies goes in the Earth and then new life emerges from the Earth in a sacred cycle of existence.

Number 7: The Mayans believed that the divine power of the gods reorganizes the order of the cosmos and reunites the human world with the supernatural and mystical worlds.

Number 8: Everything on and of the Earth relates to material reality (the body) and spiritual reality (the soul).

Number 9: *Alom* made nine drinks with the milling of yellow and white corn. With these drinks she created the muscular body and the robustness of men.

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[5] According to Diaz (1995), "the root of Tz'akol is Tsa or Tza, that is Tzamná or Itzamná, which comes from Tzab, rattlesnake, which is onomatopoeic with the sound of the rattle" (p. 8).

14. The Symbolism of Maya Numerology

Mayans perceived that natural events occurred in accordance with numerical patterns, as in the annual sequence of the lunar cycles. Numbers were related to the manifestations of nature and for this reason it was possible to determine that the universe obeys laws that allowed them to measure and anticipate certain forms of natural events. Because of these observations, "the Maya are said to have "mathematized" time, and, through it, their religion and cosmology" (Ascher 2002, p. 63).

Despite advanced mathematical knowledge of the Mayan people, they incorporated concepts of theogony[6] with concepts of numbers by utilizing symbolic elements to express their ideas about the creation of the universe. See in this context, the Mayan theology posits nine cosmic manifestations that are perceived in nature and through which the Mayan people infer the abstract manifestations of God.

The theogonic philosophy of the Mayans exceeds the limits of mathematical knowledge because it relates to the numbers of the abstract manifestations of The Great Architect, with the objective of explaining, understanding, and comprehending the organizational principles of the creation of the universe.

15. Final Considerations

This study focuses here on the ethnomathematics of the Mayan, aiming to understand how they knew, understood, and organized part of their mathematical knowledge to comprehend and explain the creation of the universe according to their believes. In this perspective, the Mayans developed a sacred and magical numbers system through the construction of mats that were elaborated in divine patterns.

Mayan people possessed a sophisticated geometric and numerical creation story of their universe, whose first record is related to sacred numerical values. From what we understand of the Mayan cultural perspective, numbers, symbols, and words could direct the priests to deities of corresponding numerical values. The Mayans were not the only Americans to use this perspective, it is important to highlight a study of the Inca quipu by Ascher & Ascher (1981) who found "... the quipu could be a demonstration of interest in the number itself; or the number could have significance because it has been invested with some meaning beyond its numerical value" (p. 140).

The study of mathematical practices as found in the Mayan sacred mat and geometric diamond patterns serve as a tool to understand and analyze the sacred power of numbers, from 1 to 9, which can be considered as a useful numerological system used by the priests to codify and interpret messages. This aspect of the Mayan culture helps us to demonstrate one use of an ethnomathematical, anthropological, and global perspective in which we might recreate, internationalize, study, and preserve a portion of the wisdom and knowledge of these unique and resilient peoples.

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[6] The genealogical account of the origin of the gods.

In this context, from a global perspective, ethnomathematics can be considered an academic counterpoint to globalization, and offers a critical perspective of the internationalization of mathematical knowledge through attempts to connect mathematics and social justice. It is also possible to perceive ethnomathematics as the academic articulation between cultural globalization of mathematical knowledge and diverse non-Western cultural groups. In this ethnomathematical perspective, it is important that individuals in different cultural groups understand the overall importance of their own mathematical knowledge. They may also need to extend the scope of this knowledge through collaboration with diverse cultural groups (other than their own) by sharing different mathematical practices that are part of a developing new context of globalization.

See in the above context, when discussing, sharing, and internationalizing mathematical practices and the ideas used by other cultures, it is necessary to recast them into an individual's Western mode, modelling allows us to translate these practices into western mathematics. In this cultural dynamism it is possible to distinguish between the mathematical practices and ideas which are implicit and those which are explicit, between western mathematical concepts and non-western mathematical concepts which are used to describe, explain, understand, and comprehend the knowledge generated, accumulated, transmitted, diffused, internationalized, and globalised by people in other cultures.

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