Mayan Elders, Mayan Mathematics, and the Weaving of Resistance in Maguey Bag Production

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Abstract
This article documents maguey bag production by two Mayan elders and presents an emergent analysis of the Mayan ethnomathematics involved in the procedure. Maguey bags are created using the vigesimal system, which provides continuity to a process transmitted orally and by example since the time of the ancient Maya. This method, handed down by Mayan elders to their grandsons, offers a glimpse into the role of mathematics in strengthening the identity and political resistance in autonomous rural communities in Chiapas, Mexico.

Introduction

The contribution of Mayan elders to the body of indigenous knowledge available today in the Mayan world is significant. While much has been lost due to the onslaught of Spanish colonialism which began in the early 1500's the knowledge that remains has been carefully handed down from one generation to the next, nurtured and preserved by elders, in a context of support from Mayan communities.

During the five years (2000-2005) that I worked at a Mayan autonomous school in Chiapas helping to support and develop Mayan ethnomathematics, promoters (teachers), students and I would have benefited greatly if Mayan elders from surrounding communities in the Highlands had been able to respond to an invitation to come and share their knowledge with us. It became clear, however, that this was not a simple proposal, due to a "low intensity" war in Chiapas directed toward Mayan peoples who rebelled against the Mexican government starting in 1994. Consequently, having elders come to our workshops to impart their knowledge of what is referred to in the Highland community as "*Tzotzil*

Mathematics" (*Tzotzil* is the Mayan language spoken in the Highlands) was not an option. Nevertheless, a group of promoters (teachers), secondary students, some community members and myself pooled our collective knowledge and did our best to develop a strong curriculum in Mayan mathematics.

Subsequently, in July 2006 in a nearby town, I was fortunate to participate in a presentation given by a Mayan elder (whom we will call "Pedro") and his grandson on the making of a maguey bag. The following summer, in August 2007, I pursued the matter further, wanting to understand more about this remarkable process that has been handed down orally and by example from grandfather to grandson since the time of the ancient Mayans. I went to an autonomous Highland community and was given a more thorough demonstration of the creation of maguey bags by a Mayan elder whom we will call "Antonio." In addition, some further clarifications regarding the content of this article were made during a short but productive fieldwork trip in July 2008.

This article will document and analyze some of the Mayan indigenous knowledge transmitted through the weaving of maguey bags (the *Tzotzil* word for maguey bag is "*nutie"*) by each of the two elders. Their example is illustrative of Mayan ethnomathematics, is part of the broader context of Mayan weaving, demonstrates the resilience of Mayan culture, and contributes to the ongoing construction of Mayan identity and resistance.

Autonomy and the significance of a tradition

Mayan elders and their grandsons weaving traditional maguey bags are situated within the autonomous project taking place in Chiapas today. Autonomous Mayan communities are committed to preserving the ancient traditions, "rescuing the culture"

(Hirsch-Dubin, 2005) and ensuring that the future continues the proud history of Mayan peoples. Such goals are possible to galvanize in autonomous communities because Mayas are actively engaged in a self-initiated and self-defined democratic process at the grassroots in rural communities in Chiapas. In essence, autonomous communities decide what is important to them through consensus, including the preservation of traditional cultural practices, and then work collectively to implement their decisions.

One way that ancient traditions are perpetuated in autonomous communities is by support for elders teaching their grandchildren, including the apprenticeship of grandsons learning the meticulous procedure of weaving maguey bags. Community support consists of an acknowledgment by the collective that ancient Mayan traditions should be preserved and practiced. Whenever possible, maguey bags are sold in order to provide some economic support to the families who pursue this time-consuming but culturally valued tradition. As a recent publication about the Mayan autonomous movement in Chiapas attests, " *indigenous rebels in Chiapas have maintained for centuries and maintain today their own languages and cultural identity, including popular and ancestral knowledges and practices*" [emphasis added] (Rojas, 2007, p. 123). As a result, there is a strong sense of pride in the ancestral practice of weaving maguey bags and the preservation and transferal of knowledge that accompanies the process.

Both elders were unable to read or write but were masterful at producing finely crafted utilitarian maguey bags. It seemed that they were not only weaving bags of maguey but were weaving a resistance that has affirmed this extraordinary work from the era of the ancient Maya until today. This tradition provides a compelling example of an

ethnomathematics practice that has endured over 515 years of Spanish and Mexican colonialism.

Assault on Mayan Culture

Carrying on a tradition such as the weaving of maguey bags in autonomous Highland communities in Chiapas is an impressive feat of resistance when seen in the context of the savagery of Spanish colonialism. The arrival of the Spanish initiated a long history, which continues today, of an assault on the culture, traditions, languages and identity of indigenous peoples. A "homogeneous vision" was imposed by the Spanish, followed by the Mexican nation, requiring an "assimilated" indigenous population (Bonfil, 1996). A profound historical example of the coercive nature of assimilation was the massive burning by the *Conquistadores* of the Mayan books or Codices, which were compendiums of astronomical, calendrical and mathematical knowledge. What remains today are copies that were sent to cities in Europe at the time, like Madrid, Paris and Dresden (León-Portilla, 2003). In light of findings over the last 20 years by Mayan studies scholars (Coe, 1999; León-Portilla, 2003), including those of a burgeoning group of Guatemalan Mayan scholars (Cojtí, 1996; Matul Morales, 1989; Montejo, 2005), we can begin to comprehend the enormity of burning the sacred texts that contained the brilliant achievements of the ancient Maya.

As we look at the Mexican nation today, it is clear that the goal of "homogenization" continues, fueled by the demands of a globalized economy and a compliant political system (Diaz-Polanco, 2006). As a result, some of the strategies to eradicate indigenous identity have changed but the message remains the same. For example, "official" government education teaches Mayan students a curriculum in which Mayan history is conspicuously absent because its version begins with the Conquest. Furthermore, even though government

schools are called “bilingual and bicultural” (Hernández Grajales, 1991), Mayan students are punished for speaking their native languages yet are unable to understand their Spanish-speaking teachers. A number of students at the autonomous school I worked at in Chiapas described parents removing their children from government schools as an “act of resistance” (Hirsch-Dubin, 2005, p. 208).

In the context of a distorted and disrespectful education, the movement for Mayan autonomy has developed an approach to education designed to counter the attack on Mayan culture, history and identity. The stated goal of autonomous education is to “revitalize language, culture and resources” (Hirsch-Dubin, 2005, p. 208). In the 38 autonomous municipalities throughout Chiapas there are now several hundred primary schools and a growing number of secondary schools in which Mayan students are able to learn about their history, speak their native language without fear of punishment, and develop pride in their Mayan identity. One aspect of the knowledge being retrieved in some autonomous schools is Mayan ethnomathematics, which consists of ancient Mayan mathematics and culturally based mathematics practices widely used (although not recognized as such) in the communities today.

This brief glimpse into the struggle of Mayan peoples to persist and thrive within a climate of negativity and outright destruction is designed to give the reader a sense of the price of maintaining cultural integrity and identity. At the same time, young Mayans, like many of the students at the autonomous school, insisted, “We are descendents of the ancient Maya. Our ancestors had extraordinary knowledge and could calculate in an advanced way. We want to follow in their footsteps because we are also Mayan” (Hirsch-Dubin, 2005).

Making a maguey bag

The intricate process of making a maguey bag begins with cutting the long cactus leaves of the maguey plant, cultivated since ancient times (see photo #1).

Photo 1 cutting maguey plant (photo by Arturo Rosette)

The leaves are then placed on a block of wood on which the natural fibers are separated from the green ones with a cloth-covered machete (see photo #2).

Photo #2: separating natural fibers (photo by Faviana Hirsch-Dubin)

Once separated, the durable fibers are carefully placed in a protected area to dry. According to the second elder Antonio, whom I observed in August 2007, the fibers dry either in a few hours or a few days, depending on the weather. Once dry, the thigh spinning of the fibers takes place, to make them as smooth and pliable as possible.

Both elders, Pedro and Antonio, explained that once the thigh spinning and twisting step is completed, the weaving of the bags begins. A simple hand-held metal weaving device is used, that holds the shape of the bag as the weaving proceeds (photo #3). Pedro and Antonio separately described and illustrated the weaving of the bag from its base to the top, alternately called “boca” (mouth) or “orilla” (edge) of the bag.

Photo #3: weaving device (photo by Arturo Rosette)

Pedro's 9-year-old grandson, whom we will call "Josue", was at his grandfather's side during the demonstration in July 2000 (photo #4). Josue had begun to weave his first maguey bag after carefully observing his grandfather and helping him with each stage of the entire process. Josue's bag measured 20 centimeters, half the size of his grandfather's bag, and was also counted and measured using base twenty. The term in *Tzotzil* for 20 cm is "*jch'ix*" and is measured using an outstretched hand from the tip of the 3rd finger to the thumb. (Fieldnotes, 2008). Josue's wide grin in response to our praise of his first woven bag confirmed the pride he felt as a young apprentice of this historic tradition.

Photo #4: Pedro and grandson (photo by Arturo Rosette)

In this context, there are two important factors to note. One is an apprentice model of learning (Milroy, 1992) in which the grandson grasped the operations by carefully following the step-by-step process of his grandfather. Secondly, it provides evidence of Mayan indigenous ways of knowing and transmitting knowledge, in which ancestral traditions are

handed down orally, experiential knowledge is gained through observations, and collective inquiry is generated as elders educate the next generation (Hirsch-Dubin, 2005).

Mayan mathematics in bag making

Pedro and Antonio counted the loops at the bottom of each maguey bag (independent of each other) using base twenty. The practice of using base twenty dates back to the ancient Mayans, who utilized fingers and toes "as a model set" (Ifrah, 2000), which refers to the traditional basis for calculating multiples of twenty. Importantly also, twenty was used because it "finished a person" (Seidenberg, 1986). As Pedro and Antonio pointed out, why use " half a person" (meaning base ten) when you could use the "whole person (or base twenty) (Fieldnotes, 2006, 2007).

Additional evidence of the use of base twenty as a unit surfaced while I was learning counting terms used in the Mayan language *Tzotzil* (Fieldnotes, 2008). The word for "one person" in *Tzotzil* is "*j'un vinik*" which is the equivalent of twenty (the sum of fingers and toes). In counting past twenty in *Tzotzil*, a second person is included as each of their fingers and toes is added until reaching two person units or forty. *Tzotzil* articulates each unit or person as twenty and expresses consecutive multiples of twenty as subsequent person units of twenty are combined. Thus *Tzotzil* embodies base twenty within its linguistic structure and practice.

The practice of using base twenty goes back to ancient Mayan mathematics, in which numbers were counted by twenties from the bottom up "as the plants grow" (Hirsch-Dubin, 2005). The weaving of the maguey bag follows the same method, using the vigesimal counting system and working from the bottom up to complete the bag. Furthermore, base

twenty, which utilizes fingers and toes, is viewed as more accurate (according to Pedro and Antonio) and continues a long tradition of Mayan numeration.

Maguey bag making utilizes a traditional measurement to create the long fiber cord, known as "*ixtle*" in *Tzotzil*, to string the loops of the bag. Elders use a body measurement stringing the fiber from the right shoulder to the end of the opposing left hand, which is the equivalent of one meter. Antonio explained that using this method he would "measure the equivalent of 400 meters of maguey spun fiber (repeating the same process to get one meter 400 times) in order to create a bag of 40 centimeters" (Fieldnotes, 2007 and 2008). The 40 centimeters was demonstrated by using an extended hand measurement described earlier (from the tip of the 3rd finger to the thumb) two times, since each of these hand measurements equals 20 cm or "*jch'ix*" in *Tzotzil*. Apparently, the use of hand measurements to express centimeters is common in weaving of all kinds in Mayan communities. (ibid) This measurement of 400 meters converts to approximately 1,312 feet of fiber for a bag that measures approximately 1.3 feet in a standard we are more familiar with in the United States. Antonio insisted in *Tzotzil* through a Spanish translator, after responding to the question about calculating the amount of fiber or "*ixtle*" needed to make a maguey bag of 40 cm, that he "doesn't make any mistakes in the length of fiber needed to complete the bag" (Fieldnotes, 2007). It is also evident from this example that base twenty provides a convenient multiple to use in measuring *ixtle* fiber cord.

What becomes clear then is that similar to other Mayan ethnomathematics practices used in autonomous communities in Chiapas, these procedures are not recognized as mathematics because the mathematics is embedded and takes time and support to emerge. Unless questions are asked that begin to reveal the ethnomathematics, the work is simply

accomplished. As in the practice of creating a 20×20 *milpas* or cornfield, maguey bags are woven using a base twenty count but are not recognized by Mayan practitioners as exemplary of Mayan mathematics. I believe this is the result of not conceiving of their work from an ethnomathematics perspective but instead carrying out age-old procedures used for practical purposes, like hauling corn cobs or potatoes.

It is interesting to note in discussions and interactions with both Mayan elders in 2006 and 2007 that starting to frame their maguey weaving tradition in an ethnomathematics context begins to make sense to them, as it is both concrete and culturally relevant. As I learned in my work with Mayan promoters and students at the autonomous school over five years however, the internalization of an ethnomathematics perspective takes a considerable amount of time to be collectively processed and seen as useful.

It is likely that more Mayan mathematics lies beneath the process of making a maguey bag that will take further research to uncover, as was affirmed by my short investigation in July 2008. Ideally, being an interactive observer from the initial cutting of the maguey leaves to the final tie-off at the end of making a completed bag (2-3 months), would most certainly reveal further mathematical approaches beyond what I have been able to elicit thus far.

Contexts for use of base twenty

Base twenty or the "whole person" is significant throughout the ancient Mayan system of mathematics, astronomy and calendrics. Seidenberg, in writing about the mathematical notation of the ancient Maya, points out that one of the words for twenty in the Mayan languages is "*uinic*…which is a variation of the term for 'human being' and in this context refers to the totality of his digits" (Seidenberg, 1997, p. 293). This linguistic term,

similar to the term "*vinic*" in *Tzotzil*, explained by Seidenberg provides additional evidence for conceptualizing base twenty as equivalent to a "whole person."

Ancient Mayan mathematics, rooted in base twenty, was one of the most advanced mathematical systems ever created, according to various sources (Closs, 1997; Garcés Contreras, 1995; Sharer & Morley, 1994). To this day, scientists and mathematicians are trying to figure out how the Mayans calculated astronomical orbits of planets and stars whose results are almost identical to those of calculations using modern technology. The Mayan mathematical system used only three symbols: a conch shell for zero; a bean for one; and a stick or bar for five. This simple yet advanced approach to numeration enabled the ancient Mayans to produce complex calculations, aided by their use of zero as both a number and a placeholder. Previous to the Mayans, zero had not been used in any mathematical systems. According to León-Portilla, The Mayans during the Classic period (around the third century) "discovered the concept of zero, principally as a symbol of completeness" (León-Portilla, 1988, p.1). León-Portilla goes on to say,

> *"What is known about zero today comes from the inscriptions in the Mayan codices and stelae. There's no parallel in the Old World until around the eighth century A.D. at which time Hindustani scholars arrived at a concept of zero within a decimal system of notation. Europe was not to possess these discoveries (including place value) until many centuries later*" [emphasis added] (León-Portilla, 1988, p.1)

What is important to draw from this example of the Mayan discovery of zero, as well as its philosophical implications, is that Mayan peoples today have had to assert the importance of their role in the history of mathematics and its philosophical extensions because ethnocentric interpretations tend to leave them out. By bringing to the foreground the brilliance of both the ancient Mayan systems of numeration, astronomy and calendrics

and the continuation of many of the same practices in contemporary communities, a more authentic version of Mayan history in mathematics and other areas, begins to be affirmed and understood.

Looking briefly at ways in which the ancient Maya and to some extent the contemporary Maya use base twenty reveals intercontextual relationships (Floriani, 1993). For example, the Mayan calendars were designed using base twenty. The solar calendar or "*Haab*" had a year of 360 days + 5 (called "*uayeb*" or "lost days") comprised of 20 days X 18 months. The ritual calendar or "*Tzolkin*" had a year of 260 days comprised of 20 days X 13 months. The two calendars are synchronized every 52 years. So calendrical time sequences, crucial to planting and harvesting crops, employed base twenty or the "whole person."

Ancient Mayan astronomy is also interrelated with the Mayan system of counting time, as both use base twenty and rely on charting the movements of the sun, moon, planets and stars. Many of the buildings constructed throughout the ancient Mayan world were intentionally positioned in relation to the solar equinoxes, solstices and eclipse cycles, as well as having the *Haab* count inscribed on their walls (Aveni, 1997). Mayan cosmology, which explored a holistic relationship among humans, nature and the universe, utilized a "whole person" or base twenty in a systematic approach that corresponded with their astronomical calculations.

Ancient Mayan agriculture, which continues through the use of 20×20 *milpas* or cornfields and complex terracing methods today, grew out of calendars and the positioning of the sun, stars and planets. Cycles of planting and harvesting were carefully followed, as certain celestial configurations were considered auspicious times to plant. In a tradition that

continues today throughout Chiapas, contemporary Mayans continue to create their *milpas* using base twenty, calculated using walking step lengths, as "it has always been done" (Hirsch-Dubin, 2005). It is remarkable to find this age-old technique of measuring cornfields being used even on steep sloping hillsides in the Chiapan Highlands.

Mayan mathematics, weaving traditions, identity and resistance

The concept of cultural identity and its social construction is a complex process. For my purposes here, identity is used to refer to the ways that Mayan people in Chiapas share cultural practices, belief systems, languages and ways of knowing. The focus is also on aspects of Mayan mathematics that resonate with and support a continually evolving Mayan identity, in which resistance has played a central role. I will highlight several aspects of this intersection.

The use of a vigesimal system or complete person in mathematics is related to ancient Mayan cosmology within a Mayan view that incorporated the natural and "more than natural" (referred to at times as "supernatural") worlds in a holistic way. Human beings were seen as tied to celestial beings and integrated into an all-encompassing universe (Sharer & Morley, 1994). Everything was (is) animate, including time, celestial bodies, nature and the unobservable (like the underworld, for example). Thus, Mayan numeration using base twenty incorporated mathematical and more than mathematical ways of thinking that represented a pattern throughout the Mayan world.

Hernández-Castillo brings together several aspects of the relationship among cosmology, the role of elders and the transmission of knowledge in her analysis of Mayan women. "*We interpret indigenous cosmovision, or the science of indigenous peoples, and*

recognize our elders as the carriers of our ancestral knowledge, let them be teachers of the next generations" [emphasis added] (Hernández-Castillo, 2005, p. 8).

So how do these points about cosmology, the role of elders and the intergenerational transferal of knowledge relate to Mayan mathematics, identity and resistance? The richness of Mayan culture, mathematics and ways of knowing are rooted in a defiant Mayan history and identity, which has been consciously maintained through successive colonial regimes. The Spanish Conquistadores sought to eradicate ways of thinking and practices it deemed "backward" and even "satanic." More "sophisticated" attempts to undermine Mayan cultural practices by Mexican colonialism have used more complex terms like "indigenism" or "assimilation" but in the end the goals are the same. Attempts to create an "imaginary Mexico" based upon a ficitious Westernized conception, as pointed out by Bonfil more than a decade ago (Bonfil, 1996), is continually unmasked by those who comprise "Profound Mexico" (ibid) whose indigenous cultural roots have contributed to the Mexican national personality. A more explicit view of Mayan identity is being collectively constructed in conscious ways today in autonomous and other Mayan communities throughout the Mayan world in spite of ongoing racist attempts to deny the dignity, power, and contribution of Mayan peoples. As Victor Montejo, the Mayan scholar from Guatemala argues, "Reaffirming identity is an excellent form of breaking away from the stereotypes that have held us mentally captive" (Montejo, 2005, p.7).

Weaving maguey bags can then be seen as a tradition that has resisted extinction, as an example of ethnomathematics (which often embodies mathematical resistance to Eurocentrism), which fits within the broader context of Mayan weaving, which has also persisted for centuries. Textile weaving is carried out predominantly by Mayan women and

is noted for “preserving the design of the Mayan universe and ancestral weaving techniques” (Otzoy, 1992). Specific designs perpetuate and convey a Mayan cosmological vision of the world, their identity, and their relationship with nature (ibid). In carrying on a tradition that Mayan mothers have taught their daughters, from generation to generation for over three thousand years, we see a parallel with the weaving of maguey bags. Both weaving traditions offer powerful examples of Mayan resilience and resistance to Spanish and Mexican colonialism by virtue of being passed on intergenerationally and continuing to assert Mayan cultural practices.

Evidence that supports the cultural significance of weaving and its correlation with mathematics contributes to how an ancient culture has managed to survive. Karlslate, in an article on the weaving patterns and designs of the *Tzotzil* Mayan peoples of the Highlands of Chiapas (Karlslake, 1987), argues that weaving “requires the weaver to memorize mathematical formulae and number sequences, which is very apt in a culture that has for centuries revered the magical quality of numerical relationships” (Karlslake, 1987, p.11). The notion of a “magical quality to numerical relationships” is also referenced in descriptions of Mayan design patterns in clothing and sacred mats (Orey & Rosa, 2007). Orey and Rosa present an integrated conception of Mayan numeration based on the calendars, astronomy and sacred interconnections of number in a Mayan view of the universe (ibid). Both sources cited here illustrate a view of Mayan cultural, mathematical practices that offer indigenous perspectives on mathematics and ways of knowing.

Before concluding, it is worth noting that the use of base twenty is articulated in a prayer used in Mayan women’s weaving. The first four lines of the prayer made to the

patron saint of weaving, Santa Rosa by young girls and their mothers in the Highland town of Chamula in Chiapas states:

> Please lend me the toes of your feet
> The ten fingers of your hands,
> Engraved heavily in my mind
> Engraved heavily in my heart… (Otzoy, 1992, p.102).

This prayer not only conveys base twenty (the whole person) but also continues a tradition that has been essential for the survival of ancient Mayan culture as passed down through the generations. Beginning to make visible to Mayan male elders (as well as women) the underlying mathematics in the weaving of maguey bags and in textile weaving has the potential to strengthen the capacity to educate Mayan youth about practices that have been so carefully preserved in Mayan communities.

Concluding remarks

As one team of promoters (teachers) said at a Mayan autonomous school workshop in Chiapas in 2003, "*ethnomathematics is created in the environment of each people, each culture, like the example of Mayan mathematics which is its own knowledge."* [emphasis added] (Hirsch-Dubin, 2005, p. 202). The same group of promoters went on to say, *"It is important to learn all aspects of the knowledge of our ancestors. We want to know everything because their knowledge is our wealth*" [emphasis added] (ibid, p. 204).

The promoters at the autonomous school articulated the perspectives quoted above after four years of working together. During that period I designed workshops in which specific arguments were made and discussed hoping to generate ways of seeing mathematics as culturally based (Hirsch-Dubin, 2005). A wealth of "ethnomathematics-like" thinking and practice was already part of daily life, as was a basic understanding of the contribution of their ancestors, the ancient Mayans. But it was another set of factors and processes over

time that allowed this thinking and practice to be valued and be articulated as "ethnomathematics."

Just as young Mayan promoters teaching the next generation of Mayan youth about the importance of Mayan mathematics is an expression of cultural integrity and continuity, Mayan grandfathers teaching their grandsons how to weave maguey bags carries on an ancestral tradition. By doing so, weaving and emergent Mayan ethnomathematics play a key role in a culturally based resistance that has endured over more than five centuries. The ancient practice of weaving bags of maguey is a powerful example of Mayan autonomous politics of knowledge. Through that lens, as well as through the Mayan language *Tzotzil* which expresses base twenty, the vigesimal tradition is kept alive, not only as a basis for counting but also as a conceptual base for a Mayan worldview.

As the documentation and analysis in this article has argued, the weaving of maguey bags by Mayan elders is part of an autonomous process taking place in communities in resistance throughout the Southern state of Chiapas, México. This extraordinary process breathes life into the history of Mayan ethnomathematics and indigenous ways of promoting knowledge from one generation to the next. Mayan mathematics, including the ongoing use of the ancient vigesimal system, is integral to an insurgent Mayan identity that has persevered over more than 515 years despite colonial attempts to sabotage its development, its growth and its very existence.

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