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Ethnomathematics

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When asked to think about a foreign country the first thing that comes to my mind is the language barrier and the customs that accompany that specific country. The culture of the citizens and how it differs from my culture are also things which peak my interest. Things which I view as "normal" may seem very odd to someone who lives thousands of miles away, and likewise, traditions that have been past down from generations of people from distant lands may seem peculiar to me. These customs and cultures of which I speak are also the things that make this world such an interesting place to live, study, and explore. One might think that mathematics has no place in a discussion of different cultures and worldly studies, citing that mathematics is purely numbers and the manipulation that occurs between them. However, adopting this train of thought would be closing the door and the mind on a topic that is bridging cultural gaps from around the globe. This relatively new field of study is called Ethnomathematics.

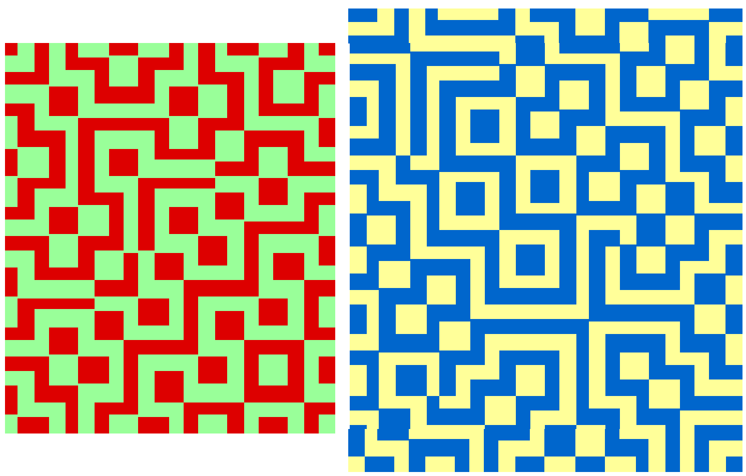
Ethnomathematics is the study of the relationship between different cultures and mathematics. It refers to a broad cluster of ideas ranging from distinct numerical and mathematical systems to multicultural mathematics education. The goal of ethnomathematics is to contribute both to the understanding of culture and the understanding of mathematics, but mainly to appreciate the connections between the two. The term ethnomathematics was coined by Brazilian mathematician Ubiratan D'Ambrosio in 1977 (Wikipedia, 2007, Sec. 2). Since that time there has been much discussion on the actual definition of ethnomathematics, and its place in the academic world.

Ethnomathematics looks at how different cultures use mathematics and how they incorporate it into their daily lives. Not necessarily in a math classroom setting, but in the actual things they do and make, such as games, designs, arts and crafts, and decorative designs. By studying and analyzing such things ethnomathematicians are beginning to better understand how the people of these different cultures think, work, and relate with others within their own culture, as well as the world around them. This field of study is helping us to understand why some cultures do the things they do, and more importantly, helping us to understand how it can relate to our own culture.

Let's begin by taking a look at some examples of ethnomathematics. The first is from the Tchokwe population in Angola, a country on the western coast of Africa. For centuries the Tchokwe used pictograms as a means of storytelling in their villages or hunting camps. Typically these drawings were done in the sand by experienced storytellers who over the years had perfected the designs and had committed them to memory. These storytellers were looked upon has having great knowledge and the more pictograms one had committed to memory the more elite this person was viewed. Young boys would learn simple designs and were taught more elaborate and intricate pictures as they progressed through their lives. Unfortunately much of this art was lost when colonialism and the slave trade caused most of the designs to be lost. If it were not for a few missionaries and ethnographers much of these patterns would be lost today.

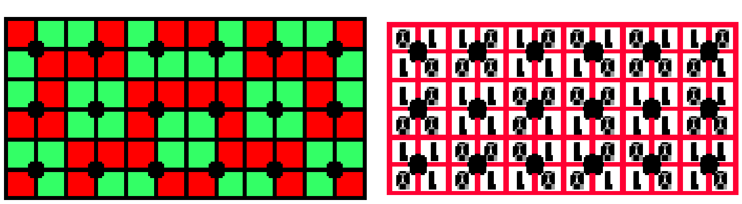
Geometrician Paulus Gerdes had been studying and analyzing the mathematical properties of these pictograms since the mid 1980's. Gerdes, the former Vice-Chancellor of the

"Universidade Pedagogica" (1989-1996, Mozambique), has noted that the designs and patterns from the Tchokwe pictograms contain many mathematical properties (Gerdes, 2002). Since the Tchokwe are descendents of the Lunda people and still today live in a region called Lunda, Gerdes has decided to call these Lunda designs. The following are two examples of Lunda-designs:


(Gerdes, 2002)

To help break these patterns down to something that he could work with Gerdes decided to put a grid over the tops of the patterns to find any similarities or shared characteristics. Once this was done he could then assign a number to designate each color. Gerdes has broken the Lunda-designs into smaller, more identifiable patterns. One such group is the Liki group, named after his daughter Likilisa.

An example would look like the following:


(Gerdes, 2002)

By making a matrix Gerdes noticed rules that must be applied to making these Liki-designs.

1. The first is that there is one unit between the border and each outside grid point.

2. The distance between all points within the grid is two units.

3. Each column contains the same amount of 0's and 1's.

4. Between each pair of horizontal and vertical grid points two units are one color, and the other two units are the other color.

5. Between the border and each grid point there is one of each color.

Gerdes then wanted to know how many designs would be possible depending on the size of each grid. He set up grids with many different rows and columns of grid points keeping track of how many different patterns he could create. To help keep track he used L(m,n), where L = Liki design, m= the number of horizontal grid rows, and where n= the number of vertical grid rows. His results looked like this:

		n									
	L(*m*,*n*)	1	2	3	4	5	6	7	8	9	10
m	*1*	1	1	1	1	1	1	1	1	1	1
	2	1	2	1	2	1	2	1	2	1	2
	3	1	1	4	1	1	4	1	1	4	1
	4	1	2	1	8	1	2	1	8	1	2
	5	1	1	1	1	16					
	6	1	2	4	2		32				
	7	1	1	1	1			64			
	8	1	2	1	8				128		
	9	1	1	4	1					256	
	10	1	2	1	2						512

(Gerdes, 2002)

Mathematically speaking what he found was the greatest common divisor between the number of horizontal and vertical rows played an important part in determining how many designs could be created. If they do not have a common divisor greater than one then the number of designs that can be created is one. Gerdes concluded that to determine the number of design patterns one must use; **$L(m,n) = 2^{gcd(m,n)-1}$** where gcd(m,n) denotes the greatest common divisor of m and n (Gerdes, 2002).

So when one looks at a Tchokwe pattern he/she should realize that they do not just happen by chance, but rather there is much more detail that goes into the creation of these designs. Also, by changing the number of vertical and horizontal rows one not only changes the pattern, but also changes the number of patterns that can be created.

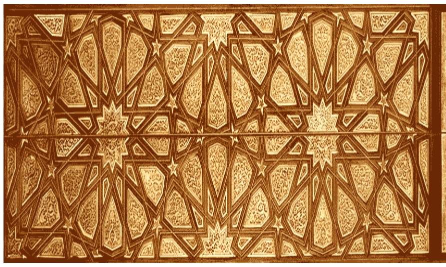
A second example of Ethnomathematics can be seen in many works of art from the Islamic culture. Based on symmetry this art can be seen in many things such as carpets, doors, screens, furniture, and on the architectural surfaces of mosques, palaces, madersas and tombs (Abas, 2001).

The mathematical process used to create these geometric designs comes from the use of symmetry transformations (rotations, reflections, translations and glide reflections) which create the simple yet beautiful patterns.

It is generally believed that the Islamic patterns come in three forms:

1. **Calligraphic patterns**- Molding Arabic lettering for words or phrases to create geometrical forms.
2. **Arabesque**- Spiral forms intertwine, undulate and coalesce rhythmically to produce stylized leaves and flora forms.
3. **Space Filling Patterns**- Polygons, and less frequently, regions bounded by circular arcs. (Abas, 2001).

The most recognizable aspect of these patterns is the use of the star and rosette shapes. Shapes with five, six, eight, ten, twelve and sixteen rays are the ones that occur most frequently.

(Islamicarchitecture.org, 2007)

Religion is believed to have had a signigicant influence on the conception of these pieces of art. The Koran offers no image of god, (only the mention of Nur, meaning light), yet states that, “God is the light of the heavens and earth” (Abas, 2001). Naturally, then, since the stars create the light from the heavens it would make sense that an artist would use these symbols to create his/her art/designs. Also a Muslim must pray five times a day and must know which direction to face. In early times the stars aided the traveling faithful by telling them which direction to face whether they were on land or at sea.

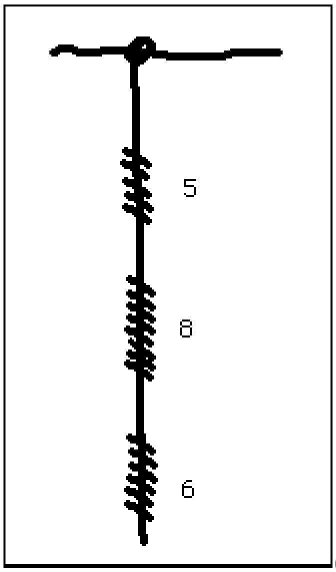
Another area which depicts the geometric symmetry characterizing the artwork of this culture is in the textiles which were created. For thousands of years carpets represented the most ancient and the most meaningful art form of this population. Within some carpets that are sill in production today one can see designs which involve interlacing to produce tessellating patterns.

(Islamicarchitecture.org, 2007)

One can begin to get an idea of how important the role of geometry is in the culture of Islam. It touches many aspects of daily life and one cannot go far without seeing its presence in some shape or form reflected in the civilization around him/her. Designs which we see as merely "neat" are considered sacred in the Islamic culture and thus play a vital role in the study of Ethnomathematics.

A third and final example of Ethnomathematics that I will discuss is the practice of knot tying, called Quipu, which was done by the Inca Indians. It is well known that the Incan civilization flourished during the 1500's with a population of around 12 million people. They were a sophisticated people with a remarkable system of roads, agriculture, textile design, and administration. One thing that many find to be missing from this culture was a highly developed form of writing. How, then, did they keep track of numerical information without the use of writing? The answer is Quipu.

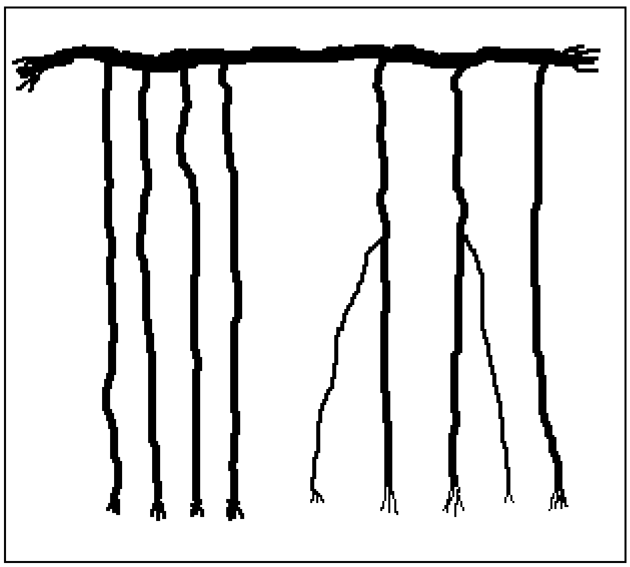
The quipu consists of strings which are knotted to represent numbers, whether they are big or small. To one larger string many smaller strings are attached. Using a positional base 10 representation, these smaller strings can be knotted to represent a value for whatever the Incans may need. If for example the number 586 needed to be represented the string would look like this:



(O’Conner & Robertson, 2001)

It is important that the spacing between the knots be uniform in the case that a zero needs to be used. An extra large gap would then be placed between each group of knots to signify the place holder.

To help them specify what it was they were counting, the Incan Indians would use color to help organize the information. For example numbers of cattle might be recorded on green strings while numbers of sheep might be recorded on white strings. The color choice depended on the type of business that was being done, where the colors represented specific things understood by context in which they were used. In addition to color coding, another way of distinguishing the strings was to make some strings subsidiary ones, these were tied to the middle of a string which was attached to the main horizontal cord.



(O'Conner & Robertson, 2001)

Although the Incas did not perform calculations with quipu it does help to explain how they stayed so organized and were able to keep track of their business affairs. These quipu were the equivalent to our modern day computers. During the Incan rule the king even appointed quipucamayocs, or keepers of the knots, for each town. These quipucamayocs were basically government statisticians, keeping official census records of the population, records of the produce of the town, its animals and weapons (O'Conner & Robertson, 2001). Clearly without the use of the quipu one could argue that the Incan civilization would not have been as successful and as dominant as they were during this time in history.

There are individuals, some being respected mathematicians, who dismiss the field of ethnomathematics altogether. Much of their objection stems from the name “mathematics” being applied to subject matter that is not developed abstractly and logically with proofs (Wikipedia, 2007). Many do not feel that ethnomathematics should be considered a mathematical field because they say it has more characteristics of anthropology. They feel that since most of the work is based on culture it really has no place in a mathematical field.

One such opponent is Richard Askey who authored “The Third Mathematics Education Revolution”. He along with other critics emphasize that ethnomathematics spends too little time on teaching useful mathematics, and too much time on teaching multi-culturalism and pseudoscience (Wikipedia, 2007). One specific claim from Askey is that the textbook *Focus on Algebra* from Addison-Wesley teaches pseudoscience when it makes claims that South Sea Islanders mystic knowledge of astronomy is more advanced than scientific knowledge. Askey along with Marianne M. Jennings feel that within our classrooms we should stick to scientifically based knowledge when educating our children.

Jennings, who wrote the article “’Rain Forest’ Algebra Course Teaches Everything But Algebra”, had a problem when she learned of her daughter’s algebra curriculum at school. Concerned that it was too full of multi-cultural references, political correctness and not enough concrete algebra, Jennings was troubled by the fact that her daughter had an A in class but could not solve an algebraic equation. When it comes to the teaching of mathematics Jennings feels that it is best to stick with material that has a scientifically based foundation, and avoid material that includes “Maya Angelou’s poetry, pictures of President Clinton, and lectures on what environmental sinners we are” (Jennings, 1996).

Whether one agrees or disagrees with the validity of ethnomathematics, the fact remains that it is here to stay. Arguments and debates will continue on how to categorize the information that is discovered and studied with this relatively new research field, is it mathematics or is it anthropology? It is evident however, that ethnomathematics shows us that throughout the world mathematics is involved in everything we as people do. The methods, processes and names may be different from culture to culture, but the end result is always the same. Without a means to organize, collect, and display data no culture or society would have been able to prosper and progress throughout the centuries.

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