Gender, Culture and Ethnomathematics

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In this paper we contemplate three considerations with regard to gender, culture, and ethnomathematics: The long-term trend in Western culture of excluding women and women's activities from mathematics, an analysis of some activities typically associated with women with the goal of showing that mathematical processes are frequently involved in said activities, and an examination of some specific examples of cultural tendencies in which certain skills of women are highly regarded. The cultures we will consider are from the regions of the Andes of South America, India, and Mesoamerica.

Overview

Let us begin with a quote. "On the one hand you have the typically feminine, gentle and woolly world of needlework and, on the other, the exciting but incredibly unwoolly world of hyperbolic geometry and negative curvature" (Higgins, 2010). This is a quote by Horace Bent, the administrator of the Diagram Prize, about the book *Crocheting Adventures with Hyperbolic Planes* by Daina Taimina (2009), which was 'awarded' the "World's Oddest Book Title" in 2009. This quote reveals something cultural. There is an assumption being made that an activity like crocheting, which is typically associated with women, has no place in mathematics. In this paper we will see that the exclusion of women from mathematics in Western culture has existed for at least several hundred years. Second, we will examine several examples of work associated with women's activities in which there is mathematical thinking involved. The examples we will consider come from traditional weavers in Mesoamerica: P'urhépecha, Otomi, Mazahua, Aztec, an Andean culture: The Inca, and from the Tamil Nadu region of India: Tamil culture. Third, we will see how the skills and work by women, including the fact that it involves mathematics, has been considered important in cultures from these three regions. As a concluding example from the Otomi culture of what is now central Mexico, we will compare how the work and skills of women were treated before the arrival of Europeans- and hence the arrival of Western culture, and how such work and skills were then considered differently afterward.

The Long and Winding Road to Acceptance of Women in Western Mathematics

There are plenty of examples of how women have been formally and informally excluded from Western mathematics, until recent times. In the first place, women were prohibited from enrolling in Western universities for any reason until the early Twentieth Century. Second, there are well-documented cases of women who were specifically excluded from formal mathematical activity based solely on gender. Details of several such cases can be found in Burton (2007). I will briefly describe one here.

We can consider the life of (Marie) Sophie Germain (1776-1831). During her lifetime, Sophie was formally prohibited from attending university classes. She wrote several mathematical papers, but wrote under the pen name Monsieur le Blanc in order to hide her gender. In 1831 the University of Gottingen granted her an honorary degree, however, Germain died of breast cancer before she could receive the diploma.

Returning to our initial example of *Crocheting Adventures with Hyperbolic Planes*, by Daina Taimina, there is a sense of disappointment that, even in current times, there are still people who believe that women and mathematics do not belong together.

Mathematics and Activities Associated with Women

There are activities typically associated with women in which mathematical thinking is involved. I would like to look at traditional art as one example of such activity. By "traditional", I mean that the artwork is mainly done by hand, and represents skills and practices that have been handed down for generations. The first example is textile art, specifically weaving and embroidery. Of course, creating textiles has been part of cultures in many parts of the world, so several of my comments here are likely valid for many cultures. My focus is on contexts and cultures in which the weaving and embroidery is done mainly by women. If we look closely at the process of traditional textile art, we will notice that there is complicated mental thinking involved, and there is mathematics, too.

Typically a traditional (textile) artist begins to learn the craft in childhood and continues learning lifelong. Regarding the Mazahua culture of central Mexico, Romaní (2005, p. 60) states that "Desde pequeña la mujer Mazahua assume que bordar es parte de su vida", which translates to: "From the time she is little, a Mazahua woman assumes that embroidery is part of her life." (See also Ascher (1991, Ch. 6) and Gilsdorf (2012, Ch. 5) for further details. In short, becoming a traditional textile artist is not something a person learns in, say, a few days. Careful observation of traditional textile artists making their products reveals that they do not look at diagrams, nor do they use rulers to measure distances while manipulating the threads. The textile project is done entirely from memory. Making textile art in the traditional way takes a long time to learn and requires recalling the details of the entire project by memory.

In fact, we can discover mathematics in the processes. To begin with, let us consider weaving. Many traditional weavers base their projects on extremely large counts of threads. Urton (1997) carefully studied the process of thread counts within the context of women weavers from the Inca culture in Bolivia. Figure 1 shows an example of the thread counts done in the process of weaving in this context.

It is clear from Figure 1 that hundreds of threads are counted as part of the weaving process. Moreover, the patterns of counting are not just raw number counts. Indeed, in order that a stripe of a certain color and width at the top match a corresponding stripe at the bottom, the number of threads must match exactly. More discussion of thread counts can be found in Romaní (2005, p. 62) with regard to the Mazahua culture, and in (1937/1993), with regard to Otomi culture.

Our next view of traditional textile art is embroidery. A main feature of embroidery is that it often includes patterns of symmetry. Thus, the person who embroiders such a pattern has used symmetry,

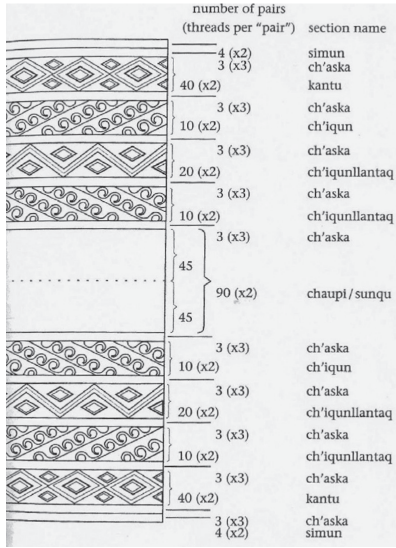

Figure 1: Example of thread counts of a female Inca weaver from Bolivia, Urton (1997).

but we would like to know if there is a way we could verify that the embroiderer understands the mathematical aspect of symmetry. In several interviews I have done with traditional textile artists from the P'urhépecha culture (Gilsdorf, 2011)), when I ask how the artist created a symmetric pattern, the kind of reply I get is something like "I just made it so it would look right." We can ask: If a person does not describe the mathematical definition of a certain concept, can it be that the person understands that concept? Let us examine how a symmetric pattern is formed. To create vertical symmetry, for instance, one must first create half of the pattern on one side, say, the left side, then create the other half, in the *opposite orientation*, so that it matches the left side. See Figure 2.

Hence, if an artist creates such a pattern in this way, the artist understands what it means to be vertically symmetric, even without a formal mathematical explanation of the definition of vertical symmetry. In Ascher (1991), you can read that symmetry concepts include non-trivial mathematical thinking. Here is a separate piece of evidence of how traditional textile artists understand symmetry concepts as they make textile projects. In his description textile of artists of the Otomí culture, Soustelle (1937/1993) states, "… es necesario … hacerlo en dos etapas, una mitad sobre el borde derecho de la banda, la otra sobre el izquierdo" (p. 94). This translates to, "… it is necessary … to make it in two parts, one half on right part of the band, the other on

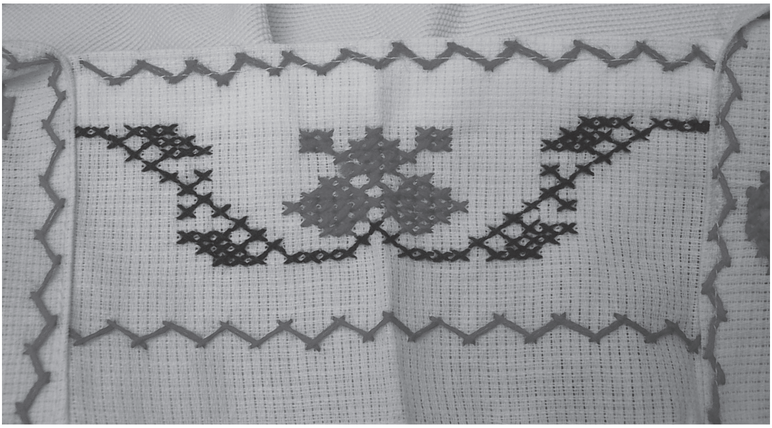

Figure 2: A vertically symmetric embroidery pattern, P'urhépecha culture. Photo ©2011, Thomas E. Gilsdorf

the left." Here we see that the artist creates each half, presumably adjusting the orientation in order to create a symmetric pattern.

The second type of traditional art to consider is *kolam*. Kolam is the art of making designs out of rice powder (or comparable substances), primarily from the Tamil culture of South India and northern Sri Lanka; kolam and similar art forms are done in other parts of Asia (see Ascher, 2002, Ch. 6). The art of kolam is done almost exclusively by women. An example of a kolam design is shown in Figure 3.

As with textile art, learning to make kolam designs begins in childhood. As Ascher (2002) explains, "Girls are taught the designs and techniques by their mothers. It is an important part of girl's training" (p. 163). Kolam figures often include symmetry patterns as you can see. They also frequently include the use of concepts from calculus and computer science. For example, a *continuous curve* in two dimensions is a graph in which there are no holes or breaks and for which the beginning and ending points are the same. Such curves appear in many kolam designs (see Ascher, 2002). Moreover, kolam designs have been studied by computer scientists because of the intricate patterns

Figure 3: A kolam example from outside a house in Tamil Nadu, India. Photo ©2009, Ontology2.

of vertices that can appear in the final product. Finally, kolam patterns have connections to the mathematical concept of fractals – see Ascher (2002, p. 176). An excellent discussion of kolam art, the mathematics involved in it, and its connections to gender roles can be found in Ascher (2002). There is no doubt that the women who create kolam designs have an understanding of nontrivial mathematics concepts involved in the art process, even if they would not express them in textbook mathematical terms.

We can summarize this section by putting the skills of the traditional artists we have considered here in terms of mathematical skills. Let us examine those skills within the framework of "Bishop's Six", that is, six categories of mathematical activity such as, *counting, locating (identifying), measuring, designing, playing (experimenting)*, and *explaining* (Bishop, 1988). It is possible to recognize each of the six categories for the activities done by the artists: In all cases, the artists *measure*, and typically without using any particular measuring tools. Also, the textile artists *count* threads, while the kolam artists keep track of counts of vertices, numbers of curves, and so on. Recall that traditional artists usually make their products from memory. That is, they *identify* the patterns and designs, including geometric and symmetric patterns, and in the case of the kolam artists, patterns that constitute continuous curves and/or vertex and sides patterns that also appear in other areas of mathematics. All artists *design* in the process of creating their products, that is, they determine ahead of time the overall design of the project. The category of *playing* includes the idea of trying different combinations or patterns within the framework of the activity. The general environment of making art as a creative activity indicates that artists often vary the designs and/or the details (e.g., colors) of the designs, hence engage in the activity of play. Finally, traditional artists learn their skill from previous generations and pass those skills to future generations. In other words, the artists participate in *explaining* their craft. In the case of textile artists, for example, a typical situation is that of a group of women who weave or embroider together. With them are daughters, nieces, granddaughters and other girls or young women of the community, learning to be textile artists.

Examples of Cultural Contexts in which Women's Skills are Highly Regarded

As we saw at the beginning of this paper, in Western culture there has been a tradition of excluding the mathematical skills of women. We can look at some examples in which the cultural tendency is to appreciate certain skills of women, hence appreciating the mathematical skills of the women who possess said skills.

The first example is from the Andean culture of the Inca from South America. In traditional Inca culture, a woman who has reached a high level of expertise as a weaver is referred to as a *mama* Urton (1997). This word *mama* is not the Spanish word for *mother*, rather it is a term from Quechua, the language of the Incas that refers to an expert female weaver. In this context, a woman who is an expert at weaving, and as we have seen, uses mathematical skills, is highly regarded in traditional Inca culture. The weaving skills, and indirectly, the mathematical skills, of those women are highly regarded.

Let us now consider the Tamil culture and the art form of kolam. According to Nagarajan (2007, p. 85), regarding the significance of the kolam within the context of female gender roles, "These women's ritual designs also mark time: dawn and dusk; the month of the winter solstice or Markali; and the abundant rice harvest festival called Pongal". Ascher (2002, p. 161) describes the connection between making kolam designs and its social importance as follows: "More than simply a folk art, the kolam tradition is closely tied to, and expressive of, the values, rituals, and philosophy of the people of Tamil Nadu". We can see from these references that making kolam, including its mathematical aspects, is intimately tied to the roles of women in Tamil culture, and the importance of the meanings of kolam, such as marking time and harvests, indicates that this work of women is appreciated and considered important in Tamil society.

Next, we go to Mesoamerica to look at the Aztecs. In Aztec culture the importance of weaving, as a female activity, is also very strong. As Brumfiel (1996, p. 456) explains, "Spinning tools served as symbols of womanhood; they were given to a female infant at her birth and placed with a woman at her death". Moreover, Brumfiel (1991, p. 226) indicates that "Thus, cloth was a primary means of organizing the flow of goods and services that sustained the Aztec state, and cloth production was women's work". Again, we can conclude that in traditional Aztec culture, the skills of women as weavers was regarded with respect and valued highly.

Thus, in each of the cultures we have considered, skills of women are considered to be important cultural knowledge. For further details about connections between gender roles of women and traditional art in the cultures we have looked at a number of resources: Aztec and Maya (textiles): Brumfiel (1991, 1996), Hendon (2006), Joyce (2000), and McCafferty & McCafferty (1991); Otomi and Mazahua (textiles): Gilsdorf (2012), Gilsdorf (2015), and Romaní (2005); Tamil (kolam): Ascher (2002), and Nagarajan (2007); Wari and Inca: Costin (1995, 1998), and Urton (1997).

Before and After: An Example of Change in Perspectives

As one last, but concrete example, let us compare how skills of women had been considered in the Otomi culture before the arrival of Europeans, and how that changed afterward. We can first consider the Aztec document *Codex Mendoza* (Ross, 1978), regarding tributes paid by cultures that were under Aztec control. Figure 4 shows a folio from the codex.

Figure 4: A folio from the *Mendoza Codex*. From Ross, 1978.

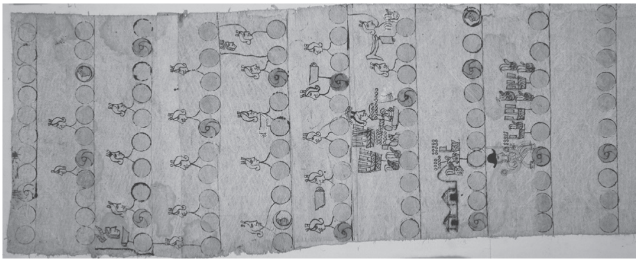

Figure 5: A page from the *Tributos de Mizquiahuala.* From the Biblioteca Nacional de Antropología e Historia, Mexico City.

The icons along the left are symbols of communities that paid tributes to the Aztecs. The icon that is fourth from the bottom is that of the community of Mixquiahuala (which has other spellings, including Mizquiahuala), and the third from the bottom is the symbol for Ixmiquilpan, both locations being part of Otomi territory. Meanwhile, observe the kinds of products that were delivered: At the top are six square shaped icons with what appear to be feathers above them. The icons represent woven cloth products while the feather -like parts on top of those icons represent the number 400. See Gilsdorf (2012, Chapter 9) for more details. The other person- shapes and shield icons represent war suits and war shields, respectively. The flag symbols that are attached to two of the war suits represent the number twenty. There are 400 jars of honey shown in the bottom right corner and two boxes of goods to the left of that. An estimate of the total number of goods that were delivered would be 2400 woven cloths, plus 448 other items; that is, 2848 items. The number of woven cloths represents about 84% of the total. Thus, most of the goods delivered as tributes were textiles and textile related products, and the vast majority of those cloths were made by women. As we saw in the previous section, the Aztecs considered weaving to be an important activity and directly associated it with gender roles of women. We can conclude that there was many cloth products made by Otomi women, those products were delivered to the Aztecs, and the Aztecs considered that work to be valuable.

Now let us jump to after the arrival of the Spanish. Figure 5 shows a fragment of tributes that were delivered to the local Spanish ruler, some time between the 1600s and about 1740. The location is Mixquiahuala, so we can assume that the tributes were made by Otomies.

The figure is sideways, so the fragment is read from left to right. There are several icons of women shown and the one icon of a man represents the local Spaniard. The symbols of women represent household maid and cooking services that were provided. Notice that not one single woven cloth is shown. (There are several other fragments from the collection of tributes, some showing food and other items, but none showing woven cloths (Hermann Lejazaru, 2001)). We can conclude that the role of Otomi women in this location changed dramatically. No longer were their skills at weaving sought, rather, the local Otomi women were valued for their service as housekeepers. This is an example of how the local culture changed.

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