RETHINKING SYMMETRY IN ETHNOMATHEMATICS

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Abstract: *The use of crystallography classifications for symmetries, in particular of the seven possible symmetry classes for repeating strip/frieze patterns using rigid motions of the plane (reflection, rotation, and translation) has been a persistent element in ethnomathematics. Popularized in Crowe's chapter in Zaslavsky's (1971)* African Counts*, and later in Crowe and Washburn's* Symmetries of Culture*, this has become a standard activity in ethnomathematics. But it bears a curious relationship to the fundamental concept of ethnomathematics as a discipline. Here I will briefly discuss the nature of this relationship, and some directions that might lead to alternative frameworks.*

1. INTENTIONALITY IN ETHNOMATHEMATICS

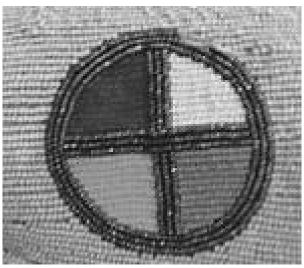
The fundamental concept of ethnomathematics is perhaps best illustrated in a comparison with mathematical anthropology. Mathematical anthropology uses mathematical modeling in historic, ethnographic, and material culture studies to describe material and cognitive patterns, typically without attributing conscious intent to the population under study. The patterns are instead seen as the structural basis of underlying social forces, or as epiphenomena resulting unintentionally from the nature of the activity itself. In part this is due to a reasonable supposition that much of the underpinnings of society would be forces unnoticed by its members (not only because such forces operated at levels beyond individual awareness, but also because regulatory mechanisms would have to be covert, obscured, or otherwise protected from manipulation and conscious reflection). But it also arose from imitation of the researcher-object relation in the natural sciences: if anthropologists were simply reporting indigenous discourse, then they would not count as scientists (as was indeed the case for non-western mathematics, traditionally only a subject for historians). Classificatory systems for kinship (e.g., Morgan 1871) were the first of these models. Later refinements of mathematical anthropology (e.g., Kay 1971) expanded this analysis to a variety of social phenomena, and increasingly complex mathematical tools.

Ethnomathematics, in contrast, stresses conscious intent in the opposite direction. I say "stresses" because neither ethnomathematics nor mathematical anthropology is absolute in that regard. Crowe is a case in point; his work has emphasized the *possibility* of conscious intent or knowledge, simply by virtue of fact that he is working with intentional designs. How might alternative approaches to symmetry further this exploration at the intersections of external modeling and indigenous intentionality?

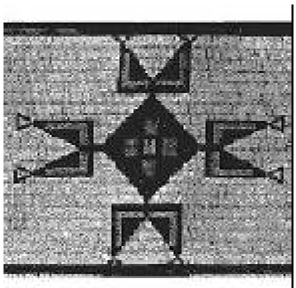
2. CULTURALLY SITUATED DESIGN TOOLS: AN ALGORITHMIC APPROACH TO SYMMETRY IN ETHNOMATHEMATICS

The Virtual Bead Loom, developed in collaboration with teachers and students at the Shoshone-Bannock reservation school in Idaho, is available online at http://www.rpi.edu/~eglash/csdt/na/loom/overvw.htm. The web page begins by showing the prevalence of fourfold symmetry in many Native American designs (textiles, sandpaintings, pottery, etc.), where the "four winds" or "four directions" provide an indigenous analog to the Cartesian coordinate system with its *x* and *y* axes.

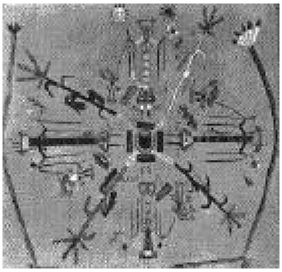
Division into four equal parts, or "four-fold symmetry", is common in many Native American designs.



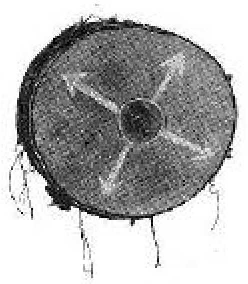
Shoshoni beadwork



Embroidery - Plains Indians

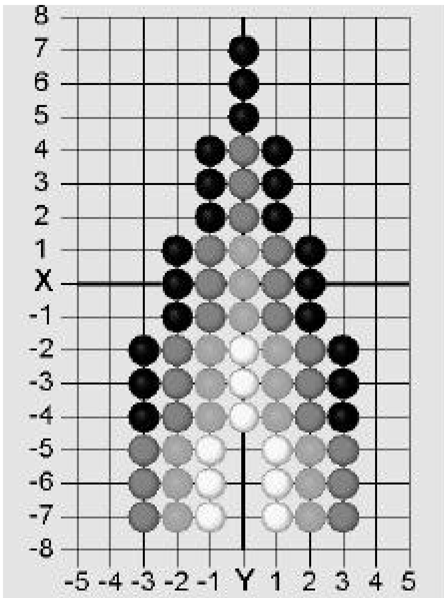


Sand painting – Navajo



Pawnee buffalo hide drum

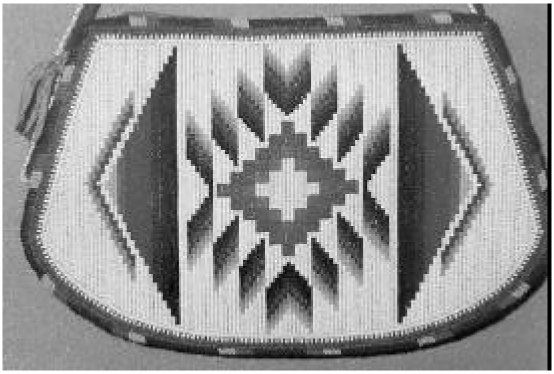
The best case for this analogy (which from the ethnomathematics point of view is a "translation" between two different mathematics traditions) is probably Navajo sand painting. In the sandpainting on our website, we see dark figures on the *X* axis, and light figures on the *Y* axis; with clear faces where the Cartesian graph has positive values and white faces for negative values. Thus dark body clear face for *X* positive, light body clear face for *Y* positive, and so on.



Virtual bead loom

The traditional bead loom also uses a Cartesian-like system (rows and columns of beads), so it was a simple matter to create a virtual loom. The virtual loom enables students to enter *x* and *y* coordinates for bead positions of various colors to create patterns similar to those on a real loom. Selecting one bead at a time was too tedious, so we have been adding "design tools." For example, you can create a filled rectangle of beads by specifying the *x,y* coordinates of the corners. We found that native beadworkers used iterative algorithms (e.g., if the first row of red beads is N_0, and you subtract one bead each time you go up one row, then your general rule is $N_{i+1} = N_i$-1) so our latest version of the bead loom includes design tools that use these iterative rules as well.

Kristine Hansen, a math teacher at the school, had been interested in the symmetries in traditional Shoshone-Bannock beadwork, and found that the Cartesian system made teaching reflection symmetry quite easy, since the design tool allowed speedy replication with reflection to any of four quadrants, simply by changing the sign of the figures. Hansen reports an assignment for creating a "Christmas Tree" pattern by replicating triangles; her students reduced the amount of translation between triangles and turned the Christmas tree into a Shoshone feather pattern. In other words, rather than the static modeling approach, in which external analysis implies that there is only one correct symmetry analysis, the design tool approach allows us to move dynamically between indigenous math and western math, creating new hybrids as well as shedding light on indigenous math that might otherwise be overlooked.



Shoshone-Bannock beadwork examples

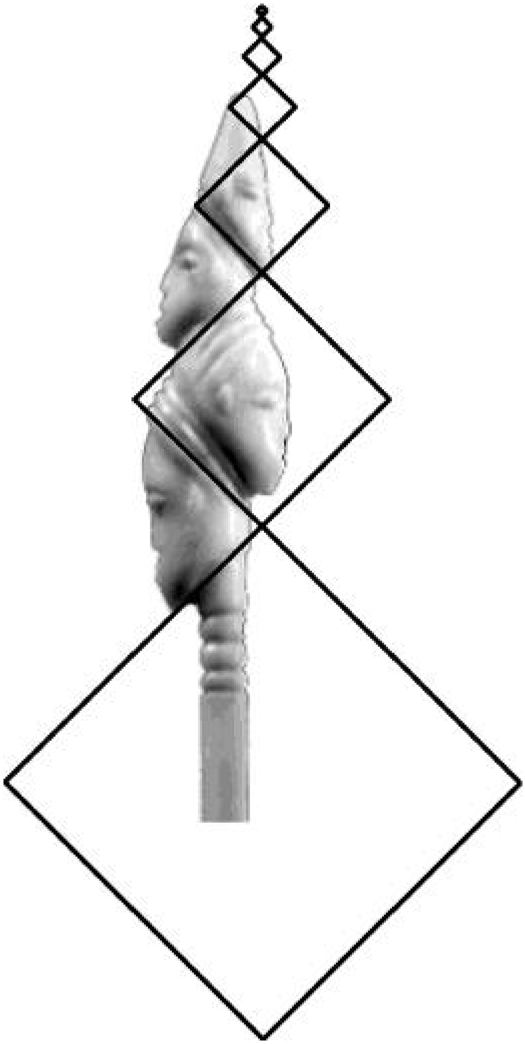
In addition to Hansen's work at the Shoshone-Bannock school, the loom is currently used in middle school classrooms with Mimi Thomas at a school serving students from the Ute reservation in Northern Utah, and with Joyce Lewis at a school serving students from the Onondaga Nation in upstate New York.

The bead loom has columns of fine thread. As the beads fill in vertically, they are aligned in rows.

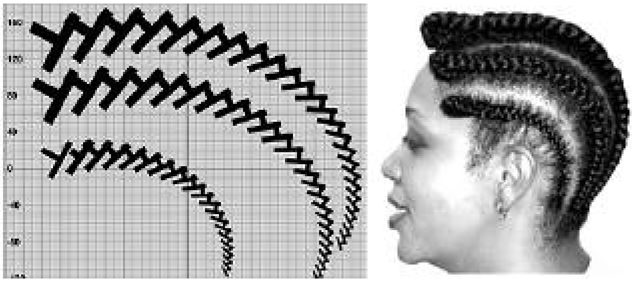
Using a simple Cartesian grid, Shoshoni beadwork provides an astonishing array of geometric forms (Candy Titus, April 1999).

3. CONCLUSION

Other Culturally Situated Design Tools have been developed for examining scaling symmetries in African and African American patterns (see http://www.rpi.edu/~eglash/csdt.html).



Scaling design from Africa is this Mangbetu ivory sculpture: Note that this sculpture not only shows scaling; it is also shows an underlying structure making use of right angles. The Mangbetu live in the Democratic Republic of Congo (formally Zaire). Their beautiful art makes striking use of geometric principles.



Fractal shapes abound in traditional African designs. One African fractal design that is also part of African American innovation in the U.S. is the scaling patterns of cornrows.

Adding scaling as a symmetry transformation opens a great deal of indigenous patterns to mathematical analysis. Examination of aperiodic patterns (cf. Eglash 1999, Figure 10.13, From order to disorder in a Bakuba cloth) can also bring indigenous designs and concepts into new mathematical appreciation. While the crystallography classifications for symmetries should remain an important tool in ethnomathematics, the development of alternative frameworks have much to offer.

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