REVIEWS

Edited by **Harold P. Boas**
Mathematics Department, Texas A & M University, College Station, TX 77843-3368

African Fractals: Modern Computing and Indigenous Design. By Ron Eglash. Rutgers University Press, 1999, ix + 258 pp., $25.

Reviewed by **James V. Rauff**

Ethnomathematics has enjoyed some fame and much notoriety in mathematical circles. Enthusiasts praise the recognition of mathematical ideas in non-western cultures, while critics bemoan the perceived lack of rigor and the tendency toward postmodernist excesses. Both camps are sure to cite Ron Eglash's *African Fractals* as evidence for their arguments.

Eglash has assembled a wide variety of ethnographic data, political-cultural commentary, and mathematics into an arresting tale of discovery and extrapolation. This book presents a roller-coaster ride through a broad range of academic disciplines, mostly not mathematical. To give the reader a feel for the experience of reading *African Fractals*, I will follow Eglash's organization.

The book begins with a short discussion of the nature of fractal geometry, the "five essential components" being recursion, scaling, self-similarity, infinity, and fractal dimension. Eglash includes the standard illustrative examples common to books dealing with fractals and chaotic systems: the Cantor middle-third set and the Koch curve. He uses the five essential components as metrics to help determine which of the wide range of African designs and knowledge systems are indeed instances of fractal geometry. Although the introductory chapter is not particularly compelling in itself, it nicely sets up the next chapter, the most appealing part of *African Fractals*.

Aerial photography holds a magical power for many people, myself included, and Eglash wields his overhead views of African architecture like a wizard. Pairing the photographs with computer-generated drawings, Eglash argues persuasively that there is indeed fractal geometry at work in the design of African settlements. Seeing the pictures, no one can doubt that the palace of the chief in Logone-Birni and the Ba-ila settlement are recursively generated and possess self-similarity. *African Fractals* is worth the $25 price of admission if all the reader does is gaze at these photographs and the accompanying computer-generated fractal patterns.

The architectural evidence for fractal geometry in some African cultures is convincing, but *African Fractals* goes on to suggest a deeper and more pervasive fractal character to African culture. First, however, Eglash must deal with two issues.

Is fractal geometry the result of some universal human characteristic, or does it arise only in certain cultures? In Chapter Three, Eglash points out that we do not see fractals in the settlement architecture of either Native America or Europe. This chapter is the weakest in the book, for it distracts the reader from the main flow of the discussion of African culture. Moreover, I lost some faith in the narrative because of two glaring errors in this chapter, particularly troublesome after the outstanding images in the previous chapter. First, Eglash attributes the construction of Teotihuacan in Mexico to the Maya (p. 42). While there is considerable evidence of Teotihuacano influence and trade with the Maya world, particularly at Copan, it is not generally accepted that Teotihuacan was a Maya city; for more information, visit the Teotihuacan website `http://archaeology.la.asu.edu/teo/` maintained by Arizona State University. The second major factual error is Eglash's attribution of the mathematical analysis of Warlpiri sand drawings to Marcia Ascher in her book *Ethnomathematics* [**1**]. While Ascher does discuss Warlpiri kinship systems, she has nothing to say about the "algorithmic properties" of their sand drawings. Apparently, Eglash has confused the Warlpiri, inhabitants of continental Australia, with the Malekula, whose sand drawings Ascher does analyze. The only publications about the mathematical properties of Warlpiri sand drawings that I am aware of are the two notes [**5**] and [**7**].

The second issue that Eglash must deal with before proceeding is a central one for ethnomathematics: what constitutes mathematics in culture, and what does not? Eglash does a very nice job of delineating and classifying the possibilities, and he is careful to apply these categories to his subsequent analysis of fractal designs in African culture. Fractal designs of a group of people might be understood in different ways, ranging from unintentional by-products of some other activity to intentional designs whose character may be either implicitly or explicitly realized. This continuum is central to a raging debate in ethnomathematics. Does the existence of mathematical structures in a culture in and of itself count as mathematics, or does the mathematical creation need to be intentional? Eglash positions himself firmly in the camp that requires intentionality.

Specific examples of African designs that exhibit one or more of the "five essential components of fractal geometry" constitute the second part of *African Fractals*. Eglash also places the examples on the continuum of intentionality. The following list gives an idea of the breadth of Eglash's work.

Geometric algorithms. These include Mangbetu iterative squares sculptures, and Chokwe sand drawings that are intentionally designed as Eulerian paths.

Scaling geometry. Examples include windscreen designs showing power-law scaling, kente cloth stretching, logarithmic scaling in Ghanaian designs, and adaptive scaling in hairstyles. The discussion of windscreen designs powerfully affirms the sophistication of traditional engineering and architecture.

Numeric systems. Eglash shows that Bamana sand divination is similar to pseudorandom number generation using shift registers, and he finds self-organization in the board game Owari by viewing it as a one-dimensional cellular automaton.

Recursion. African culture is permeated by recursive design and recursive knowledge systems. We see many examples drawn from religion, dance, kinship, sculpture, and weaving. Iteration and self-reference abound. After reading this jam-packed chapter, no one will deny the potency of recursion in African thought.

Infinity. African knowledge systems use infinity "in the sense of a progression without limit" and represent it iconographically as a "completed whole." I was unsatisfied with this discussion of infinity, but, in fairness, I must say that to do the topic justice requires a book-length essay like Jadran Mimica's splendid treatment of Iqwaye counting [**4**].

Complexity. In a rapid dash through some basic notions of cybernetics and an idiosyncratic look at the Chomsky hierarchy of formal languages, Eglash argues for the existence of feedback loops and self-organization in African cultures arising from group intentionality.

The following statement summarizes the second part of the book: "four of the five basic concepts of fractal geometry—scaling, self-similarity, recursion and infinity—are all potent aspects of African mathematics," but "a quantitative measure of dimension is completely absent." Thus ends the more mathematical portion of *African Fractals*. One may quibble about some of the assertions (for instance, "mathematical complexity theory is based upon fractal geometry," which confuses chaotic dynamical systems with the theory of computation), about some omissions (the largest single source for the study of Tusona [**3**] is not even cited), and about flawed editing (Archimedean is misspelled on p. 76 and the shift-register example in Figure 7.2 has missing and incorrect entries), but the contention that fractals exist in African cultural artifacts and are intentionally and algorithmically produced is undeniably established.

Mathematicians are accustomed to books ending with suggestions for further research or applications, so they will be unprepared for the four chapters of humanistic "implications" that conclude *African Fractals*. Eglash wants us to consider what we should make of the presence of fractal geometry in African culture. He wants to get beyond the description of the fractal designs and knowledge systems and into the deeper cultural meanings. He eschews a particular epistemological framework and opts for a "toolbox" of approaches. One important tool is what he calls participant simulation, meaning the collaboration in mathematical analysis between ethnographer and informant.

Subsequent pages treat a variety of issues that are of some concern to ethnomathematicians, Africanists, and social theorists. In a discussion of the politics of recursion, Eglash states that "self-organization is not necessarily liberating; it can serve to support social control rather than resist it." He also suggests that European colonists may have failed to recognize African cities as such because the cities were organized by fractal rather than Cartesian principles. Arguing for a relation between recursion and sexuality in culture, Eglash invokes Ada Lovelace and Alan Turing. The bottom line of these arguments, as put forward by Paul Ernest [**2**] and much earlier by Raymond Wilder [**8**], is that mathematical knowledge is a social construction. This is an important point for ethnomathematics. It must be the case that mathematical knowledge is dependent upon culture and that mathematical ideas may develop differently in different cultures before we may even consider that there is an ethnomathematics.

Eglash's assertions will appeal to those who are sympathetic to constructivist theories of mathematics, but will not convince readers unfamiliar with anthropological and cultural argumentation. His tendency to assert what some other scholar was thinking (pp. 193, 202, and 213) may be off-putting to those unaccustomed to this kind of analysis. I must also admit to being a little skeptical of the suggestion that Cantor got the idea of the middle-third set through his cousin Moritz from a design on an ancient Egyptian column (pp. 207–208).

The book closes with some observations and speculations on the future for African fractals. Eglash observes that fractal design has become part of modern African architecture. Of special interest to mathematics educators is the discussion of how knowledge of the prevalence of fractal geometry in African culture should influence how mathematics is taught. Perhaps the most important result coming out of ethnomathematical research is that culturally informed mathematics materials are successful; see the short survey and bibliography in [**6**].

African Fractals is not a perfect book, but it is a book that mathematicians should take a look at. It is the first book to treat a single mathematical notion from the point of view of African culture, and it raises several important questions about exactly what should be and can be considered mathematics. It is a good place to see what ethnomathematics is all about, for it represents the better side of ethnomathematical research. Even if the anthropology and the mathematical and cultural philosophy seem unappealing, you should pick up a copy of *African Fractals* if only to wonder at the aerial photographs of those fractal African settlements.

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Millikin University, Decatur, IL 62522
jrauff@mail.millikin.edu