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Decolonizing Ethnomathematics

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RESUMO

Etnomatemática surgiu como um projeto de descolonização. No entanto, questionamos se ela está cumprindo sua missão, uma vez que não apenas tem idéias intrínsecas contraditórias, mas também suas discussões filosóficas iniciais foram substituídas por receitas para pesquisa e prática em sala de aula baseadas em definições e métodos acríticos e superficiais. Neste artigo, pretendemos contribuir para recuperar o impulso descolonizador da etnomatemática. Depois de analisar a proposta teórica original de D'Ambrosio e o método de Gerdes com base nessa teoria, desconstruímos os princípios da matemática escolar como sua padronização platônica, abstrata, epistemológica e características argumentativas, bem como a teoria antropológica funcionalista na qual a etnomatemática é frequentemente formulada. Finalmente, oferecemos uma perspectiva alternativa baseada em filosofias e epistemologias indígenas que contribuem para a descolonização da etnomatemática.

PALAVRAS-CHAVE: Epistemologias indígenas, Dimensões Políticas da Matemática, Matemática e Relações Sociais, Críticas de Etnomatemáticas

ABSTRACT

Ethnomathematics emerged as a decolonizing project. However, we question whether it is achieving its mission since not only does it have intrinsic contradictory ideas but also its initial philosophical discussions have been replaced by recipes for research and classroom practice based on uncritical and superficial definitions and methods. In this article, we

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aim to contribute to recuperate the decolonizing impulse of ethnomathematics. After reviewing D'Ambrosio's original theoretical proposal and Gerdes's method based on that theory, we deconstruct school mathematics principles such as its platonic, abstract, epistemological standardization and argumentative characteristics as well as the functionalist anthropological theory in which ethnomathematics is often framed. Finally, we offer an alternative perspective based on indigenous philosophies and epistemologies that contribute to decolonizing ethnomathematics.

KEYWORDS: Indigenous epistemologies, political dimensions of mathematics, mathematics and social relations, ethnomathematics critiques

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Ethnomathematics: A decolonizing movement

Ethnomathematics is a decolonizing movement. It challenges Eurocentric acculturation associated with cultural imperialism. It recognizes that the assimilation of Eurocentric academic mathematics causes learners to conceive of it as more important than their popular (indigenous, traditional, or labor-related) mathematics. D'Ambrosio (1997) and Gerdes (1997a) argue that academic mathematics, commonly conceived as apolitical, historically has been used to legitimize the power of European elites and their surrogates, to sort and position students in stratified societies, such as the modern ones, where the elites assume management roles in the productive system. For example, evident in the work of Organisation for Economic Co-operation and Development (OECD) and its Programme for International Student Assessment (PISA). The developing countries unreflectively copy the developed countries curricula, reinforcing power structures in the societies (Gerdes, 1997a, p. 224). Twenty years later, this continues with the hominization of curricula that OECD's PISA causes on national curricula. For D'Ambrosio and Gerdes, it is necessary to create ethnomathematics curricula that challenge and overcome the idea of apolitical and universal mathematics.

Based on D'Ambrosio's ideas about the psychological blockage, Gerdes proposes the rescue of indigenous mathematics. Children belonging to oppressed (mainly indigenous) cultures experience this blockage when their daily, "ad-hoc knowledge" is displaced by academic mathematics in schools. Children feel ashamed of their knowledge and even forget it. As a solution to this problem, Gerdes proposes to find the underlying mathematical structures of those daily practices and to incorporate them into the curriculum, using D'Ambrosio's (1997, p. 238) three steps method, which he argues builds up scientific theories: "1. How are ad hoc practices and solution of problems developed into methods? 2. How are methods developed into theories? 3. How are theories developed into scientific invention?" (p.19). D'Ambrosio is convinced that "in this way, knowledge evolves" (2014:101, Bernales translation). Using this method, Gerdes (1997) observes and interrogates how indigenous people make crafts, build houses, and play games or he analyzes the crafts without interaction with the creators. Gerdes (1997, p. 238) discovered that the mathematical structures coincide with the school mathematics contents based on so-called Western academic mathematics such as Pythagoras triangle, properties of polygons, and so on. He affirms that the

> contents taught in elementary schools have their origin in [ancient, precolonial] Asian and African schools, with some similarities in the indigenous cultures of the Americas. They show that not all the contents have their origin in the so-called West. They show that a Western mathematics does not exist. What exists is a universal mathematics, patrimony of all the humanity (p. 151, Bernales translation).

Although we find Gerdes' view reductionist, we agree what historians have packaged as "Western mathematics" is an aggregate of mathematical

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ideas many of which originate in cultures other than Western ones such as African, Asian, and Arabic (1997, p. 238). For this reason, we use the adjectival phrase "so-called" to refer to them. Gerdes (1997) speculates that when indigenous students find these shared structures in their cultural practices, teachers should engage students to reflect on the "impact of colonialism" and "the historical and political dimensions of mathematics" (1997).

Gerdes (1997) defines his methodological approach to ethnomathematical research. He seeks to find underlying mathematical structures of cultural artifacts that correspond to the mathematical contents of school curricula, and this is not uncommon in current ethnomathematical research (see, for instance, Martínez Padrón & Oliveras, 2015; Gavarrete & Albanese, 2015; and Lúcio & Sabba, 2015). For this reason, we contend that researchers must analyze their theoretical and methodological frameworks profoundly to understand whether they decolonize the school mathematics.

Platonic mathematics

Ethnomathematics as a program to research the underlying mathematical structures of cultural artifacts can be problematic. This critique is especially valid when an investigation is exclusively associated with a Platonic view of mathematics. The efforts some ethnomathematics researchers fail not only to challenge beliefs in the Platonic view of timeless, fixed mathematical structures that humans unveil but also ultimately reinforce this view. On the one hand, this belief is the foundation of a homogenous and universal character of school mathematics (Urton 1997:16-17, Hottinger 2016:141). On the other hand, the mathematics of human groups is not framed in this Platonic view. In this sense, the results of this kind of research show us a distorted picture of how people around the world do mathematics. As Hottinger (2016) states in her review of Vithal and Skovsmose's critic of ethnomathematics, "identifying the mathematical abstractions within the activity usually involves translating those abstractions into [so-called] Western mathematics" (p. 134). Urton confirms

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this idea pointing out that the anthropological oriented studies of mathematics that have adopted this immutable mathematical truth of Platonic philosophy have not found other structures in indigenous mathematics that do not match the so-called Western mathematical structures. (1997, p. 18).

It is important to mention that critiques also emerged from within the ethnomathematics community of scholars. In a conversation between Ascher and D'Ambrosio (1994), Ascher discusses the use of classifiers in other cultures, explains how they relate "the numbers to the context so that the context is not forgotten or overlooked" (p. 39), and states that in contrast to Western mathematicians, who believe that the power of mathematics lies in manipulating decontextualized symbols, it is more powerful to recognize "what the symbols stand for and gearing the approaches used to that" (p. 39). D'Ambrosio agrees, replying that contextualization has been wrongly associated with lack of abstraction and that abstraction could also be interpreted as a distortion, an oversimplification, a form of reductionism because just a few decontextualized variables are considered. Ascher adds that simple linear programming (created using few variables) does not work if the context is not recognized, using an example of constraining linear equations formed to construct the cheapest and more nutritional food for pigs. It did not work because the taste of the pigs was not contemplated, so they never ate it.

Epistemology

D'Ambrosio suggests that abstractions are not the paradigm of mathematics education since they are oversimplifications of the reality. He also states that abstraction and context can coexist. He agrees with Ascher's position that context can help researchers to understand the conception and meaning that people ascribe to mathematical symbols. However, we see a contradiction between these ideas and D'Ambrosio's three-step method. A scientific theory (his second step) is a generalization that can be applied to many realities, and, as such, the theory rejects specific contexts. Also, he assumes that all of humanity acquires mathematical knowledge as scientists do. This assumption is problematic. As we later argue in the "Abstraction" section, there are other ways of acquiring knowledge that require a kind of reasoning that is different from an evolutionist sequence from "concreteness to abstraction," something that Ascher criticizes.

Though nearly a quarter century has passed since D'Ambrosio presented his three-step method, current contributors to the ethnomathematics literature still recommend it as a procedure to understand how other people think. For instance, in their presentation of a supposed "epistemological dimension of ethnomathematics," Rosa and Orey (2016) reproduce D'Ambrosio's method without elaboration, without empirical evidence, and without reflection on theoretical advances (see, Rosa & Orey, 2016, p. 12).

The bridge between academic and popular mathematics

In the dialogue, Ascher concludes that word problems do not help too much because "it is exceptionally difficult to take abstract mathematical statements and apply them in a real-world context" (Ascher & D'Ambrosio, 1994, p. 40), something that was analyzed in depth by Lave (1988) in her research about supermarket shoppers, using her theory of situated cognition. Walkerdine's (1997) research about supermarket recreations in the classrooms confirms it too. When the supermarket is recreated in the school, the context is not the supermarket, but the school and children are not shoppers but students working under the rules of school mathematics discourse wrapped in a shopping foil. This recreation is neither a real supermarket context nor a real supermarket discourse. The supermarket game is entertaining for children, but they laugh because of the difference "between prices and goods (a yacht for two pence for example) and pretend

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to be wealthy shoppers, put on middle-class accents and generally have a good time. However, they do not get better at mathematics" (p. 205). The same problem appears in Hottinger's (2016) analysis of Lipka and Adams's (Lipka & Adams, 2007) work among the Yup'iks, where, for example, the argumentative communication of school mathematics contradicts Yup'ik values, so Lipka and Adams try to look for a way that does not contradict those values. However, they are unable to find a way, as Hottinger argues:

> While the modules based on Yup'ik traditions might serve to initially interest students in the lesson, by the end of the lesson students are being encouraged to interact with the mathematical knowledge in a very normative way—via proof and argumentation. This does not challenge singular, universal constructions of rationality, nor does it offer alternative subjectivities within which students might be able to locate themselves (2016, pp. 135-136).

In agreement with Hottinger, we see that if ethnomathematics researchers insist in finding the immutable and normative Platonic nature of school mathematics, including its argumentative reasoning, in the mathematical practices of other human groups, they will reinforce the Eurocentric universality and colonialism that they try to overturn. For us, a bridge between school and popular mathematics is impossible. Therefore, what can we do? In the next sections, we offer alternative ways to think about ethnomathematics outside of a Platonic paradigm.

Abstraction

We introduce in this section ideas that challenge the concrete-abstract duality. In other cultures, concreteness and abstraction coexist in mathematical signs. In contrast, in Western mathematics, the concept of number is abstracted from the qualitative attributes of the things counted.

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However, in other cultural contexts, a mathematical sign is not entirely divorced from the thing it represents nor from the social and cosmological contexts in which the activity develops.

We understand cosmology as

> the set of ideas, common to a culture, that express the basic order of the universe: that means, the general geometry of the space and time, and the forces that promote the natural and social events and the principles of interconnectivity among them, besides the classification of this phenomena in a coherent pattern… In other words, a cosmology is a framework that allows the ordering of the natural and social forces of the universe, which enables their manipulation by the people of a society (Earls and Silverblatt 1976, p. 300, Bernales translation).

We chose this definition as it links the utilitarian and transcendental nature of mathematics.

As D'Ambrosio says, contextualization does not mean lack of abstraction. For instance, in Mimica's (1988) study of the Iqwaye conception of number, the body is used to count in a sophisticated system based on exponentiation. In this system, a finger can represent many numbers at the same time (1, 20, 400, etc.) because humans are metaphorized as fingers. In many occasions, this kind of counting is framed in commercial exchanges that use shells as currency with the same characteristic of the numbers: they are not entirely detached from the person that exchange the shells, but they retain part of the essence of that person, so they can be tracked after many exchanges, knowing who was their original owner. This system also reveals the conception of the origin and flux of life (embodied in the myth of the "creator") and the kinship and social relationships associated with it.

Another example is Urton's (1997) analysis of Quechua numbers. The Incas have been admired for their use of large numbers even though they did not have a writing system. In an evolutionist view, large numbers are

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associated with societies and states that have large populations to control and are thought be abstract (Crump, 1990). However, Urton (1997) found that Quechua people establish kinship relationships among the numbers, where, for instance, the mother is the number 1, the breeder. The numbers are not detached from their cosmological and social context in which they are conceived and used. There are situations in which specific numbers and counting should be avoided by certain people and for specific things. For example, just women (considered as the breeders) can count their herds to prevent their individualization and with it, the sterility of the group. A woman secures its reproduction.

Ascher and Ascher (1997) criticize evolutionist ideas that conceive of non-literate groups as primitive and concrete and literate ones as civilized and with the capacity to abstract. This conception continues to permeate how the mathematics of non-literate people is understood. For example, they state that discussions about the relation of body parts to number words and the creation of "high" number words have an evolutionist tone. They conclude that high number words reflect "in a language community how people wish to count, and is unrelated to intelligence or ability to formulate abstractions" (1997, p. 27).

Why do modern societies wish for abstract numbers? To answer this question, we need to return to the conversation between D'Ambrosio and Ascher about the contextualization and abstraction as an oversimplification as well as try to briefly analyze their understanding about how mathematics is used in the sciences, in capitalist economies, and in nation states.

Decontextualization, fetishism, and standardization

According to Latour (1987), abstract mathematics is essential in science because it allows the scientists, economists, and engineers to reconstruct the world in the laboratory or office. Researchers decontextualize plants, animals, humans, weather, soils, and so on from

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their original environments with the use of mathematical and technological tools such as double entry tables, thermometers, barometers, meters, scales, clocks, and so forth. These decontextualized data are recombined in laboratories, recreating the objects using, as D'Ambrosio stated, few variables. For example, researchers reconstruct a person as a combination of characteristics such as age, income, sex, level of schooling, race, and ethnicity.

Using these decontextualized data—abstract and precise mathematics—a scientist makes sure that the information arrives without being deformed by the traveler who gathered it in its original context. Also, the scientist can compare data from around the world since his tools extract and convert those data into something homogenous and comparable. In other words, the tools standardize these data and make them comparable and controllable, so the scientist controls the world without leaving the laboratory. The economist portrays the economic situation of millions of people using a few numbers and without leaving his office. Can these reconstructed structures in the laboratory come back to their original context? According to Latour, it is not possible, unless the original context is transformed into a laboratory. For this reason, we consider that D'Ambrosio method fails in its third step and that the bridge between scholar and daily, indigenous mathematics is impossible.

Using the idea of fetishism, Karl Marx explains how human products suffered the same decontextualization process to become commodities to enter the capitalist market. Rotman (1988) finds that the numbers used by Western mathematicians have experienced the same process. They are conceived as natural objects and not as human creations:

> human products [e.g. commodities or numbers] frequently appear to their producers as strange, unfamiliar and surprising; that what is created may bear no obvious or transparent markers of its human (social, cultural, historical, psychological) agency, but on

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> the contrary can, and for the most part does, present itself as alien and prior to its creation. (Rotman, 1988; as cited by Urton, 1997, p. 23)

Indigenous mathematics does not work in this way because the knowledge that is inscribed in mythical thought is transformed by each person. The personal seal or style that each person prints when she uses and transmits knowledge is evident, it is not hidden. Lave (2011) portrays how tailors' apprentices in Liberia are exposed to the different repertoires of master tailors and that the apprentices have a considerable amount of freedom to choose, use, combine and recreate those repertoires in the way they want. Storytelling works similarly. Each person has her version of the same story, and nobody complains. Nobody claims for objectivity or precision. However, what would happen if we decide to question a scientific tool? For example, what would happen if we want to change the base 10 of the meter for a base 12? This change is one of the discussions that the creators of the metric system had according to Alder (1995) whose fascinating research about the creation of the metric system shows the role that the needs, interests, and ideals of capitalist businessmen, politicians, and scientists play in it. For example, standardization was not only a homogenizing need that allowed businessmen to expand their businesses and open new markets quickly, but it also was synonymous with justice and freedom (from the translators of local measurements, who, according to the authorities of the central state, took advantage of the local populations).

We cannot change the metric system since, as Latour explains, this is a black box, and it would mean that we not only have to discuss with each person and thing that alienated to achieve the triumph of the base 10 criterion in the several discussions that the creators of the system had but also to convince the current users, the scientific community, political leaders, and so on. Moreover, if we decide to abandon the metric system, it will be difficult to communicate with others where it has been institutionalized as the only measurement system.

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For this reason, Bishop (1993) found that the school curricula is oriented to develop a Mathematica-Technological (MT) culture. It is already embedded "in modern societies' activities, structures and thinking" and is questionable since "[w]e now are in danger of taking the ideas and values of universally applicable mathematics so much for granted that we fail to notice them, or to question them, or to see the possibility of developing alternatives" (p. 7). In other words, "Back to the basics" is almost impossible, so the universalism of Western culture is guaranteed. Bishop warns:

> There has in particular been the widespread development of a belief in the desirability of technological and industrial growth. Underlying this technological revolution has been the mathematics of decontextualized abstraction, the mathematics of system and structure, the mathematics of logic, rationality and proof, and therefore the mathematics of universal applicability, of prediction and control. (Bishop, 1993, p. 7)

In short, in Western academia, abstraction serves to standardize. It is required by societies and systems such as the modern nation-states, developed during their processes of both, formation and consolidation as states, and positioning (regarding power sharing) into the global community during the XIX and XX centuries (Ogle, 2015), and the capitalist market. Standardization allows homogenization and self-control, every individual voluntarily tries to please the standard (Walkerdine, 1997). As Bishop explains, it is difficult for people who have been socialized in these systems to conceive mathematics in other ways. However, research about how people negotiate, and resist structures and systems can be productive. After analyzing the kind of anthropological focus that D'Ambrosio, Gerdes and most of the current ethnomathematics researchers employ. We will later focus on that research.

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Functionalism

These authors use a functionalist notion of culture with its correspondent methodology. This notion is not commonly found in current anthropological research. Anthropology was born serving colonialism, using evolutionist theories to sort, label, and control people around the world. The functionalist theories that replaced them also serve colonialism. They tried to conceive the world as positivist sciences do, and as Lave (1988) states, they remain framed in the conception of a closed, timeless culture conceived as a coherent whole, which perpetuates patterns and norms that are adopted homogeneously by the individuals that belong to it. This is why a craft object is enough to get mathematics information in this framework. The motivations, style, goals, interests, emotions, beliefs, use, religious ideas, and social (including political) relationships that influenced the craftsman during the process of creation are irrelevant. This is where the colonial view remains. What is important is the pattern that the authorized ethnographer perceives from her distant, objective eye. The phenomena that are not recognized as patterns are not worth analysis. They are considered "exceptions, ambiguities or irregularities" (Rosaldo, 1989, p. 32), even when the craftsman finds them as vital. Moreover, the craftsman's child should learn the interpretation of the ethnographer of her parents' knowledge when she goes to the school, an interpretation that, as we explained above, usually shows their mathematics in Platonic terms, which is a distortion. In other words, this mathematics is showed as a folkloric product, and not as the result of changing social and political relationships, and this diminishes Gerdes' goal to enable students to understand the historical and political dimensions of mathematics.

The homogenizing character of the functionalist theory is explicit in D'Ambrosio conception of culture in which the "individual behavior is homogenized in certain ways through mechanisms such as education to build up societal behavior, which in turn generates what we call culture"

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(1997, p. 18). It is not clear where D'Ambrosio takes this idea about education as a mechanism of homogenization, but we think that there is not enough evidence to affirm that homogenization of knowledge is a goal pursued by the mechanisms of socialization of every human group. Moreover, homogenization, as we mentioned above, is related to standardization, something that is not required by most indigenous societies.

From the 1970's, from both outside and inside the field, theorists have questioned classical anthropological theories and methods such as functionalism. Currently, theorists attempt to break the dualities of individual and society, subject and object, mind and body, as well as nature and culture that classical theories imply. It is contradictory that ethnomathematicians use traditional methodologies that sustain those dualities, which are bizarre for most human beings and whose mathematics are not inscribed in them. One of the attempts to overcome these dualities in the field of mathematics education is Lave's (1988, 1991) Situated Cognition and Bishop's (1993) proposal to counteract the colonizing effect of academic mathematics.

Mathematics as a social activity

Bishop (1992) analyzes how the values embodied by the scholar curriculum are interpreted, accepted, rejected or negotiated by the students. In contrast to a functionalist notion, individuals are not passive recipients who simply and automatically internalize cultural messages. Instead, they selectively and even subversively interpret cultural meanings in accordance with their personal and social goals, which are changeable and can even spontaneously emerge. People negotiate their social position while they negotiate the cultural resources offered by the society such as the curriculum (Lave & Wenger, 1991; Wenger, 1998).

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Examples of this situation are in the literature. Gorgorió and Planas (2005) study how immigrant students interpret and negotiate their social position and mathematical knowledge in high school classrooms in Barcelona. The authors take Bishop's (2002) idea of transition, which implies that children bring their history and knowledge to the school, so the shifts from home to school, and in this case, from their school in their country of origin to the one in the receiving country, are commonly experienced as discontinuities. According to Bishop (2002), transitions are more difficult when children are less familiar with school culture's contents and reasoning. Gorgorió and Planas (2005) show not only how different are the norms, values, and understanding of what mathematics is, but also how social representations play a vital role when norms are created and negotiated such as the preconceptions that some teachers and students have about the mathematical abilities of children from different ethnic groups. For example, in one class, the students should determine in which neighborhood people have more space to live using only data about population and neighborhood size. Emilde, a Dominican student, thinks that it is necessary to contextualize the problem: do they live in flat or houses? He is thinking about the difference between poor and rich neighborhoods. We think he is right because even if a town like Paterson, New Jersey, can have the same population and size of a sector in Manhattan, they are not going to have the same space to live. However, the teacher and some Catalan students dismissed his request telling him that his mathematical reasoning is not useful or that he is not willing to use mathematical procedures. This kind of situations caused him to refrain from participating in the class. Avoiding functionalism leads the researchers to conceive Emilde's silence not as a psychological blockage but as an attitude of resistance.

Ferreira (1997) provides another example of how the Jurunas of the Amazonia (Brazil) do mathematics negotiating their social position. They want to appropriate the "White people's" mathematics, mainly, in a market

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situation, to be able to defend themselves. However, they do not only use some numbers and algorithms learned in the school and some notions about market prices; they include their ideas about reciprocity and social relationships in their market transactions and, therefore, in their mathematic calculations. Once the Jurunas discovered which power relationships are behind the abstract numbers, they try to use them in their favor and in their way. What kind of social and power relationships are present in this kind of calculations and negotiations? The Jurunas knew how they should answer, according to the expectations of school. Nevertheless, not only do indigenous people negotiate the market norms. Lave's study about supermarket shoppers also reveals that city dwellers also negotiate apparently fixed structures, solving dilemmas that appear according to the context of each shopping event. Human beings can be so subversive that XV century Neo-Platonists explored Platonic ideas using allegorical symbols, whose essences are not immutable, fixed, and eternal, as well as require a kind of non-argumentative reasoning (Benjamin, 1998, Wittkower, 1977). What happened later? Why did European knowledge, and mathematics with it, lose its mythical and fluid character? We can find some clues in Daston's (1991) analysis of the transition from subjective to objective knowledge in Europe. For reasons of space, we are not going to develop her ideas here but want to point out that she links the rise of the concept of objectivity with the Protestant and Catholic church's attempts to control knowledge concretely, the subversive uses that ordinary people gave to curiosities, portents, and miracles.

Other ways of conceiving mathematics: The spiritual guiding of knowledge

In the ethnomathematics literature, we found research about other structures that does not imply a static character. Consider fractals (Eglash et al., 2006, Eglash and Foster, 2017), which are patterns that repeat themselves at many scales, where the parts have the same structure as the

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whole. In the case of the African fractals analyzed by Eglash and Foster (2017), the fractals are framed in a philosophy based on a circular flow with two underlying principles: (1) fractals produce a negative feedback, equilibrium, equality and stability; and (2) they produce a positive feedback that is self-expanding, generative and even chaotic. It is only "when we see how stability and instability are coupled that we can grasp the system as a whole" (2017, p. 121). They assure us that although self-generation work in various ways among the different African cultures that use fractals, their spiritual structure is similar:

> pairs of lower gods that embody complementary forces of order and disorder, and a distant 'high god' whose life force combines these traits, creating a fractal—the dance between order and chance. Fractals are the self-similar patterns mathematicians use to characterize living structures: branches of branches in trees and lungs; folds of folds in brains and intestinal villi; clumps of clumps in tiny cell organs or giant coral reefs. Complexity theory, which is the science of self-organization, shows that these fractals arise from a coupling of negative and positive feedback. (p. 121)

Are fractals something universal? Are we reading African fractals as projections of our own culture? In a sense, as we mentioned above when we pointed out that Urton found suspicious that anthropological studies about mathematics have not discovered structures different from Western ones. Did Western academia appropriate these structures from indigenous cultures? We are not able to answer these questions; we want to highlight the fluidity and self-generating character of these structures that imply another kind of reasoning, different from the fixed essences of Platonic mathematics.

Fractals are also reflected in social relationships. For example, the flexible self-generating bottom-up character of the African fractal architecture allows more egalitarian relationships empowering women

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because it will enable them "to create new homes if they wanted a divorce or to extend old homes if they wanted to shift the family structure" (Eglash and Foster, 2017, p. 121).

It can be said that fractals are represented using Platonic static representations. However, Eglash proposes to use computer programs to introduce the study of fractals in school that will allow students to understand their flexibility and dynamism. These programs not only allow the simulation of the fractals dynamism but also, in the case of African fractals, they allow the insertion of the social and philosophical context (with all their spirits) in a very natural and fluid way. In that sense, in contrast to what Bishop feared in the 1990's, technology is contested and used under a different philosophy guided by the spiritual world. Moreover, according to Eglash et al. (2006) this use of the technology can help to go "Back to the basics," in Bishop's words, and revise our convictions, which is what Bishop claims:

> What happens when you ask traditional Afro-Cuban drummers to create a mathematical simulation of their rhythms or graffiti artists to draw on a computer screen? At the technological end, it is useful for probing our own convictions: How do we reconcile our sense that zero degrees lies along the horizontal, with the Yupik understanding that the horizontal is at 90 degrees? How do we reconcile our understanding of mathematics as a human invention with the Shoshone position that it existed before humans? Computational ethnography helps us make our own assumptions visible; we begin to see that some 'self evident' aspects of math or technology are actually choices that could have been otherwise. (as quoted in Eglash et al., 2006, p. 350).

However, there is a point that we find problematic: how do we reconcile fractals with the scholar curriculum? Eglash et al. stated that in the case of the cornrow hairstyles that they worked in the classroom, they changed "the

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emphasis from fractal geometry to transformational geometry" (2006, p. 350). However, we wonder if, on the one hand, this does not interrupt fractals' intrinsic dynamism. On the other hand, we question whether the reasoning of the hairdressers corresponds to this thinking on the base of rotations, translation, and so forth. Is the claim of correspondence a distortion about how the hairdressers think? We mentioned above that Platonic mathematics lead us to a logical, rational, objective, argumentative knowledge as well as allegories lead us to a non-argumentative and metaphorical knowledge. What kind of reasoning do fractal structures engender? How can ethnomathematics researchers and educators infuse cultural manifestations of fractals into mathematics curricula?

There are other attempts to represent geometry with dynamic structures. In the frame of its declaration as a protected heritage site, Belaunde (2012) analyzes the Shipibo-Conibo kené designs (Peruvian Amazon). Plants "with power" (ayahuasca and piri-piri) communicate these designs to crafters who materialized them over the surface of a body (clay, fabric, human body, and so on). Tourism has increased both the demand for the kené art and ayahuasca rituals. In turn, the demand has encouraged the development of a new variation of this art that children of the designers have created. They use "natural and acrylic dyes, make original combinations of kené geometric patterns and figurative drawings that they learned at school" (2012, p. 126, Bernales translation). The ayahuasca is ingested by both men and women, while the eyes of the women designers are doctorate with piri-psri to have a vision in which "the designs appear in the imagination or dreams 'as an extended fabric'" (2012, p. 128, Bernales translation). These plants share an origin with the anaconda, mother of the water in the Amazon, so it is the mother of all the designs. These plants have therapeutic effects, so when they are used carelessly (without fastening or sexual abstinence, for example), they show opaque designs that can cause illness and death.

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Belaunde thinks that it is a mistake to interpret the meaning of the geometric strokes, curves, and lines as if they "were merely figurative representations or individual ideograms" (2012, p. 132, Bernales translation). Rather, the strokes depict "a red of abstract roads by which the beings mobilize, traveling, communicating each other and transporting knowledge and power" (2012, p. 133, Bernales translation). Knowledge is not only communicated by humans but also by animals, plants, spirits, etc. that inhabit this and other words, who also have intelligence, will, and agency (Descola, 2005). These roads are everywhere, in the sky, such as the Via Lactea, and on Earth, such as in the rivers or in the tiny leaf veins of the plants with power, which "contain a great therapeutic power because it is in the extremities, in the shoots, that the power of growth of the plants is concentrated thanks to which new roads and designs are generated" (2012, p. 133, Bernales translation). Belaunde opposes the idea of recording the designs in inventories since they would appear as fixed and timeless and this circulation of knowledge would disappear.

It is interesting to see how close this mythological and dynamic mode of knowledge acquisition to the one that is described by Eglash about the African fractals. In another point of agreements with Eglash, Belaunde also views industry and technology not as obstacles but rather as a new kind of knowledge that is an object of desire and fear "for being emblematic of the incorporation of the 'other,' desirable and powerful at the same time, and potentially charged of illnesses and violence" (2012, p. 135, Bernales translation).

We contend that it is crucial to understand how in other cultures knowledge can be guided by spirits and how they inscribe mathematics in their dynamic philosophies. This realization can help enrich and reorient discussions, research, and classroom practices of ethnomathematics.

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Conclusion

Globalization brings both, the homogenization and standardization of Western mathematics, technology and life style, and the opportunity to escape from that homogenization, appropriating that technological knowledge in creative ways (such as the knowledge leaded by spirits does). Ethnomathemtics' mission is to help to challenge this homogenizing tendency, questioning the principles and need of current scholar mathematics and lobbying for introducing into the curricula a kind of mathematics that is based in a different philosophical and epistemological framework that the one required by the capitalism and the nation-states system. Losing the battle in this field could mean the loss of the indigenous and local knowledge. Ethnomathematics should also incentive creative ways of appropriation of Western academic knowledge that respect the integrity of the philosophy and epistemology of the non-academic cultures who make those appropriations.

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