Respect for Ethnomathematics: Contributions from Brazil

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"Mapping time, space and the body: Indigenous knowledge and mathematical thinking in Brazil" (Ferreira, 2015) brings people, land, and numbers together in the fight for justice. In this extraordinary voyage through ancestral territories in Brazil, the Xavante, Suyá, Kayabi, and other nations use mapping as a tool to protect their human rights. Mathematics activities inside the classroom and in everyday life help explain how Indigenous Peoples understand the cosmos and protect its living beings. Ethnomathematics makes another contribution to a growing literature on the mathematical and scientific thinking of Indigenous Peoples around the globe. It makes mathematics alive and culturally relevant for students of all national backgrounds worldwide.

Indigenous Mathematics in Brazil

Squatting on the white sandbanks of the Xingu River, Chief Carandine Juruna carefully sorts out the bamboo arrows he has just exchanged for pottery with the upriver Kayabi. As he sets aside the different fish, game, and bird-hunting weapons, according to specific arrowheads, the 60-year-old man makes sure each household that contributed with animal-shaped clay pots receives its share of goods. Large families are privileged in the quality and number of arrows they get, and so are good hunters, hard-working pottery makers, elders, and the Juruna to whom the Kayabi were previously indebted.

The Juruna nod approvingly as their leader distributes the arrows, commenting on the quality of the bamboo, feathers, wax, and tree-bark ties employed by the Kayabi. The transmission of wealth is only one element of a much broader and enduring contract between the Juruna and the Kayabi. It embodies and records the entire credit structure of the community, including symbolic, interpersonal, economic, and emotional associations that reach far beyond the sole exchange of property—a “system of total services” (Mauss, 1990, p. 5). The fairness of the leader’s distribution of goods is not put into question, nor is there a concern for immediate material profit, in this vast system of services rendered and reciprocated.

Meanwhile, an employee of Funai, the Fundação Nacional do Índio (National Indian Foundation) in Brazil, standing nearby, nervously operates his calculator, attempting to stipulate a price for each arrow he intends to buy from the Juruna and resell in Brasília, the country’s capital. Antonio’s reasoning is based on the monetary profit he customarily earns from the sale of indigenous “art craft.” Waving the number of Brazilian bills that represents a “fair” price for the 20 arrows he wants, Antonio is outraged when Tarinu Juruna, Carandine’s son, remarks that “only 7 arrows are for sale,” and that he himself will calculate their monetary value. The reasoning behind the “exorbitant” price Tarinu arrives at is far beyond Antonio’s comprehension. Unwilling to accept or understand a system that attributes different values to goods, Antonio angrily tosses the piece of paper listing Tarinu’s calculations and shouts in indignation:

> I came all the way from Brasília to help you guys and you want to cheat me? Where on earth does 7 times 5 equal 125? I’ve pacified more than 500 Indians in my life, I’ve caught malaria more than 100 times in 20 years and you guys want to charge me $125 for 7 arrows! I could get arrows just like those anywhere in Brasília for as cheap as $2.50 a piece! You lazy Indians know nothing about money, about buying and selling. It’s true what people say, that Indians are too stupid to learn math. [January, 1982]

A few miles downstream, along the Xingu River, shaman Intoni Suyá is busily drawing the 12 underwater creatures whose environmental knowledge provide the Suyá people guidance to fight court cases against insatiable mega-landowners. Horse fish, stork fish, needle fish, a couple of *human fish*, as well as the anaconda and sting rays, and other beings, feature prominently in Intoni’s narrative, too. The shaman resorts to the animals’ ancestral erudition in identifying the sacred locations of Suyá territory. In this respect, Suyá practices of land occupancy clash abruptly with non-Indigenous ideas of land ownership and jurisprudence. The Suyá are most interested in creating, negotiating, and redistributing resources within broad territories, in the generous spirit of a true gift economy. Their cosmology and everyday practices show local and extended families supporting one another in an economy of gift exchange in which the goal is to circulate, rather than accumulate resources. The discourse of land ownership according to Brazilian jurisprudence relies heavily, instead, on the basic tenet of capitalism: the expropriation and accumulation of wealth. Multiple Brazilian map books produced since the early 1980s convey very clearly Amerindian perspectives of land occupancy, which differ greatly from the complicated and convoluted process of "demarcation" of Indigenous territories by the Brazilian federal government.

Swimming downstream, the 12 hybrid creatures (Fig. 1) dodge floating debris dumped into the Xingu River by cattle ranchers, timber and mining companies. Patches of bubbly brown foam sail alongside big and small logs, on their way to sawmills farther north into the Amazon. Determined to protect the underworld of animal existence, the sacred fish-like animals work in unison, conferring with each other on how to best school the Suyá people about fighting for their rights and protect the land from its greedy invaders. Shaman Intoni Suyá explains in detail the incredible knowledge conveyed to humans by the sacred underwater beings:

Figure 1. The 12 underwater creatures. Intoni Suyá, 1999.

1. The *diacuí* or flute fish. It has a lot of bones and only moves and swims when other fish do. Suyá men should learn from the *diacuí* that they should never act in isolation, but act collectively in trying to regain disputed territories.
2. This little blue creature is the boss of the *diacuí* flute fish. This means that eventually a political or religious leader can tell a Suyá to act in isolation.
3. The black fish, *peixe preto*, is just like a canoe, but it is a fish. When it wants to surface from the depths of the water, it does so as a canoe. The Suyá people treasure their canoes and should learn that no matter how appealing cars or airplanes appear to be, canoes are the valued means of transportation because they are genuinely Suyá.
4. The needle fish, *peixe agulha*, floats on the water's surface. It has the capacity of being in the water while surveying from

inside what's going on outside above the surface, without raising any suspicions. Suyá men should act accordingly in the court case, trying not to raise unnecessary suspicions about, for example, the eventual use of violence if the results of the court case are not successful.

5. The sieve fish, *peixe peneira*, is full of holes but it is still a fish. This fish can swim swiftly against the current, because the water will pass through him and push him even further upstream. Suyá people must have this ability of fighting against strong currents.
6. The anaconda, *sucuri*, which in the beginning of times broke the waters loose from the grips of the humming bird, who kept the precious liquid hidden in secretive underground hideouts. Suyá people need the strength of the *sucuri* to fight against the white men, *caraíbas*.
7. The *peixe cavalo*, horse fish, is just like a horse, but a bit different. It is yellow and black and can live underwater. Unknown to the Suyá before contact with the *caraíbas*, the horse is strong-smelling and therefore a dangerous animal that is able to survive in hostile environments, underwater. Surviving hostilities is a key strategy today for the Suyá.
8. The *socó*, stork fish, which has the same ability as the *peixe cavalo*, but enhances its flying ability with a swimming one. Same traits the Suyá should cultivate during the court case: show the expert [myself] the Suyá's ability to envision their territory from above, as well as from an underwater perspective.
9. The gourd fish, *peixe cabaça*, which looks like a gourd but is a fish. He lives in the bottom of the river, but is still full of mud. Despite its dirty appearance, the gourd fish is very clever because it is deceptive. It pretends to know nothing, but it is very knowledgeable.
10. This is a human being, *ser humano*, but a water creature as well. It can tell all the fish to move around at any given time. Humans are more powerful than animals, so when they feel weaker than animals, they need to regain their strength by resorting to the power of the human fish, *peixe humano*.
11. It is a sting ray, *arraia*, that lives under the ground, but also inhabits the rivers. The *arraia* can be deceptive and sting those

who are unaware of its ability to become invisible. The Suyá should only resort to violence against *caraíbas* when really needed, since stinging can cause the *caraíbas* to spread diseases, throw bombs, and engage in other acts of violence that can decimate the Suyá population.

12. This one is also a human being, *ser humano*, but also lives in the water. All humans come from the waters, and therefore the importance of the disputed rivers and lagoons to the Suyá people. All our headwaters are in the hands of the *caraíbas*, big farmers, the gold miners that make the waters dirty with poison that kill the fish, and make our children sick.

Two thousand miles down South, outskirting the São Paulo metropolitan area, Guarani children of the Itaóca Village place their bodies on the frontline of this rich industrial state. They demand that the physical demarcation of their ancestral territories respect the 2007 United Nations Declaration on the Rights of Indigenous Peoples (UN DRIP). Guarani mapmaking ascertains the Itaóca villagers' right to the occupancy of their land. In their intricate and detailed maps, the youth show how knowledgeable they are about using mathematics to ascertain their human rights to land, quality education, food security, and health services.

Guarani children are indeed 21st century Indigenous Brazilians, associates of the largest Indigenous nation in Brazil, the 40,000-member Tupi-speaking Guarani. Their mapping activities demonstrate a systematic response to the dehumanizing conditions under which their parents live and work on the reservation, at dumpsites, in hospitals, and as cheap labor force for missionaries, farmers, tourists, and government officials. The Land-without-Evil, which they aspire for, depicts an apocalyptic vision of time and the body familiar to anthropologists and other social scientists. The youth reject the passivity of their elders, who seem to have been bludgeoned into accepting the continual assaults and violations of their dignity as human beings that have become part of everyday Guarani life in the Itaóca Village, just next door to the buzzing activity of São Paulo City.

Within the sprawling limits of São Paulo megalopolis, lies the Instituto Cajamar—a learning community center founded by Paulo Freire and other revolutionary educators in the 1970s. This is where young Guarani leaders, in the company of other Indigenous and non-Indigenous educators, engage in map-making activities to secure ancestral land rights. The young Indigenous leaders commemorate the first two decades of Indigenous Peoples, from 1995 to 2014, with a Book of Maps, bringing together people, land, and numbers in the fight for social justice. During the course of the workshop, our conclusion, reached by more than 60 teachers, was that "Mathematics is important for the autonomy of Indigenous Peoples." Self-determination, which includes the right to free, prior, and informed consent (FPIC), detailed in the UN DRIP is, indeed, of particular importance to Indigenous Peoples worldwide.

In Brazil, more than 3,000 Indigenous schools are now operating and dozens of universities are sprouting throughout the country. They are successfully strengthening Indigenous systems of knowledge by using map-making as a pedagogical tool. Most of these schools use their own intercultural and multilingual curricula to teach mathematics, history, geography, biological sciences, and language arts. These curricula not only meet state and federal standards, but also bring mathematics education to a whole new level. The curricula have increasingly been designed by, or with strong input from, the communities and the local teachers themselves. States and municipalities, often supported by the federal government, have passed important legislation supporting community-based calendars and cultural pedagogies.

Map-books and atlases have figured prominently in the Indigenous Education Movement, which gained force in the 1980s with the fall of the military dictatorship in 1985 and the Brazilian Constitution of 1988. Maps of several kinds were crucial for the protection of ancestral lands. The right to ancestral lands was enshrined in the new Constitution, a victory of Indigenous Peoples' own making. The Movimento Organizado Indígena put up a massive fight alongside nongovernmental organizations to protect ancestral territories. Different kinds of maps mentioned in *Mapping Time, Space, and the Body* have been at the forefront of this liberating rights-based movement. Many of these maps have been produced in Indigenous schools and in teacher-training programs throughout Brazil and South America. This work has spiked a much higher interest in school-taught mathematics as well as Indigenous mathematical knowledge. Mathematics was by far the favorite subject at Indigenous schools where I taught in Brazil, mostly because the mathematics we studied in school had real-life implications.

Real-life Mathematics Earns Respect for Indigenous Knowledge

The arrow problem featured in the opening of this paper, where Funai employee Antonio tried to buy arrows from Tarinu Juruna for far less than their value, is best understood in the context of real life. Of course 1 + 1 in the abstract equals 2. But in the context of Juruna, Suyá, and Kayabi peoples of the Xingu Indigenous Park, central Brazil, who practice a gift economy, 1 + 1 was *not* an accurate mathematical model for the real-life problem at hand. Nor was 7 × 5 the correct model because more was involved than paying $5 cruzeiros for each of 7 arrows. The men were requiring Antonio to pay his debt of $72 + $18 cruzeiros (the currency at the time). And they wanted a fair price of $5 for each of 7 arrows for a sum of $125, as Tarinu explained to his classmates in school. So there were two different models clashing. Antonio's model was 7 × $2 = $14 and no payment of his debt. Tarinu's model, in turn, added up to $125. Since Antonio refused to pay that amount, the final answer to the arrow problem was $0. Here, the clash was between two real-life economic models: capitalism *versus* gift-exchange.

Other real-life examples of great practical importance documented in *Mapping Time, Space, and the Body* were the map-making models of Indigenous territories that won official recognition as demarcated, protected federal lands. Shamanic map-making activities in the Xingu Indigenous Park relied on the lived experience and shamanic knowledge of spiritual leader Intoni Suyá. In their successful court case, the Suyá people won the possession of a section of their traditional landbase, the *Terra Indígena Wawi,* adjacent to the Xingu Park in central Brazil. The people later disputed farmers' challenges to that decision, winning again in court in 1998. Intoni evoked the power of humans and animals over the environment, its goods and resources, applying Suyá mathematical knowledge to this real-life problem and its hands-on solution. The information provided allows us to construct models, for mathematical, environmental, and other sciences, by using different kinds of maps to represent the impact of deforestation on and around Indigenous lands in Brazil and throughout the Americas.

In addition to mapping territories, other real-life situations have generated intense interest in mathematics among Indigenous Peoples in Brazil. Worldwide, real-world applications have also been credited for boosting interest in mathematics, as reported by the *New York Times* in its series "Number Crunch" (*New York Times*, 2013). Like other communities across the planet, Indigenous Peoples in Brazil are able to identify important mathematical models in practical situations and map their relationships using such tools as diagrams, tables, graphs, and flowcharts. They have also made extensive use of photographs, drawings, and paintings all along, as shown or mentioned throughout my aforementioned book, *Mapping Time, Space, and the Body*. Brazilian Indigenous Peoples can analyze those relationships mathematically to draw conclusions, focusing on their own mathematical knowledge, often referring to Indigenous rights as human rights. Indigenous Peoples routinely interpret their mathematical skills in the context of the situation they live in and help create. In addition, they reflect on whether the results make sense, possibly improving mathematical models that can help improve mathematical achievement in mathematics education. What these models have in common is that real-world applications, such as designing maps; building houses, schools, fences, and canoes; negotiating sales and purchases; cooking; and reckoning with family relationships, reveal that mathematically proficient students can apply the mathematics they know to solve problems arising in everyday life, society, and the workplace.

The latest news and reports show that despite Brazil's economic and social inequities, the country is improving its international education standards. Brazil is considered a strong performer and successful reformer in education. By setting individual quality goals and then leaving schools, Indigenous or not, free to choose how best to achieve them, Brazil's Education Development Plan has "effectively transformed the country into a giant laboratory of best education practices," according to a Pearson Foundation report. "Improving the education of its citizens is vital for Brazil's future economic development. With children under 15 years of age accounting for one-fourth of its population of 200 million, the challenges are huge. But progress is being made" (www.pearsonfoundation.org/oecd/brazil.html). *Mapping Time, Space, and the Body* shows that Indigenous Peoples' mapping activities in Brazil are contributing to the country's overall successful performance in mathematics literacy today.

Notwithstanding Brazil's wide-ranging educational reform, the country still has much to improve. The United Nations Children's

Fund (UNICEF) office in Brazil points out that inequities still persist in the country, especially in relation to regional, ethnic and racial, and socioeconomic differences. So that the country's success rates in education can effectively benefit its minorities and the poor, UNICEF believes that public policies that reduce poverty and inequality in all its dimensions need to be implemented. Nevertheless, Brazil's experience with education in the last decade shows how a country facing major challenges in teacher preparation, infrastructure and student commitment, and with a highly decentralized education system, can use national and international benchmarks to identify problems and propose solutions. Indigenous Peoples have played a big part in these advances. In fact, in July 2014 the 66th Annual Meeting of the *Sociedade Brasileira para o Progresso da Ciência* (Brazilian Society for the Progress of Science, SBPC) inaugurated the *SBPC Indígena* to discuss the Indigenous universe in its scientific program (see http://www.sbpcnet.org.br/site).

Improvements in Brazilian Indigenous education supply a useful lesson for mathematics education in the U.S. the *New York Times* (*NYT*) Editorial "Who Says Math Has To Be Boring?" (www.nytimes.com/2013/12/08/opinion/sunday/who-says-math-has-to-be-boring.html) asks: Why are girls and minorities missing from science and mathematics classes? The answer is disturbing, but not surprising: "A big reason America is falling behind other countries in science and mathematics is that we have effectively written off a huge chunk of our population as uninterested in those fields or incapable of succeeding in them" (*NYT*, 2013, p. A28).

Just like Indigenous Peoples in Brazil, women and most ethnic minorities in the United States have internalized the false belief that they are incapable of mastering Science, Technology, Mathematics and Engineering (STEM) fields as well as men. More than half of the U.S. population will be made up of minorities in 2043. It seems imperative that one of the most dynamic sectors of the U.S. economy no longer remain a male and largely white and Asian domain.

There is plenty of evidence that Indigenous Peoples in the U.S. also developed mathematical ideas based on their real-life experiences. Many of these examples can be useful in instructional materials to meet Common Core State Standards for Mathematics. This most recent renaissance in Indigenous scholarship, associated with information documented by mathematicians and social scientists, has spurred a variety of pedagogical materials. These include lesson plans and activities involving problem-solving and critical thinking, frequently in the context of real-life situations. Such didactic publications refer to either the acclaimed Curriculum and Evaluation Standards for School Mathematics (National Council of Teachers of Mathematics, 1989), or else the controversial Common Core.

Multicultural Mathematics: Critical Thinking and Real-life Situations

The truly multicultural history of mathematics also provides useful material for today's classrooms. For example, the children's book, Senefer, *A Young Genius in Old Egypt* (Lumpkin, 1992), tells the story of the African people of Egypt who developed the first ciphers or symbols for numbers. The events in the book, inspired by the life of Ah'mose, the scribe, and Senmut, an advisor to the female Pharaoh Hatshepsut, took place 3,500 years ago. Senefer grew up learning how to model with mathematics, raising obelisks and designing temples in Egypt. Can Senefer's wisdom help our mathematics classes today? Can we use multicultural examples to encourage students of color and broaden the cultural outlook of all students? A number of scholars, starting in the 1960s, dedicated enormous effort to make that happen. They were inspired by Ubiratan D'Ambrosio and Claudia Zaslavsky, pioneers in ethnomathematics. Take a look at the International Study Group on Ethnomathematics (ISGM; see http://isgem.rpi.edu/) for many excellent resources. Based on real-life situations, the works of ethnomathematicians offer a multitude of multicultural classroom-ready resources for mathematics teachers and students (e.g. Lumpkin, 1997a, 1997b; Zaslavsky, 1987a, 1987b).

Improving the representation of African Americans, women and minorities, Indigenous Peoples included, in the U.S. would also enrich American scientific research and development, because these populations would add a different perspective to workplaces currently dominated by white men. As the *NYT* article "How Teacher Biases Can Sway Girls From Math and Science" recently argued, entrenched stereotypes about who does well in science and math also work against minorities in classrooms (Miller, 2015). Many teachers give up easily on girls and minorities because they are not expected to do as well as white students.

These entrenched stereotypes begin to give way as teachers and students realize the value of Indigenous mathematics. Some examples of integrating Indigenous knowledge of mathematics into the standard mathematics curriculum were presented here. Others are in my book *Mapping Time, Space, and the Body*. But the question remains: How to integrate Indigenous mathematics and other non-European sources of mathematics into STEM programs? That is the challenge still facing all of us today.

References

Ferreira, M. L. (2015). *Mapping time, space, and the body: Indigenous knowledge and mathematical thinking in Brazil.* Rotterdam, The Netherlands: Sense Publishers.

Lumpkin, B. (1992). *Senefer, a young genius in old Egypt*. Trenton, NJ: Africa World Press, Inc.

Lumpkin, B. (1997a) *Algebra. Activities from many cultures.* Portland, ME: J. Weston Walch, Publisher.

Lumpkin, B. (1997b). *Geometry. Activities from many cultures.* Portland, ME: J. Weston Walch, Publisher.

Mauss, M. (1990). *The gift: The form and reason for exchange in archaic societies*. New York, NY: W. W. Norton. [First published 1925]

Miller, C.C. (2015). How teacher biases can sway girls from math and science. *New York Times*, 2/7/2015, p. A10.

National Council of Teachers of Mathematics (1989). *Curriculum and evaluation standards for school mathematics.* Reston, VA: Author.

New York Times (2013). Number crunch. *Editorial*, 12/11/2013, p. A28.

Zaslavsky, C. (1973). *Africa counts. Number and pattern in African cultures.* Boston, MA: Prindle, Weber & Schmidt.

Zaslavsky, C. (1987a). *Mathematics games and activities from around the world.* Chicago: Chicago Review Press.

Zaslavsky, C. (1987b). *Multicultural mathematics: Interdisciplinary co-operative-learning activities*. Portland, ME: J. Weston Walch, Publisher.