Indigenising University Mathematics - About Traditional Knowledge

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What follows should be framed as a starting point for our discussion. We invite you to share your views and experiences and help us shape this segment of our project.

The notion of traditional knowledge, as "the holistic total of an indigenous people's understanding of the world," (1) is a complex system that allows (and invites) multiple entry points of inquiry.

The approach that we propose is built on the following three pillars:

1. The definition of traditional knowledge as stated by the World Intellectual Property Organization:

> Traditional knowledge is knowledge, know-how, skills and practices that are developed, sustained and passed on from generation to generation within a community, often forming part of its cultural or spiritual identity. (2)

2. We accept Australian mathematics educator Alan Bishop's claim that:

> Mathematics, as cultural knowledge, derives from humans engaging in these six universal activities in a sustained, and conscious manner: counting, locating, measuring, designing, playing and explaining. (3)

3. We use the term mathematics in the sense of Brazilian mathematics educator Ubiratan D'Ambrosio's definition of ethnomathematics, i.e., as a term that includes:

> a very broad range of human activities which, throughout history, have been expropriated by the scholarly establishment, formalized, codified and incorporated into … academic mathematic but which also "remain alive in culturally identified groups and constitute routine in their practices. (4)

Our goal is to promote the inclusion of "knowledge, know-how, skills and practices" generated over centuries by Indigenous peoples in a wide range of mathematics related activities, including teaching, research, and mathematical modelling. This inclusion will provide the learners, users, and practitioners of mathematics with a set of powerful tools to better understand the complexity of the world around us.

To underline the connection between Traditional Knowledge and (ethno)mathematics, as an example, we draw a parallel between a document that discusses Traditional Knowledge and an article on ethnomathematics.

In its document "Intellectual Property and Traditional Knowledge" the World Intellectual Property Organization states:

> What makes knowledge "traditional" is not its antiquity: much Traditional Knowledge is not ancient or inert, but is a vital, dynamic part of the contemporary lives of many communities today. (…) Traditional Knowledge is being created every day and evolves as individuals and communities respond to the challenges posed by their social environment. (5)

In his article "Ethnomathematics and education" Marcelo Borba, a Brazilian mathematics educator, claims:

> When the solution of this problem involves a mathematical treatment, the solution contributes to the development of ethnomathematics in this culture. Over time, this ethnomathematics is probably going to be more efficient than the models stored in textbooks and written in codes not always accessible to a given cultural group, because it is connected to the culture where the problem was generated. (6)

In essence, both above quotes describe two "ceaseless cycles" that D'Ambrosio called "the basis for the theoretical framework upon which we base our ethnomathematics concept;" one at the individual level:

$$\ldots \text{ reality} \xrightarrow{information} \text{individual} \xrightarrow{strategy} \text{action} \xrightarrow{"facti"} \text{reality } \ldots$$

and the other at the level of the cultural group:

$$\ldots \text{ reality} \xrightarrow{history} \text{society} \xrightarrow{culture} \text{action} \xrightarrow{events} \text{reality } \ldots$$

Next, to illustrate some of the dynamics between Traditional Knowledge and mathematics, we offer three examples.

In Example 1, Traditional Knowledge is both a source and a corrector of mathematical notions. This example also shows that there are situations where Traditional Knowledge is not, to use a mathematical term, transitive. We observe that this seemingly simple idea, i.e., the idea that Traditional Knowledge of two different cultural groups may (and probably will) overlap, but are not identical, in the context of mathematics has been a major challenge throughout the history of mathematics. Think, for example, about the emergence of the non-Euclidean geometries, or the computer-generated proofs of mathematical facts that are not human-verifiable.

In Example 2, we use the work and the words of Delaine Tootsie-Chee, a member of the Hopi Nation, to illustrate Traditional Knowledge as a unison of "knowledge, know-how, skills and practices." We observe that Tootsie-Chee uses extensive mathematical terminology to describe both the process and the outcome of her work.

In Example 3, we describe the stone fish traps used by indigenous peoples across the Pacific Northwest region. With this example, we demonstrate the side of Traditional Knowledge that may be described by using the terms like *mathematical thinking*, *topology*, *engineering*, *geography*, *marine life*, and *sustainability*, among others.

Example 1: After stating that "[t]he History of Mathematics privileges the codes and techniques developed, organized and formalized in a specific style in academies emerging from the Mediterranean Basin," D'Ambrosio's reflects:

> It is impossible not to recognize that the codes and techniques developed as strategies to express reflections on space and time, such as measuring, quantifying, inferring, and also the emergence of abstract thinking in non-Mediterranean natural and sociocultural environments, many which were completely different to those coming into contact with them. The perception of space and time, which is the basis to generate measuring and quantifying, are a natural response to natural environment. (7)

In other words, D'Ambrosio argues that "a specific style in academies emerging from the Mediterranean Basin" was imposed on the rest of the world all the way to the level of challenging and possible negatively impacting the particular group's "natural response to natural environment," i.e., group's Traditional Knowledge.

D'Ambrosio further explains the idea, to again use mathematical terminology, that *global* should not necessarily be imposed on *local*, by observing:

> It is impossible to deny that space in the Arctic tundra is perceived differently from space in the Mediterranean region. The Arctic days and nights alternate in six-month cycles, completely different to the patterns and seasonal difference found in the Mediterranean Basin. Hence, the concepts of measuring and quantifying, which originated in the alternation of days and nights must be different. Every region of the World has its proper perception of time. The same is true for space. (7)

Example 2: Delaine Tootsie-Chee is a Hopi potter. Bowls that Tootsie-Chee creates are beautiful pieces of art, but with their prefect shapes, complex designs, and rich symmetries, those bowls are also undoubtfully mathematical objects.

Tootsie-Chee explains that:

> Passed down from family members in her clan, forming earth into beautiful painted pottery has been her calling since she was a young girl … It's not just artwork, it's a way of life, from digging the natural clay out of the ground, making the pigments and shaping the pots with her hands and tools that have been passed down through generations. Nampeyo, the famous potter who resided at Hopi house in the 1900s, is her ancestor, and Tootsie-Chee carries on the tradition as closely as possible. (8)

At a recent workshop, Tootsie-Chee provided the following details about the process of creating a clay bowl:

> Hopi potters don't use a potter's wheel, yet they get their pots nearly perfectly circular.

> I have to use my fingers. I have to feel the nature of the air bubbles. I need to eliminate the air bubbles as I go along. So, I format the way the bowl is shaped. I start with the shape of the bowl…
>
> I do not use a pencil or a ruler or anything to help me[1]. It's the shape of the pot that gives the diameters and tells me how it's going to be equally divided. I use the four directions. I make a line with the paint on the pottery. And when I begin painting, I always consider the first circle as the top circle, which represents unity, you as a person, a whole year, a complete circle. And then there's the second circle with the opening in it to release negativity. There's no geometric measurement. It's what the pottery tells you.
>
> I really don't have any sketch. I do not plan my designs on the pottery. It just comes to me naturally. (8)

But, as any mathematical object, Tootsie-Chee's bowls and pots are abstract representations of natural phenomena and the underlying, possibly implicitly expressed, ideas.

At one point during the workshop, an activity based on connecting significant points on the pot that workshop participants analyzed under Tootsie-Chee's directions, produced a new, previously, invisible shape:

> Delaine called this construction Orion's Belt, after the constellation. "If you ever consider looking at astronomy, that helps. Look at the stars. They help us." (8)

Example 3: Across the Pacific North-West region, First Nations used stone fish traps as a traditional way of fish harvesting.

The stone fish traps are sometimes large and complex networks of the stone walls that submerge at high tide but are exposed at low tide. As the tide began to roll out fish gets trapped inside the area bounded by the stone walls and the shore.

John Anthony Pomeroy, an archeologist, describes the stone fish traps in the village of Bella Bella in the following way:

> The shape most often is slightly bowed, the concave side of the bowing towards the stream. Often these have fairly large piles of rocks at either end of the trap against the shore or are built utilizing large boulders which crop out at the shoreline. Natural topography is utilized to take advantage of large boulders or the narrower part of the stream bed. The amount of work involved in constructing these traps must have been considerable, as some of the stones in the traps often are quite large and would have had to be moved considerable distances. This indicates the importance of the traps to the people building them. I suspect that it would take more than a single individual to construct them — probably a family unit or perhaps a group of villagers. (10)

[1] Tootsie-Chee explained that she uses only her fingers and her hand for measurement.

In short, constructing stone traps was an engineering project that required quite a bit of designing and planning. To construct such a large and important object would not be possible without what is now called “mathematical thinking.” For example, even prior to construction, one had to know about the location of the trap, the type of trap, the shape of the trap, the size of the trap, the configuration/topology of the trap, the periodicity of the tidal changes, the behaviour of the fish, and so on. Optimization, another mathematical notion, may be used to describe some other components of this kind of project: from how to optimize available resources (labour and the available material, as examples) to how to optimize the outcome: securing a reliable source of food for the community over a long period of time.

The fish stone traps were sustainable ways to support a First Nation’s food supply over many centuries. Our First Nation collaborators shared with us recent photos that display the clearly visible remains of old fish traps on their traditional territory. The fact that these structures are still there, after many decades of general disuse, is a testament to the skill and knowledge of the ancient builders.

One of our collaborators used the term “multipurpose” for the fact that the stone traps on Ahgykson (also known as Harwood Island) were “busy” throughout the year catching the seasonal fish. That is another concept that fits well in "mathematical thinking."

Bibliography:

(1)
https://www.sfu.ca/ipinch/sites/default/files/resources/fact_sheets/ipinch_tk_factsheet_march2016_final_revised.pdf

(2)
https://www.wipo.int/tk/en/tk/#:~:text=Traditional%20knowledge%20(TK)%20is%20knowledge,its%20cultural%20or%20spiritual%20identity.

(3) Bishop. A. J. (1988). Mathematics Education in its Cultural Context, *Educational Studies in Mathematics*, 19, 179-191.

(4) D’Ambrosio, U. (1985) Ethnomathematics and its place in the history and pedagogy of mathematics. *For the Learning of Mathematics* **5**(1), 44-48.

(5) https://www.wipo.int/edocs/pubdocs/en/tk/920/wipo_pub_920.pdf

(6) Borba, M. (1990) Ethnomathematics and education. *For the Learning of Mathematics* **10**(1), 39-43.

(7) D’Ambrosio, U. (2017) Ethnomathematics and the pursuit of peace and social justice. *Educação Temática Digital* **19**(3), 653-666.

(8) https://aimathcircles.org/wp-content/uploads/2021/04/Bluebird-Issue-10-Recap-Counting-Stars.pdf

(9) https://www.nhonews.com/news/2018/dec/04/hopi-potter-delaine-tootsie-chee-carries-family-tr/

(10) http://archpress.lib.sfu.ca/index.php/archpress/catalog/download/43/15/696-1?inline=1

Unused:
https://www.wipo.int/tk/en/tk/#:~:text=Traditional%20knowledge%20(TK)%20is%20knowledge,its%20cultural%20or%20spiritual%20identity.

https://www.afn.ca/uploads/files/env/ns_-_traditional_knowledge.pdf

https://blogs.ubc.ca/traditionalknowledgetechnology/revaluation-of-indigenous-cultures/what-is-indigenous-traditional-knowledge/
https://repository.upenn.edu/cgi/viewcontent.cgi?article=1172&context=anthro_papers