”Ingeniero como vos”: An analysis of the Mbyá-Guaraní Practices Associated with Engineering Design

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Abstract

The Mbyá-Guaraní are a group of nomadic people that have inhabited impenetrable territories in South America for centuries [1]. They are one of the groups that had the least amount of contact with the Jesuit missions of the 17th century, thus maintaining most of their traditional ways of knowing, doing and being. To date, however, there has been little discussion about how their cultural and social practices and Indigenous knowledge have contributed to their meaning and sense-making practices related to engineering. The purpose of this study is to generate knowledge on how native engineering practices (indigenous engineering) are enacted, and use this body of knowledge to describe how non-Western ways of knowing, doing, and being also have a place in engineering discourse. This study seeks to bring together, honor, and incorporate the voices, histories, practices, and emic perspectives of indigenous communities to the engineering community, and to evaluate the knowledge/power nexus when engaging in community engagement projects with indigenous communities.

Introduction

The Mbyá-Guaraní is an indigenous community in South America primarily located on the imposed geopolitical boundaries of the modern countries of Argentina, Paraguay and Brazil [2]. The Mbyá-Guaraní communities are known for their subsistence practices since the times of the Jesuit missions in South America. Some of these practices include the cultivation of corn, manioc, peanut, squash, watermelon, and beans among others [3]. The communities have also thrived in this area due to their hunting, fishing, gathering, and handcrafting practices [2]. Moreover, these communities have accumulated and culturally developed bodies of cultural, social, historical, and cognitive knowledge and skills that are essential for their household and individual functioning and well-being.

Traditionally, different groups of Mbyá people have been known for their resistance against White people and their culture and language. This resistance also meant that, until recently, much of their cultural practices remained a mystery for outsiders [4]. When the first Jesuit missions arrived to South America, the Mbyá-Guaraní put up a fierce resistance against not only the Jesuits but also anyone who wanted to penetrate their culture [2,5]. They maintain a united tribal life and have created small communities that are–in most cases–not influenced by external cultures. Occasionally, they come in contact with people external to their communities. In fact, some of the Mbyá-Guaraní have been forced to assimilate to the customs of other ethnic groups due to the lack of governmental support and neoliberalist practices in the region [6,7].

Research has indicated that the Mbyá-Guaraní possess "extensive knowledge of the healing properties of the forest plants" [2, p. 204]. They also practice subsistence agriculture, extract cane (*tacuarembo* and *tacuapí*) from the forest, make crafts for religious and commercial

purposes, and share information about more than 229 species of *guyrá* (birds), 80 species of wild plants, and 11 species of bees and wasps [2,3,5]. They are also known to possess a wealth of resource management, extraordinary craftsmanship skills, build entire communities and water irrigation systems, and unquestionably hold a great amount of native scientific, including astronomical, knowledge [3]. There is, however, limited research that describes the language [8] and few studies describe transliterations processes in the community.

Despite the wealth of knowledge, skills and practices among the Mbyá-Guaraní, there is little discussion about the complexity of their social and cultural practices, and how those practices are used to generate engineering knowledge. The current master narrative has created a dichotomy and boundary between what is engineering and what is not [9,10]. This dismissal of indigenous knowledge in engineering comes from a long history of oppression, demonization and persecution [11]. For example, Domingo Sarmiento, one of the most influential political figures in Argentina, sought to exterminate indigenous communities and promoted the eradication of the "savage indian" by supporting assimilation programs that aligned with White, ethnocentric ideals [12]. Unfortunately, to date, these ideals have penetrated and permeated our society, shaping how we perceive the world around us.

To counter the existing narratives about the lack of contributions of indigenous communities to engineering, and to dispel the myth that engineering is primarily a cognitive process separate from sociocultural practices, we sought to investigate how a Mbyá-Guaraní community in Misiones, Argentina, built engineering knowledge through social and cultural practices. This study seeks to describe how native practices are used to enact engineering across different contexts and in holistic ways.

Indigenous Knowledge

Indigenous knowledge is a fundamental resource that must be promoted to support the well-being of different indigenous communities that are often threatened, primarily by Eurocentric approaches to science and engineering. According to Battiste [13],

> *Indigenous knowledge is far more than the binary opposite of Western knowledge. As a concept, Indigenous knowledge benchmarks the limitations of Eurocentric theory – its methodology, evidence, and conclusions – reconceptualizes the resilience and self-reliance of Indigenous peoples, and underscores the importance of their own philosophies, heritages, and educational processes. Indigenous knowledge fills the ethical and knowledge gaps in Eurocentric education, research, and scholarship* (p. 5).

This excerpt from Battiste provides a better understanding of how Indigenous knowledge is not only complementary to the Western conceptualization of science, but it is also a way of life. Indigenous knowledge does not separate the individual from the history, culture, and surroundings (e.g., the context). Western science and knowledge, on the other side, try to separate the object (science) from the subject (the scientist). Thus, Western science rhetoric has

created a false perception of objectivity and neutrality while perpetuating the idea that science, and consequently engineering, are apolitical and objective.

Aikenhead and Ogawa [14] described Indigenous knowledge as "wisdom-in-action" (p. 553), which encompasses a journey toward wisdom that differs from the Eurocentric process to "know." Indigenous knowledge involves a very intimate process, a journey to wisdom that is related to human action [11]. Different from Western conceptualizations of science, Indigenous knowledge is "participatory, experiential, process-oriented, and ultimately spiritual" [15, p. 36]. It is communicated and learned through oral tradition and modeling through others, listening to stories, through songs, religious or spiritual ceremonies, dancing, celebrations, and is embed in their language [14]. All of this knowledge, skills and practices are generational and typically fall on the hands of elders. Battiste and Henderson [16] argued that Indigenous knowledge is holistic in nature and that there is no separation of science, art, philosophy or aesthetics in Indigenous thought, which contrasts the Eurocentric scientific dominant discourse which seeks to separate the scientists from the contents in which they exist.

Moreover, understanding Indigenous knowledge is also a political act because it involves the renegotiation of what science means across contexts [14]. A study conducted in Venezuela tried to describe how the traditional cultural practices of slash and burn techniques used by local indigenous groups were based on a narrow and ignorant perception of the local cultural and environmental logic and not on valid scientific bases [17]. Trying to understand the perspectives of the indigenous community and their Indigenous knowledge led to reconceptualizations of what was predominantly considered "valid" and "scientific." According to the study, the conflicts that emerged from the different perceptions of the stakeholders contained enough overlap that could be conducive to constructive changes for sustainable practices. Thus, the mutual understanding is necessary to overcome stereotypes and challenge the master narrative of science and engineering. This study provides an argument for the need to understand and acknowledge how indigenous knowledge can be the foundation for a broader understanding of scientific and engineering practices beyond disciplinary or epistemological lines, and to recognize engineering activity as a political act that is in no way isolated from subjects or contexts.

Positionality

The engineering design process has been revisited in many textbooks, conference papers, and presentations, and it is consistently taught in the engineering curriculum in students' capstone course as a culmination of their degree. Traditionally, the focus of the engineering design process tends to be on the technical specifications and requirements of the design. Though recently, more humanistic aspects of the engineering design process have been incorporated [18,19,20,21], as it stands, engineering design and the traditional engineering narrative are not focused on the epistemological and emic systems that surround it. Often, the master narrative in engineering education has impaired our ability to critically analyze how engineering is enacted in different contexts, including those that embed Indigenous knowledge.

This paper is not intended to provide a comparison between traditional conceptions of Western engineering practices and Indigenous engineering practices, but to describe practices that are centered around the voices of indigenous people. We recognize that this space is necessary because engineering has benefited from the extraction of knowledge from indigenous communities without giving credit to their systems of knowledge.

We posit that if engineering education is to be shaped as an emancipatory rather than oppressive practice, principles of equity and social justice must be articulated and implemented in the engineering narrative and the ways in which engineering knowledge and knowledge construction are described and recognized. This project is motivated by the gap currently existing in engineering education in terms of our understanding of engineering knowledge and what constitutes engineering in terms of Indigenous knowledge. We recognize that knowledge is not a one-way street and that Western traditions have benefited from Indigenous knowledge even if it is not evident in the curriculum, the discourse, or everyday practices. We argue that a reconceptualization of engineering knowledge, which can be described as a construct, and the decolonization of the curriculum is necessary to develop critically conscious engineers. We also acknowledge that we are not indigenous people ourselves, or possess Mbyá-Guaraní knowledge, and our analysis should be interpreted as indicative and not definitive [14]. We also recognize that entering this community involved thinking more broadly on our position as researchers and the power dynamics at hand. We are committed to the long-lasting relationships with the community and recognize that this is not about ourselves, but about surrendering to new emic perspectives. We seek to join forces with a community that seeks to have a voice but have been neglected a seat at the table and deserve to be part of the conversations.

Context of the Study

This analysis centers on a specific telling case [22,23] of a Mbyá-Guaraní community in Misiones, Argentina. The community consists of 20 families and approximately 100 inhabitants. The families work together and most of their activities are communal in nature, including ceremonial events. The Mbyá-Guaraní people in the community are connected to other communities in the region but at the same time maintain their own traditions. It is very common for these communities to preserve some nomadic behaviors. For example, some individuals or entire families frequently move to other Mbyá-Guaraní communities, even across national borders (e.g., Paraguay and Brazil). The Mbyá-Guaraní people form part of the larger "Guaraní Nation" [24], a group of ethnicities that share commonalities in terms of language and sociocultural practices. Other ethnicities in this group include the Avá, Aché and Kaiowá people. It is estimated that there are about 100,000 individuals in the Guaraní Nation living in approximately 500 communities spread across Argentina, Bolivia, Paraguay and Brazil [24].

The community in this study was accessed by connections made by author de Paula, a local Argentinian citizen. Both Mejia and de Paula visit this community every year and have built significant relationships with some of the community members. Both authors were invited to visit the community to learn more about their history and their traditions. In this study, we focus

on how the community members built traps to capture animals endemic to the region. We focused on how Indigenous knowledge was used to "engineer" artifacts. The visits included tours of their community for one week. However, we were not allowed to visit their religious and ceremonial sites, which are closed to outside visitors. The community also houses a cultural and artistic center where members of the community engage in artistic activities and create products that are sold to outsiders.

The social structure of the community was based on a patriarchal model–although changes are occurring and a few communities now have female *caciques* (leaders) that are in charge of the community affairs. Elders in the community act as religious leaders and keepers of culture and tradition, while younger generations are in charge of planting, building, gathering and hunting activities. Typically, most of the artisanal work is done by women and children while older male community members are in charge of manual labor (e.g., building, harvesting, etc.). In addition, some members of the community receive government subsidies to help with their every-day expenses.

Data Collection and Analysis

Visits were made to the community to gather information about their sociocultural and “engineering” practices. Note that the word engineering is in quotation marks because the work engineering comes from a Westernized conceptualization and it may not have the same meaning for the Indigenous community or even exist in their linguistic practices. Data was collected from interviews, observations, and analysis of artifacts. Most of the data was audio recorded during tours of the community, including a tour of the forest where a member of the community explained how they made traditional traps and the significance of their spiritual house. For this paper, we decided to focus on the traps and the spiritual house because these were the most tangible examples of Indigenous knowledge translated into what a Westernized approach would describe as "engineered" artifacts. Pictures of these artifacts are included in this paper.

All the interviews were done in Spanish, which was a secondary language for the participants. After the data was collected, audio recordings were transcribed and analyzed following a deductive coding approach to qualitative research [25]. The results and analysis obtained from the data are presented in the following sections. It is important to emphasize that this analysis is in no way a description of the more than 500 Guaraní communities in the region. However, this study serves as a telling case of a phenomenon that may have similarities with other communities [22,23].

Limitations

From our first visit to the community, we understood that there were power relations at hand and that acknowledging our positionality as researchers was very important. Thus, building trust with the community was imperative. Although a good level of trust was built during the visits, it is not clear how much information was shared depending on the level of perceived trust from the community. In addition, most community members speak Mbyá, their language, and only a few

community members spoke Spanish. Both authors are native Spanish speakers but had limited contact with the vast majority of the community members, and most discussions happened between the authors and two guides. There is the possibility that there was some information that was lost during translation. Thus, language was one of the most salient limitations as well as the perceived trust from the community.

Results and Discussion

The tour to the community began with a visit to a replica of their *casa espiritual* (spiritual house), which was a clear example of Indigenous knowledge. The house was built with *barro* (clay), rocks, sticks, and had a very strong foundation. Figure 1 shows the replica of the spiritual house. Only members of the community are allowed to enter the house; therefore, we were only allowed to see the replica of the house, which is smaller and was specifically built for outsiders to see.

According to the guide,

> *La casa espiritual es donde se danza y se ora. En el mes de enero se hace mbtá (pan tradicional de maíz) y se lleva a la casa espiritual. Allí las personas reciben su nombre espiritual en esas ceremonias.*
>
> [The spiritual house is where you dance and pray. In the month of January, *mbtá* (traditional corn bread) is brought to the spiritual house, where people receive their spiritual name in these ceremonies.]

Figure 1. Replica of the inside (left) and outside (right) Mbyá-Guaraní spiritual house

The spiritual house embodied the Indigenous knowledge of the community. A communal practice that included not only the technicality of building a house, but the spiritual connection to it. It was the place where they received their spiritual names, which are not recorded in the Argentinian official records. This demonstrates not only the departure from traditional Western

forms of knowing and doing, but also a form of resistance to hegemony. Thus, as indicated by Battiste and Henderson [16], there is no separation between science, art, building, communal practices or aesthetics in Indigenous thought, even when it encompasses engineering practices. The house was built not only for shelter, but the foundation, orientation, and material selection was embedded in a particular purpose. The holistic conceptualization of a "house" also contained aspects of spirituality, functionality, and mysticism.

The *casa espiritual* was constructed by the community. Everyone participated in the construction and, as part of the community, it belongs to everyone. In fact, there is only one *casa espiritual* in every community and it becomes the epicenter of all activities. One of our guides indicated that,

> *La casa espiritual es donde se aprenden a hacer las casas. A los chicos se les enseña a construir esas casas [casas espirituales]. Una persona de la comunidad, un adulto, enseña a las demás personas. Es conocimiento de generaciones. Toda la comunidad colabora para construirlos.*
>
> [The spiritual house is where you learn to make houses. The children are taught to build these houses [spiritual houses]. A person from the community, an adult, teaches other people. It is knowledge of generations. The whole community collaborates to build them.]

This excerpt describes why communal knowledge is important not only for cognitive processes but also for sociocultural processes. Within these processes, we also observed that knowledge was always shared and that competency is not assessed on predetermined ideas but that it is part of the journey to wisdom [14]. Competency in terms of Indigenous knowledge is related to survival, communication, modeling, listening, and participating in different ceremonies [14], which completely deviates from Westernized conceptions of assessment.

Indigenous knowledge in the community also centered on a relational understanding of different components to make something tangible. When building traps, community members relied on their knowledge of their surroundings and observation patterns. For example, a simple trap that is made by children is specific for birds and small animals where the children use flexible and light materials. These traps are usually located in areas where birds and small animals tend to look for food, which is usually close to the roots of the trees. Figure 2 shows an example of this trap. The children learn from their parents or older siblings and, aligned with Indigenous thought and the idea of the whole equilibrium of the ecosystem, these traps are not designed to kill the birds. The traps are meticulously built so that the release mechanism of the trap does not harm or scare the animal. The release mechanism used an arch with an adjustable stick (toggle stick) that, when moved by the paws of the animal, was triggered and activated the mechanism. Figure 3 shows the release mechanism for the trap, which was used across different contexts for different traps, thus demonstrating transliteration of knowledge across different contexts.

Figure 2. Representative example of small trap used for birds and small animals.

Figure 3. Representative examples of release mechanisms for traps. Note the arch and toggle stick used to activate the mechanism.

These representative examples of artifacts created by the community encompass the essence of Indigenous knowledge. It is relational (e.g., focuses on the relationships between knowledge, tradition, and all creation), place-based, dynamic (e.g., based on observations, changes, insights, relationships, action/reaction), generational, and context-specific [14]. It is communal and shared because everyone in the community needs to learn how to contribute to the larger social and cultural aspects of the community. The animals that are trapped are not always killed or eaten though, following a holistic view of nature, which is also part of Indigenous knowledge [13,16]. Sometimes animals are caught to have them as pets. The traps are designed with great precision to ensure that the force does not kill the animal. If the goal is to kill the animals, then the design must change–and it is changed according to the needs of the community. Such changes require a great amount of knowledge about the environment, materials, scaling up, and the correct use of certain tools. Also within the design considerations, it is important to know the context and the environment. For example, one must understand the behavior of animals, how they move, whether they are diurnal or nocturnal, or what type of food they consume.

Conclusion

Observing members of this community share their culture and traditions with us was an enriching experience that allowed us to witness Indigenous knowledge and their generational collective efforts. The Mbyá people have successfully transliterated this holistic knowledge across two millennia and they have embedded it in sustainable practices that they continue to use in their everyday lives, to build houses, places of worship and hunt.

Although there is no Westernized conception of engineering (e.g., use of an engineering design model) in the community, community members acknowledged the value of their practices in maintaining their well-being. In fact, as we were observing the different traps made by community members we mentioned that the design of the trap was “muy ingenioso” (very ingenious). One of the community members mentioned “si, ingeniero como vos” (yes, engineer like you). This conversation made us realize the importance of acknowledging their voices and to surrender to the ways of knowing, doing and being while valuing the impact of all indigenous communities on the social fabric.

Indigenous people’s voices have historically been (and continue to be) neglected. Although their practices overlap with certain Western methods, it is important to recognize their unique perspectives and provide the space to recognize what they have contributed to this world. Western, ethnocentric methods have also benefitted from them but there is usually little to no mention of this contribution in traditional engineering practices. We want to use this experience to highlight the significance of the knowledge of these communities, and how future generations of engineers could benefit from understanding that engineering is a sociocultural practice that cannot exist in isolation.

Future studies and plan for action include more conversation on how to decolonize the engineering curriculum and integrating more native engineering practices in traditional engineering classrooms. It is important to recognize that everyone has benefited from native engineering practices (e.g., wildlife population monitoring, ecological relationships, sustainable harvesting practices, and canoe or snowshoe artifacts that were quickly adapted by European

settlers), which in some instances were taken from indigenous communities by violent means or through genocide. Current efforts include the development of engineering curriculum that showcases how indigenous communities create and harness energy through sustainable means. The curriculum is also intended to question who is doing engineering, where engineering is done, and whose knowledge is valued. Primarily, the ultimate goal of future research is to use these frameworks and reconceptualization of engineering to work together with communities and form long-term relationships to validate and recognize indigenous knowledge in engineering spaces.

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References

[1] M. Bonomo, R. C. Angrizani, E. Apolinaire, and F. S. Noelli, "A model for the Guaraní expansion in the La Plata Basin and littoral zone of southern Brazil," *Quaternary International,* vol. 356, pp. 54-73, 2015.

[2] C. Galindo-Leal and I. de Gusmão Câmara, Eds., *The Atlantic Forest of South America: biodiversity status, threats, and outlook*. Washington, DC: Island Press, 2003, p.^pp. Pages.

[3] M. Pochettino, M. Martínez, and M. Crivos, "Landscape domestication among two Mbyá-Guaraní communities in Misiones, Argentina," *Ethnobiology and biocultural diversity,* pp. 696-704, 2002.

[4] L. Cadogan, *Diccionario Mbyá-Guaraní Castellano* vol. 78. Asunción, Paraguay: Biblioteca Paraguaya de Antropología, 2011.

[5] M. Crivos, M. R. Martínez, M. L. Pochettino, C. Remorini, A. Sy, and L. Teves, "Pathways as" signatures in landscape": towards an ethnography of mobility among the Mbya-Guaraní (Northeastern Argentina)," *Journal of Ethnobiology and Ethnomedicine,* vol. 3, p. 2, 2007.

[6] R. K. Reed, "Mbyá Resistance And The Politics Of Space In Asunción," *Urban Anthropology and Studies of Cultural Systems and World Economic Development,* pp. 261-291, 2015.

[7] R. K. Reed, "Environmental Destruction, Guaraní Refugees, and Indigenous Identity in Urban Paraguay," in *Climate Change, Culture, and Economics: Anthropological Investigations*, ed: Emerald Group Publishing Limited, 2015, pp. 263-292.

[8] M. N. De Paula, *A description of the sound system of Misiones Mbya*: West Virginia University, 2016.

[9] C. Baillie, A. Pawley, and D. M. Riley, Eds., *Engineering and social justice: In the university and beyond*. West Lafayette, IN: Purdue University Press, 2012, p.^pp. Pages.

[10] A. L. Pawley, "Universalized narratives: Patterns in how faculty members define “engineering”," *Journal of Engineering Education,* vol. 98, pp. 309-319, 2009.

[11] W. A. Wilson, "Introduction: Indigenous knowledge recovery is indigenous empowerment," *American Indian Quarterly,* pp. 359-372, 2004.
[12] D. Zalazar, "Las posiciones de Sarmiento frente al indio," *Revista Iberoamericana,* vol. 50, pp. 411-427, 1984.
[13] M. Battiste, *Reclaiming Indigenous voice and vision*: UBC press, 2011.
[14] G. S. Aikenhead and M. Ogawa, "Indigenous knowledge and science revisited," *Cultural Studies of Science Education,* vol. 2, pp. 539-620, 2007.
[15] H. Michell, "Nēhîthâwâk of Reindeer Lake, Canada: Worldview, epistemology and relationships with the natural world," *The Australian Journal of Indigenous Education,* vol. 34, pp. 33-43, 2005.
[16] M. Battiste and J. Y. Henderson, *Protecting Indigenous knowledge and heritage*. Saskatoon, Saskatchewan: Purich Publishing, 2000.
[17] I. Rodríguez, "Conocimiento indígena vs científico: el conflicto por el uso del fuego en el parque nacional Canaima, Venezuela," *Interciencia,* vol. 29, pp. 121-129, 2004.
[18] J. D. VanderSteen, C. A. Baillie, and K. R. Hall, "International humanitarian engineering," *IEEE Technology and Society Magazine,* vol. 28, 2009.
[19] C. Mitcham and D. Muñoz, "Humanitarian engineering," *Synthesis Lectures on Engineers, Technology, and Society,* vol. 5, pp. 1-87, 2010.
[20] J. VanderSteen, K. Hall, and C. Baillie, "Humanitarian engineering placements in our own communities," *European Journal of Engineering Education,* vol. 35, pp. 215-223, 2010.
[21] J. A. Leydens and J. C. Lucena, "Social Justice: A Missing, Unelaborated Dimension in Humanitarian Engineering and Learning Through Service," *International Journal for Service Learning in Engineering,* vol. 9, 2014.
[22] J. C. Mitchell, "Case and situation analysis 1," *The sociological review,* vol. 31, pp. 187-211, 1983.
[23] J. Mitchell, "Typicality and the case study," in *Ethnographic Research: A guide to general conduct*, R. Ellen, Ed., ed London: Academic Press, 1984, pp. 237-241.
[24] G. Grumberg, B. Meliá, and M. M. Azevedo, "GUARANÍ RETÃ: Los pueblos guaraníes en las Fronteras de Argentina, Brasil y Paraguay," Asunción, Paraguay2009.
[25] J. Saldaña, *The coding manual for qualitative researchers*, 2nd ed. Thousand Oaks, CA: SAGE, 2015.