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## **Introduction to “Indigenous Knowledge and Ethnomathematics”**

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### **1. Preliminary remarks.**

The present volume aims to offer some more insights on the relationships between indigenous knowledge and ethnomathematics. These relationships have a history, as some of the texts remind us (e.g. Almeida, Vandendriessche). We think it is important to elaborate on the possible links between both domains because of the richness involved, and because mathematics education on a global level is likely to benefit from such lines of research. In the conclusions to this volume, we indicate some points which may have potential for the future. It is good to question old views in both disciplines: many mathematicians will regard their thinking as context or culture-free, on the one hand, while some anthropologists will claim that the ethnoscience studies of recent decades are uncritical types of reductionism, stereotyping thinking in other traditions as particularistic and weaker instances of what was developed in Western history. Although classification studies and the later ethnoscience approaches can be arguably described as emanating from such frames in the 20th century, the combined interdisciplinary work by mathematically literate anthropological researchers in the present volume questions this sort of type casting. What was called ethnomathematics in the ‘70s and ‘80s of the past century has since matured, mainly thanks to an in-depth collaboration of knowledgeable researchers in both disciplines. It appears that the mere evaluation of the relationships between Indigenous Knowledge and what is nowadays called Ethnomathematics cannot be reduced to a “culturalist” bias on native knowledge (as it was to some extent in the early days of the American ethnoscience scene: Descola, 2015). It is the hope of this book’s editors that the contributions to this volume will allow for a renewed and substantially deepened discussion on these issues.

Most of the chapters in this volume were the subject of a presentation in a symposium, as part of the “18<sup>th</sup> International Union of Anthropological and Ethnological Sciences (IUAES) World

Congress”, Florianopolis, Brazil, 2018<sup>1</sup>. However, the texts have been thoroughly reworked in order to become substantial contributions to the field we work in. A few texts are new and were invited afterwards: M. Baker, A. Chronaki, L. Tiennot, S. Oliveira et al. The editors added a comprehensive introduction and conclusive remarks.

The structure of the book has been discussed thoroughly among the editors, since a book is, of course, altogether different from mere proceedings at a conference.

## **2. The book’s structure.**

### **Part I “Ethnography and mathematics”**

This part presents papers focusing on particular ethnographic studies, in order to reveal the obvious and visible, but also the hidden or deep structural mathematical features in particular and diverging cultural phenomena.

Céline Petit offers the first ethnographic text under the title “*Creating ‘Evocative Images’ sunannguanik iqqaigutininik: Procedural Knowledge and the Art of Memory in the Inuit Practice of String Figure Making*”. This study begins with the amazing fact that string figure making can be found around the world. It proves to be a widespread activity of procedural knowledge. The chapter focuses primarily on the Inuit tradition.

The meanings of String Figure Making are diverse, ranging from cosmological and ecological referencing to more strictly social roles and uses: indeed, it is often found as a means of socializing, in the guise of storytelling while making the figures. Petit analyzes String Figure making as a kind of procedural activity, which is important in knowledge transfer, memory training and to frame cultural learning processes. Moreover this tradition has symbolic meaning in different groups: the figures can be a hindrance during hunting endeavors, causing trouble during the hunt.

Petit then goes on to reveal the structuring and recurring patterns and relations, which can be identified as mathematical relations. Especially geometric forms with their hidden or explicit

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<sup>1</sup> The idea of elaborating this book on “Indigenous Knowledge and Ethnomathematics” has emerged during the Panel “Indigenous Mathematical Knowledge and Practices: (Crossed-) Perspectives from Anthropology and Ethnomathematics”, coordinated by Eric Vandendriessche, Rik Pinxten, and Céline Petit, as part of the 18<sup>th</sup> International Union of Anthropological and Ethnological Sciences (IUAES) World Congress”, Florianopolis, Brazil, 2018. The organization of this panel and thereafter the implementation of this book project would not have been possible without the financial support of the French National Research Agency (“ETKnoS” Project, 2016-2021).

symmetry relationships are highlighted. In the final paragraphs, the impact of the recognition of this tradition for mathematics teaching is explained.

In “*Modeling of implied strategies of Solo expert players*”, Luc Tiennot makes an in-depth analysis of several forms of sowing games. These games were probably invented in Africa, but traveled to a larger area around the world, throughout Eastern South America, and Southern Asia in particular. They are combinatorial board games for two players that consist in moving seeds—organized in the board’s “cups”—, thus “sowing and capturing” the latter seeds through precise rules and procedures. The chapter concentrates on a particular complex form of these sowing games, called *Solo*, that are played from Central to Southern Africa, including Madagascar, where the author has carried out field research. Among the different kinds of *Solo*, Tiennot studies the sowing games *bao*, originating from Zanzibar, and the different variants of this game that he has observed throughout Madagascar. The different forms of the game show the complex use of mathematical operations. The author manages to show how systematic ethnographic work on these games can reveal the mathematical algorithms which are hidden in them. To this end, Tiennot also introduces different modeling tools (symbolic writing, and mathematical graphs in particular) for encoding and analyzing the procedures implemented by the players during the game. This modeling approach allows us to gain a better understanding of how the sowing game experts can play so fast, by anticipating the outcome of each move (without “overloading their short-term memory”) through the implementation of “optimized movements”.

In “*Sand drawing versus string figure making*”, Eric Vandendriessche compares two activities of the Northern Ambrym Islanders in Vanuatu, which are both seen as forms of “writing” in the local knowledge. One is the making of string figures with hands, feet and/or mouth. The other is drawing a continuous line in a loop with the finger in the sand (or dusty ground). Both express and record knowledge on either particular mythic entities or specific environmental phenomena in the area.

In the second place, and most importantly, the author investigates what notions, terms and concepts of operation, procedure, sub-procedure, symmetry and iteration can be found in both types of practices and how these reveal shared geometric and algorithmic properties. In this way, ethnographic detail and in-depth analysis on mathematical thinking in these practices are offered as material for the basic discussion in this volume, going from a particular ethnographic context to the general interdisciplinary field of investigation the editors have in mind.

## **Part II “Impact of indigenous culture on education in general, and on mathematics classes in particular”**

Here the reader will find two Brazilian studies. Both rightly claim that Brazil has a particular and very interesting history with regard to the impact of native cultures on educational programs. Apart from these two articles, a chapter is included that focuses on projects in the north of Greece.

In “*Indigenous school education*”, Sérgio Oliveira, Liliane Carvalho, Carlos Monteiro and Karen François first give a synthetic overview of the history of Indigenous peoples in Brazil, from the beginning of the invasion/colonization (from 1500 on), when these peoples have been decimated by the invaders, and thereafter subjected to colonial authorities and religious institutions. After independence (1822), different educational programs have attempted to acculturate these populations. It will take more than 150 years, through different Indigenous movements’ struggles, to see public policies emerge in Brazil, and the creation of the Indian’s National Foundation—FUNAI, finally granting civil and political rights to Brazilian indigenous people, including legal regulations of their lands, education, culture, and health. Our authors show that the development of local educational systems, progressively taking into account the cultures of the various Brazilian Indigenous societies, has been done through a long process which finally led to legal recognition. Recently, these political and educational advances have been deliberately dismantled, by the federal government, seeking to “deconstruct the rights and guarantees of social policies aimed at indigenous peoples. Education was the hardest hit by these constraints.”

However, various Brazilian indigenous communities continue to struggle for an intercultural education based on the respect of diversity. It is indeed the case of the Xukuru of Ororubá people settling in different villages in the state of Pernambuco. They “strengthen their ethnic identity and reinforce their struggles through a socio-political organization”. In particular, the Council of Xukuru Indigenous Teachers of Orurubá which seeks to discuss issues related to intercultural education, helping indigenous teachers to entwine the official curriculum with their own local culture. It is in collaboration with the latter council that our authors have undertaken a collaborative research program related to the teaching of statistics. The chapter ends with the description of this experiment: At first, Oliviera’s team carried out a participant-observer ethnographic research, in order to better understand the Xukuru cultural context. Thereafter, a collaborative working group was formed with both indigenous teachers and our researchers, in order to determine how teaching statistics could be correlated with the Xukuru’s

concerns, while implementing a (locally based) course plan on statistics (related to the use and preservation of water resources in these communities). Indeed, the results of this local experiment suggest that such pedagogical projects (when carried out in collaboration with local educational institutions) can enhance the relationship between the local curriculum and indigenous communities' challenges.

The role of so-called non-western worldviews and formal reasoning procedures in the general educational landscape of a large and intensely diverse country like Brazil illustrates a point that will have much relevance in the future, for many countries in this progressively mixed world.

In "*Indigenous mathematical knowledge and practices*" Cecilia Fantinato and Ketio Leite focus on a particular topic: within the context of Brazil's studies of mathematics and education, one finds a series of six consecutive congresses (2000-2016). The authors analyze formats and presentations during these nationwide conferences and indicate how they got to be progressively more interested in and marked by native perspectives in mathematics education. They show how the political focus allowed for this shift over the years, combined with the successful development of cohorts of "native" teachers. Brazilian ethnomathematicians Maria Cecilia Fantinato et Kecio Leite give an overview of the research in ethnomathematics carried out in Brazil over the past 20 years, dealing with issues related to indigenous knowledge and culturally based education. Since the seminal works by Ubiratan D'Ambrosio in the 1980s, the ethnomathematics research field has significantly developed in this country (as nowhere else in the world) and institutionalized in many Brazilian Universities. In order to draw a picture of the impressive Brazilian production in ethnomathematics, the authors first analyze the different topics addressed throughout the five editions of the Brazilian Congress of Ethnomathematics (CBEm), from 2000 to 2016. Notably, this brings to light an increasing interest—over this period—for research devoted to indigenous mathematical practices and knowledge and their pedagogical implications. The chapter demonstrates that the reasons are threefold; first, there are over 300 different indigenous societies in Brazil. This great linguistic and cultural diversity in this country offers invaluable opportunities for carrying out such research, which few ethnomathematicians have undertaken since the 1980s. Secondly, in 2008, a law was adopted, establishing the guidelines for National Education, while including in the official curriculum the mandatory topic "History and Afro-Brazilian and Indigenous Culture". Consequently, this led to an increase of the number of works on indigenous mathematical knowledge and their possible uses for the elaboration of culturally based curricula. Thirdly, the development of Indigenous Intercultural Licentiate University Courses implies an increasing "capillarization of Ethnomathematics in teacher training courses" from undergraduate to graduate education.

As a consequence, Brazilian academic research in ethnomathematics is conducted by indigenous researchers who belong to the societies/communities under study. The chapter thus raises some issues regarding the research methodology implemented by these new generations of researchers arguing that they do not need to carry out genuine ethnographies—as non-native researchers did—since they are dealing with their own cultures.

In “*Subverting epistemicide through ‘the commons’: Mathematics as a re/making space and time for learning*”, Anna Chronaki and Eirini Lazaridou focus on the global—and the Greek—push towards detached and presumed universal mathematics and mathematics educational programs, emanating from the neoliberal think tanks of our time. With an in-depth ethnographic research on alternative developments in one particular region of Greece (bordering on Macedonia) the authors characterize two opposing educational lines of development.

The first trend yields what is called “epistemicide”, resonating with critical studies within mathematics education and schooling in general. The term epistemicide refers to the destruction of local, but also of situated learning processes and contents, replacing them with so-called global universally powerful alternatives. The authors describe what this trend allows for and is producing in the local community: the destruction of knowledge (hence the specific term “epistemicide”) and the uprooting of the local people who are enduring this trend. The second trend is observed as a local alternative and goes by the name of “radical pedagogy of commons”. It is linked to a profound criticism of mathematics education, as it is emerging in for example South America, with an ontological shift towards a “pluriverse” instead of the western-dominated so-called universal knowledge. In that sense the study relates to the project of this book, and it prefigures some of the theoretical critiques in Baker’s chapter (part III). Also, it exemplifies what was precedingly referred to in this field as “street mathematics”, which may be interpreted as ethnomathematics in western cultural contexts. The authors’ study shows how the explicit explorations of mathematical knowledge in and through local places, objects, experiences and ways of dealing with the wide-ranging local world of experience allows for emancipatory alternatives: mathematics learning through walking, producing and other human and human-nonhuman phenomena.

### **Part III: “Meta-studies”**

The former parts deal with particular cases or cultural traditions, introducing the reader to a lot of empirical research, mostly by ethnographers or by ethnographically informed mathematicians and educators. In Part III we introduce three texts that take a “bird's-eye view”

on the subject of this book. Both texts aim to sketch the broad panorama of knowledge, education and the urgent question of decolonization, which becomes particularly relevant in mathematics education today.

In *“The Tapestry of Mathematics”*, Kay Owens affords a synthetic picture of the (ethno-) mathematics that has been developed for several millennia in Papua New Guinea, Melanesia, and South Pacific. This work has been carried out through the analysis of different kinds of sources borrowed from anthropology, archeology, linguistics, and social geography in particular, as well as ethnomathematics, and more recent personal fieldwork observations. Over time, the migratory routes and “intense language contacts” in this geographic area, would presumably have changed the characteristics of the proto-language counting systems (associated with either Austronesian or non-Austronesian language families). As a result, Papua New Guinea shows an incredible diversity of counting systems (still in use among the more than 700 hundred different Papuan indigenous societies). The concepts of “base” and “cycle” (introduced by Z. Salzmann in 1950, and later used by late ethnomathematician Glenn Lean (1992)) enable us to highlight/analyze the amazing and unique tapestry of counting systems from Papua New Guinea. Owens thus brings to light the ingenuity of the human mind, for creating different ways for quantifying the world. This analysis further shows that the latter counting systems are deeply linked to cultural patterns, as well as a “tapestry of transactions” related to a long history of trading. Consequently, numbers generally do not exist “in isolation.” They are primarily used for quantifying and qualifying “relations between people, objects and other entities”. Besides the mathematics embedded in counting and measuring systems, this chapter brings us into the “tapestry of mathematics in art”, reminding us of the large number of different Papuan activities with a geometric character, such as carving, tapa painting, string figures, etc. related to intellectual work on curves as well as ordered sequences of spatial operations. Finally, this chapter makes the point that the extremely diverse and old indigenous formal thinking in PNG may open up the discussion on what is mathematics and what should be on the school curricula anew.

In *“Indigenous mathematics in the Amazon: kinship as algebra among the Cashinahua”* Mauro de Almeida takes a bird’s-eye view on the question of mathematical skills and concepts, while considering both the older discussions (from the perspective of mathematicians and philosophers) and the more recent ethnographic studies on mathematical practices in different cultures. His contribution reveals the hidden or embedded mathematics in a large set of ethnographic material, principally dealing with kinship. The chapter is deeply rooted in previous works in mathematical anthropology on kinship systems (Weil 1949, Courrège 1965,

Lévi-Strauss & Guilbaud 1970). It is moreover in line with Marcia Ascher's ethnomathematical studies (1991) on the Australian Aboriginal Warlpiri and Ni-Vanuatu Northern Ambrymese kinship rules, arguing that the implementation of such complex kinship systems (that modern algebra helps to analyze) can be seen as genuine indigenous mathematical practices. Here, de Almeida presents in detail the Cashinahua terminological system of kin relationships, where order is established along the criteria of generation, moiety and sex. The argument, which is painstakingly developed in this contribution is based on the isomorphism in the system of kinship relations, on the one hand, and the mathematical structure of dihedral groups in algebra on the other hand. The detailed explanation of this isomorphism between both an indigenous ordering system (i.e. the Cashinahua kinship structures) and an established part of pure mathematics (i.e. group theory) is innovative and reformulates some of the older discussions in anthropology. Finally, de Almeida demonstrates that the underlying algebraic structures that regulate kin relationships are also at the heart of basketry weaving practices, through the transformations of basic patterns and designs implemented in such technical accounts.

In his *"The Western Mathematic and the Ontological Turn Ethnomathematics and Cosmotechnics for the Pluriverse"* Mike Baker sketches a broad meta-discussion: he states that we are presently wrestling to overcome the singular world ontology of modernity with a pluriversal ontological politics of knowledge and education. It is ontology and politics: de-westernization goes together with political shifts in the world. Reference to the movement under Walter D. Mignolo's postcolonial critique is central to this appreciative reasoning. The analysis is meant to be appreciated as a deep intellectual critique, since Baker places himself in the company of those philosophers and postcolonial thinkers who want to promote an ontological turn. The relationships between the human knower and his/her metaphysical view on reality (humans versus nature, or holism, etc.) is the focus of this paper, together with the socio-political turn of our time under the guise of the de-westernization of knowledge.

This critical in-depth analysis of the status and role of formal thinking in general and mathematics in particular leads the author to situate ethnomathematics in a pivotal positioning in the profound upheaval he is witnessing. He invites the reader to look at a deeper level of ontological processes in order to discuss this shift at the level of explicit knowledge. The link between a knowledge specialism (i.e. mathematics) and the broad politically laden field of education in a decolonizing world offers unforeseen horizons. The founding of these processes in the context of shifts in anthropology-cum-political contexts is innovating in a field that is presently deeply stirred. The strong relationship the author develops between present-day critical anthropology and mathematical education is very up to date. This link is yielding what

the author refers to as “the ontological turn” in philosophy and some scientific disciplines, thus relating to a contemporary epistemological and political discussion, with a major role for ethnomathematics.

*Conclusion.* The book formulates conclusions that go beyond the materials presented through detailed studies. The field of mathematics education, in as far as it allows for indigenous knowledge to be integrated in the course materials and in the teaching procedures, has been maturing over the past half-century. The pioneers came either from anthropology or from mathematics. The former had little competence in mathematics as such, while the latter did poorly on research with living human beings whose cultural background they did not share. Over the years we found more and more convergences between both, with a clear growth for genuine first-hand ethnographic material (such as presented here, especially in Part I). The volume’s editors begin with this observation to sketch possible future avenues of interesting and emancipative work in this domain. They launch open invitations to future scholars in this fascinating field.

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