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Conclusions to “Indigenous Knowledge and Ethnomathematics”.

Some lines of possible further research in ethnomathematics

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In the concluding chapter we, the editors of this volume, want to highlight some challenges and opportunities for future research. By definition such a chapter is speculative rather than a summary or mere comment on the contributions in this book. We sincerely think that the globalization of the world invites such speculative suggestions. Globalization in a colonial perspective was clearly meant to trigger a uniform westernized (and probably Christian and free market) future for humanity. However, in the present predicament, globalization tendencies show a much more diversified and indeed “poly-form” world in emergence. Yes, education through schooling is prevalent worldwide, and mathematical skills matter more and in a more universal way than ever before. But on the other hand, the colonial uniformization of minds looks less successful and possibly less likely, let alone desirable to many, than in times past. A mixture of goals, values and dreams seems to take the stage today. Cultural traditions change rather rapidly, but they do not disappear in favor of one uniform western perspective on the world. Moreover, in various indigenous societies worldwide the decolonization process (d’Ambrosio, o.c.) entails claims to take the local cultural traditions more into account in the educational system. Also, success or failure of educational programs gradually teaches the old dominant conquerors to show more cautiousness and more modesty with regard to their own value system and knowledge as well as to those of other traditions. We think that it is at this point—which may well be a turning point in history—that the relevance of anthropological and ethnographic studies on indigenous mathematics and of ethnomathematics in educational contexts may be reconsidered. In these conclusions, we outline some ideas in this respect.

a. More ethnography of diverse, local mathematical knowledge.

For one thing, the “old” idea in anthropology that cultural traditions are likely to disappear will continue to motivate researchers to document more of them. In that sense, a first line of thinking is, obviously, that of further empirical studies of cognitive procedures and products of what is generally recognized as mathematics. One line of differentiation in the material found was introduced by A. Bishop (1988): he distinguished between Mathematics (with the capital M) and mathematics. The former category holds all those elements of knowledge that are understood as part of the modern scientific discipline which goes under the same name. This category was developed in academia in western countries primarily, notwithstanding some historical inputs from other origins (such as India, Islamic countries, etc.). For a long time, mathematics was generally presented—at least in Europe and North America—as a disciplinary field that emerged in ancient Greece, and would have achieved a mature form—in relation to systematic uses of hypothetico-deductive methods—through the works of Euclid, Archimedes and Apollonius in particular (Brunschvicg 1912, Boyer 1968, Bourbaki 1984). In contrast, other mathematical traditions, from different parts of the world (from Asia in particular), were most often considered as basic/elementary mathematics, lacking in abstraction and rigor (Granet 1934, Rey 1937, Kline 1972).

In the last decade though, fundamental research in the history of ancient mathematics has brought to light sophisticated mathematics, based on algorithmic practices, developed in the ancient worlds (Mesopotamia, China, India in particular), in various historical, cultural and social contexts (Keller 2015, Yiwen 2016, Proust 2019). De facto, these new outcomes in the history of mathematics have significantly yielded epistemological gains regarding our understanding of mathematics (Chemla 2012), and Science at large (Chemla & Fox Keller 2017), leading in return to new historical insights on mathematical traditions from the Hellenistic period until the 19th century (Netz 2009, Acerbi & Vitrac 2014, Smadja 2015).

At the same time, other projects in the history of mathematics have concentrated on mathematical practices carried out in non-scholarly communities from Europe and the United States (Durand-Richard 2016, Morel 2017, Tournès 2018).

In the old differentiation, Bishop (1988) referred to counting and measuring traditions and such. We think it is very important to point to several other domains of thinking

possessing mathematical aspects: rituals, artworks, cosmologies, even farming and hunting or fishing, and other domains can be salient constituent parts of cultural traditions with a more or less rich mathematical knowledge (Pinxten, 2016). Since such domains, with their typical activities and products, may be more relevant to particular traditions than the decontextualized western mathematics, it is important that the research on this reservoir of situated or contextualized knowledge should be studied by anthropologists and social scientists and educationalists in the most open way possible. For these reasons we will not continue to use Bishop's distinction between a capital and a lowercase m in mathematics.

The relevance of this open-ended research is enhanced by the fact that children grow up, until now, during early childhood in family or peer group contexts, developing a worldview and cognitive and linguistic anchors in the pre-school world they inhabit. When they make the step to primary school, it is obvious that the gradual transition towards or integration into the implicit worldview of that school system should at the very least, be guided pedagogically: it should not be left exclusively to the pupil to get a grip on likenesses and differences between the local or traditional and the school worldview.

For example, it is good to know that some traditions learn and think in so-called verb languages (with practically no nouns, and hence no basic grammatical structure of "noun phrase" and "verb phrase" in Chomskian terms; Navajo and other Athapascan languages are examples of verb languages, Pinxten et al., 1983). Hence, reasoning with sets and objects is different, if not almost inconceivable in the pre-school mental setup of the child raised in such a cultural-linguistic context. Less dramatically, the Turkish language does not grammatically distinguish between singular and plural objects in nouns. When Turkish immigrants have to depend on the presumed "naturalness" of such grammatical signifiers (singular versus plural form) in the European language of their textbook, they are lost, except when the teacher is aware of this difference and can guide the child (as was shown in lengthy fieldwork with Turkish immigrant children, Center of Excellence, Ghent University: Huvenne, 1994). Similar examples exist. It follows from the few examples mentioned and from the many ethnographic data we have by now that it is important to gain more knowledge of the very diversified cognitive categories, learning strategies and cultural contexts in the world. The

ethnographic reports we have so far are not really representative of the vast and varied array existing in the world.

b. More anthropological research.

Cultures, ways of thinking, styles and learning procedures differ around the world. In the short history of anthropology, we have learned that ethnographic descriptions offer the basic material concerning human ways. They help us to come to grips with the tremendous cognitive diversity which is so typical of our species. At the same time, they reveal two profound shortcomings of empirical work as such.

On the one hand, the researcher in human affairs is a human being. We have learned from the so-called self-reflective trend in anthropology of the past decades that systematic conscientious analysis of the researcher's cognitive categories, attitudes and values constitute a subconscious frame in the researcher's mind. This frame will allow a partial, often distorted or truncated and one-sided view, resulting in research questions that cannot really be called "objective" (see e.g. Fabian, 1984, on the way that for centuries, temporality notions biased research on time in other cultures). Hence, the researcher should be aware that his or her own biases might play an important role in the actual research processes with subjects from other cultures.

On the other hand, and in an even more general sense, human beings enter into processes of ethnographic research in a deeply insecure way, which results in the utter impossibility of the famed scientific rule of "reproducibility of any particular research". Humans can misunderstand, lie, withhold data when there is a lack of trust or understanding between researcher and subject, and so on. In a more general and intrinsic way: human beings, more than members of any other species and in contrast with "inanimate" material (of the natural sciences) learn from each contact with others. Hence, a second run in order to check on the data of the first moments of research is not possible in the sense in which it happens in inanimate phenomena: the subject is always changing in and by the process of research. In a second round the subject will recognize or not, refuse to collaborate on the basis of former experiences, and so forth: hence, genuine corroboration of results is only partially achieved.

In light of all of this, the invitation to collect more ethnographic data stands, but it also suggests a critical and cautious handling of empirical data. Although a few ethnomathematical studies have been carried out in that perspective in the last decades (Pinxten, 1983; Chemillier, et al. 2007; Vandendriessche, 2015), there is a lack of in-depth ethnographical/ethnomathematical studies, aiming to analyze the form of rationalities/reasonings that underlie these practices possessing a mathematical character, carried out worldwide in various societies. Progress on that issue would allow us, on the one hand, to better understand the kind of mathematics students could learn while practicing activities such as string figure-making, basket-weaving, sand drawings, “as such”, in and of themselves (see Vandendriessche this book) in the math classroom, and, on the other hand, to contribute to an epistemological reflection on the nature of mathematics.

One way of deepening our knowledge in social sciences in general and in anthropology in particular is by striving for comparative studies. Comparison will allow for model and theory building. The listing of mathematically relevant (or salient) activities may be a starting point for comparative research: a vast amount of ethnographic data can at least be categorized in this first scheme of up to twelve different types of activities with mathematical relevance. At the same time, the comparison of the combinatorial/geometrical/arithmetical properties at work in these activities (when practiced in a similar way in different societies) should contribute to an improved understanding of the nature of mathematical knowledge and practices involved in these various activities. Such a formal comparison of cultural and cognitive aspects of different practices comprising a mathematical character should further contribute to developing a new epistemological framework for the study of such practices.

On the basis of such categorization, it will then be possible to go to the next step, i.e. using particular categories with specific groups of cultural subjects in the process of sophisticating formal thinking in ever more varied and/or abstract contexts towards mathematical knowledge in a school setting. This is the subject of the last paragraph of these conclusions.

2. Mathematics education and ethnomathematics.

Our general point is that children don't enter primary education with a "clean slate", but with a worldview and perspective on natural and social reality, with experiences and learning procedures that have been formed in the linguistic and cultural world they learned to acquire and share by growing up. We take the stand that it is a good educational choice to take this pre-school background into account when introducing children to a corpus of knowledge and learning procedures such as Mathematics education. The tremendous, but selective dropout rate due to math classes we have witnessed so far is, we think, largely the result of disregarding the children's pre-school mental context. Dropout data are high in particular immigrant groups in Europe. For example, any city in Belgium today shows that 20 to 25% of the pupils leave school after many years without any diploma (PISA, 2010). The dropouts, who enter society without sufficient qualifications to compete for the better jobs in the adult world, are identified primarily as children of immigrant populations. At the same time, we now know that certain groups (notably Japanese and Chinese populations) have high performance rates. Our claim here is that the type of studies ethnomathematics is engaging, in may shed more light on the cultural aspects (e.g. religious, cognitive and moral traditions, but also learning strategies) and contextual constraints that are likely to play an important role in the pupil's transition from child-in-a-particular-culture to successful learner in the presumably universal mathematical knowledge.

In some research the relevance of the pre-school worldview for mathematics education has been a focus. For example, Bishop et al. (2015), Barton (2006), but also older work (Pinxten et al., 1987) investigate cognitive differences next to contextual aspects, gender differences, linguistic structural diversity, and so on. This is not to say that all or any of these dimensions will always and exclusively determine whether performances in mathematics classes will be good or bad. But it certainly looks as if the set of these dimensions offers a panorama of children's mental setups from which educational programs can then selectively and particularly work to reach out in a differential way to each child or group of children (as cultural subjects). An obvious reason why these "setups" are important is that they allow for an approach of education that respects and enhances the child's motivation and preferences, rather than negating, or worse killing them.

Starting with more knowledge and a better understanding of these aspects of the children's worldview makes it possible to look at the entries for mathematics education that seem most appropriate in any particular case. We clarify this statement with an example. Designing is one of the mathematically salient activities we pay attention to. In the cultural tradition of Pacific seafarers, the initial "catamaran" was developed as an alternative to simple canoes. Ages ago, by means of (ethno-) mathematical thinking these seafaring cultures developed a canoe with a stabilizer, carved from simple trees found on the island they inhabited. Over the years this "catamaran" (as it became known after westerners discovered this strange and ingenious boat in the 19th century) was used rather successfully to navigate on the ocean and make trips of up to hundreds of miles between the islands. They dug out a boat from a palm tree, in one piece. Then a stabilizer is cut and attached at the appropriate distance from the main hull, and attached by means of small beams. Without doubt many generations of experience go into this boat making. But on top of that, islanders developed a star chart made of twigs on the basis of which they could orient themselves on the open sea. Finally, knowledge of sea currents, of the relative warmth of the sea and so on complete this kit of procedures and cognitive data for the "illiterate" Micronesians (Gladwin, 1975). With the Second World War, the motor boat was introduced in the area. However, today the cost of oil is too high for the islanders and depending on the motor boats would starve them. Hence, the old knowledge and technology of boat building and seafaring is picked up again and promoted in schools, this time with the addition of solar energy GPS devices. It is obvious that children know about this, since they are raised in this context. Our suggestion is that such cultural knowledge should be the basis of at least some of the mathematics classes, with full recognition of and respect for the indigenous tradition (amongst others: Rubinstein, 2004).

Examples like this abound, from string games (this volume: Petit, Vandendriessche) to house building, music and rituals, and so on. Our suggestion is to select any one of them in the context of particular groups and graft the basic course in mathematics teaching on them. In this way, we want to promote the "reality-based" approach of Freudenthal (e.g. 1985) and diversify it in the context of the many cultural traditions all over the world, in order to allow for a better entry in the field of mathematical thinking by working with the children's insights (Bishop et al., 2015). Of course, this will entail that a uniform pedagogy, let alone unique and uniform teaching curricula and materials (like the New Math approach) should be dropped. This may come as a shock to

mathematicians of the rationalistic school, but it meets the criticisms voiced by those who want to develop links between the social sciences and mathematics education. Chances are that along the way children may indeed come to love mathematics in a variety of its manifestations instead of hating it as an ill understood discipline that first and foremost has you fail in school (Hersh & John-Steiner, 2011).

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