Ethnomathematics, a challenge.

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Abtsract
Working with Navajo Indian informants in Arizona, USA I became aware of the capabilities of children and adults to find their way in vast and clearly 'chaotic' canyons. One thing I did was describe what people actually did and said about their ways to find the way back home in such contexts.
A second one was to use these data in order to build a curriculum book for a bicultural school on the Navajo reservation.
I start from this example to ask what the political choices are, which I confront when working with such material: how much mathematics (or is it Mathematics) is needed in daily life? And what mathematics should we promote or develop, without becoming colonialist again? I introduce the concept of multimathemacy (after multiliteracy) to discuss the political agenda of ethnomathematics.

This abstract belongs to the text we prepared for the 4th ICEM at Towson, University. The text ('Politics in an Indian canyon') is being processed for publication in 'Educational Studies in Mathematics'). However, at the ICEM conference Rik Pinxten delivered a keynote lecture, which differed radically from the text. We present a summary of that oral presentation here.

1. Ethnographic case[1]

Navajo Indians in the Southwest of the USA are storytellers, meaning that they not work with Power Point or even do not care to draw and show pictures or objects while telling their story. We will stick to their ways to begin with, and only sparingly use other means to sketch the example We present the mere story.

The little boy Chee Benally walked with his herd of sheep and goats in the huge canyon to the east of Round Rock Trading Post, New Mexico. His father had herded sheep here some thirty years ago, and his uncle had a place with a coral 'nleidi', way over the mountain. Chee pointed with his lips in the direction of his uncle's place while saying 'nleidi' to his mind. He had been with his uncle past year to assist in a healing ceremony. They had gone by pick-up truck and it had taken three hours. He would never be able to find the place again: the car had turned twenty times, gone through a wash, over two mesas along endless dirt roads.
Chee was seven now, and he was wandering alone. His parents let him go herding alone since almost a year. He always took Chuck with him, the old shepherd dog. The dog was careful, and he was able to hold a herd of fifty sheep and goats in his spell. But most of all Chee felt safe with him. The dog would run ahead of Chee and immediately spot or smell a Gila Monster or a rattlesnake.

[1] In order to protect the people concerned from sometimes aggressive touristic curiosity I changed most place names and the name of the boy in the ethnographic example.

Chuck would approach these animals by running in circles around them until Chee would be close enough to throw little pebbles at them, so they moved away. A young dog might charge towards these animals, but Chuck always left a safe exit for them. Especially in the heat of the day, when the sun was standing straight in the south and high in the sky, Chee had to watch for these reptiles. They were baking in the sun and chose the easy paths that people and animals would follow as well. It required skill to spot them and then let them move away. If they got scared you would be in danger, or they might attack one of animals in the herd. The knack is to have the sun in your back when you happened on one of these, so you would be able to see them clearly and not be blinded.

Chee had walked for several hours now. The sun was coming up and making the sky white when he started, and now it was straight up in the blue sky. He had started out down the small path that runs from the hooghan to the little dip where there would be water during winter time. At the dip Chee had taken to the left, almost to the west . That was the only way to get through the canyon: there was a small and narrow ridge which Chee could see from the bottom of the dip. That is where he would get over the top of the canyon wall with the herd. Behind that ridge was a slope to the left ending in Owl rock, but Chee was not going there on this journey: there would not be enough to eat for the herd, since the soil was dry and dusty when he passed there last week. So, instead he would take to his right on the ridge and guide his herd through a narrow pass full of green plants. The soil was always a bit moist and in summer you could take a trip and be safe from the burning of the sun right up to the end of that pass. Coming out of the pass he had paused to eat, and then moved on in the direction of Badger rock. He did not see the rock for a good time, since it was hidden by the black wall of Snake rock which extended right across you, from the south to the north. It had to be followed for a long time until one could see the small pass, which was hidden behind the three juniper trees. They were the only trees sitting together up there, on the edge of Snake rock. When one did not know there was a pass behind them, one would keep following the rock for miles, without being able to cross it.

Chee had found the pass and started climbing the steep path, while Chuck barked to the herd which was wary of following Chee up the rockside. After a remarkably short climb Chee reached the flat top of the rock, where all of a sudden he saw Eagle's Nest, the small flat stone, only a few yards away from him. At that point he started looking for Badger rock. A whole range of rock formations was spreading out before him, as far as the eye could see. He stood above the canyon of his parents, and could not see anything of it beneath him. He carefully looked at the rocks in the distance in front of him and recognized Badger rock after a while. The sun had it stand out in a red glow, a little bit away from a large ridge that Chee knew ran from east to west. He could walk at ease now, almost on a flat surface until he would reach a small canyon he had to cross, straight to Badger rock. When he would make a turn to the right at this standing rock called the Badger, he would walk away from the sun and reach the arroyo of Salt Water in a short time. The animals would be thirsty by then. He had looked for the Badger for a long time, and then suddenly it had popped up to his right, only so far away. His grandfather had described the rock and told him the story about how a silly badger had got stuck in the rock ages ago and had become a rock himself. The rock was the end of the trail for children younger than Chee. It

was an absolute border for them, not to be trespassed at any time. Stories had it that children who did go beyond changed into strange animals. Chee knew now that these stories were only meant to scare children. He had wandered beyond that point and returned safely. But he had been scared because behind Badger rock the landscape suddenly changed and tilted a bit downward. After a short distance you could not recognize any of the rock formations you had spotted before, so you might get lost easily.
From reaching Badger rock straight on, he had to take to the right. One had to walk half a day, until the sun was almost set, to reach a cave with rock paintings. That is where Chee would spend the night safely. There was a small coral and some water under the cave, so the herd would be safe there. In the morning he would see the sun rising over the coral, and know where the east is. From there he would go down the arroyo with the herd, heading a little bit to the south until the sun was at its highest. Then Chee would try to cross a mesa after noon and go down a long slope with some high reed and thick shrubs which would lead to the hooghan of his parents, all the way to the northwest. If he was lucky he would arrive at the hooghan when the sun was setting just behind it, which would color the whole sky orange and have the hooghan stand out as a dark mole.

Chee had followed this trajectory maybe ten times, and he had learned to recognize each rock and each little dip and grassy spot along the way. His father had discussed the trajectory with him, each time he reached home again. Chee had learned to take his time. If something would happen to him or to the herd on this kind of trip, there was no way of saying how he would manage to reach the hooghan again. So, he learned to take his time and spaced his trip according to the water places, the rocks and the tree formations he knew about along the way. Every time he had to choose a particular path, or anytime a passage known to him would be blocked by something, he carefully looked around at the big rocks and reoriented his herd by meticulous reference to them. He got lost sometimes, since canyons are tricky and turn and twist without your noticing it. But happily enough the sun and the big rocks had always helped him to find his way again. (For more ethnographic detail: Pinxten et al. , 1983, Pinxten et al. , 1987, Farella, J., 1993).

It is almost impossible to picture the real 'landscape' Chee is tracking through: one is almost always dwarfed by the enormous red mesas and other rock formations one wanders through, and the paths one can follow are sinewy and winding constantly. No 'straight' line will be definable as the shortest distance between two points one can see. That is to say, the eventual straight line in visual perception is always irrelevant for the spatial environment, let alone for the walking paths one chooses and follows in this two-day journey. Of course, I can make a map of the path(s) Chee follows in his trip, but the map will by necessity focus on some elements in the experience of the boy and disregard others. For example, the changing positions of the sun, which are essential for some choices he makes, will not be represented in a graphic map.
Chee works with the following elements in order to orient himself:
-the sun: different positions will announce where Chee should be at certain moments of the day: if his spatial markers mismatch with the sun' s positions, he

knows he is in serious trouble. For example, if he does not spot the cave near sunset of the first day, he missed the track., and is in danger.
-certain conspicuous rock formations: one shaped like an owl, one shaped like a badger, and one extending for a long way (in fact even from Lukachukai to Rock Point , which is almost 50 miles) like a multicoloured snake. These are major references or markers.
-the general topological notion of path is essential: covering distance by walking past markers from place to place, taking into account different environmental shapes (canyon or pass or flat stone, etc.).
-the cardinal directions, based on the trajectory of the sun and on the position of big rocks or mesas, play an important role in Chee's orientation.
-the need for water and feed for the animals is essential in the notion of path Chee uses.
-adjacency and separation are two topological notions which have an important status in Chee's movements: he sees a rocky wall in the distance which offers him a reference point which is separated from his action range (i.e., concretely the series of mesas and rocks of which Badger rock is a part), and he knows that a small canyon is immediately adjacent there and has to be found in order to continue his journey successfully.
-climbing and going down slopes and passes, narrowness and wideness are non-metrical spatial notions which play a primary role on Chee's orientation.
-in front and behind, up and down, left and right are the projective notions Chee knows and uses to build up his mental map of the environment.

If we make abstraction of most of the actual rocks and mesas, dips and canyons we could draw a little map to represent the major features of the orientation system Chee works with. However, that would Chee out of his context and into the schooled context we expect from him, at the expense of the home knowledge. For the sake of the argument, we will not do that: we want to leave as much room as possible to the 'other' knowledge, and hence refuse to work with the schoolish registers that Chee undoubtedly acquired already. For this particular case we will not draw a map of 'Chee's orientation system', since Navajo do not draw maps and actually feel very uneasy with fixated representations of parts of the natural environment: you do not make a scale model of the earth or part of it, and you do not fixate in any way parts of nature. F.H. told one of us once: 'The only thing that is still, is a dead body'. It is not done to have graphic representations which sort of summarize what is there in a fixated way. So, when we attach this 'mental map' it is clearly our addition as westerners. Then, is the description of Chee's journey fiction? Or faction? Or is it knowledge? Personally, we would advocate it is all three, and by doing so we are in the midst of political questions and choices. Inadvertently we keep hearing this remark by a great linguist, anarchist and school director, who started and ran one of the few bicultural schools on the reservation. Discussing some of the present issues with him, he said: " by drawing the kids in the schooling system we have them loose most of their oral and original knowledge and make them part of our way of dealing with the world. I often wonder: aren't we making 'petits bourgeois' out of them?".

2. Ethnomathematics is a major project.

What is the status of EM?

Human beings have a brain, one or more languages and a complex context of education and survival. All thinking and learning of humans is, I advance , situated. That is, it is co-determined by the contexts (historical, cultural, religious,..): in this I follow L. Vygotsky/J. Bruner/M. Cole.

Mathematics is a form of thinking and learning of humans. Logically, it takes different forms in different contexts. Ethnomathematical studies have shown over the years how formal thinking is shaped in a variety of ways through different cultures. It is clear that every culture develops some form or other of formal thinking: counting, measuring, drawing, and so on. When we try to establish the epistemological status of the formal thinking EM has found, we have different possible answers: on the one hand, we were taught historically in the West that a unique form of formal thought emerged in our cultural history, which does noet really compare to anything else in the world: Aacademic Mathematics. Or what Bishop (1988) called M, to distinguish it from m (denoting the formal reasoning of common people and of different cultures). The question then arises what this AM (or M) amounts to, how it develops, and so on: on this question I side with those who plea for a naturalization of epistemology (Piaget, T. Kuhn, Quine, and so on) and claim that all thinking is human, contextualized and situated thinking. That implies that I object to the attribution of a divine or otherwise decontextulaized and nearly theological status of knowledge, including mathematical knowledge. At the same time, we can see that in western history learned knowledge (and certainly mathematics) has long been given a non-empirical and indeed a next to infallible status. Objecting to this I choose for a reshuffling of the status of the m's of this world vis-à-vis the M : Academic Mathematics is nothing else but a particular and particularly strong or efficient subcategory, originated in a context (with an intercontextual history).

Saying this implies that we should start using Ethnomathics (EM) as the generic term and see AM as a particular instance of EM.

Of course, this is a programmatic statement. From it follows that we design a research program to fill this in properly: what epistemological arguments do we have to think this way about AM? Barton's book on language and mathematics (Barton, 2008)holds some arguments of this sort, looked at from an analytical philosophical point of view. J. Needham's deep and broad works on Chinese science Needham, 1965) offers arguments from a comparative epistemological perspective, and so on. Because we tend to have the very sustainable view in anthropology nowadays that humanity is one, notwithstanding the cultural diversity we witness, this epistemological line of research promises to be the most powerful one, dismissing the exclusivist status of one or the other particular knowledge tradition at the same time.

Mathematics education:

This branch of pedagogy aims at making explicit, and at developing and sophisticating formal thinking in people. The standards (to define the goals) of the learning process need to be discussed. We can take the standards of AM, or

that of another local branch. If we take AM as the norm, we should at the least see it as situated knowledge as well.
Math education can start from the situated knowledge (the cultural background and foreground) of the learner or we can deny that and consider pupils as 'little mathematicians' (which is closer to the AM norm, I guess) . In my view the latter attitude is responsible for a lot of the crisis and failure in math education. Indeed, if AM is taught as a knowledge sui generis, out of and beyond contexts of experience, it is likely to happen that insightful learning of mathematical knowledge will be rare or at the very least more accidental than systematic. EM, on the other hand, in education should best be the leading principle, provided we see learning indeed as situated learning (of pupils in their contexts) rather than "learning brains". That is to say, children (and adults) learn through experience in insightful ways in contexts. Education should then best start from a recognition and use of these contexts in a perspective that is known as 'situated learning'. My suggestion on this point is that the very fruitful work of socio-historical and socio-cultural learning psychologists should be considered with the earnestness they deserve by those involved in EM education. To put it shortly: they are our allies in the line of research EM is developing. One reference may suffice here: the synthetic work 'Cultural psychology' of Cole, one of the translators and defenders of the Russian school of Vygotsky in the Anglosaxon world. We should invite these people to our meetings and see waht EM can gain from their learning theory.

which curriculum?

We live in a world of multiliteracy: the younger generation lear,ns about and speaks with the world through written language, but also through TV, PC, internet, comics, film, music, grafiti etc. In mathemtical education, we propose that one can speak about multimathemacy: next to and combined with the formal eductional means, a pupil of today has a foreground knowledge which includes street capabilities, mobile phone communication, all sorts of media and what not together wioth the schoolish formats . The new visual culture in our environment has impact on knowledge transfer and we need to understand that suirvival in this mixed and worldwide reality implies 'literacy' in these media and contexts.
The schoolish curriculum does not suffice in this case: EM has understood the importance of the fringes and borders involved and has nibbled a bit on them. The result is that for now we are as EM tolerated as specialists CAR REPAIR (to make an analogy): where the normal schoolish curriculum fails, the EM approach will mend the damage to some extent: it draws on non-school contextual knowledge, starts from preschool capabilities, and so on. This draws pupils closer to the problems of mlathematics, and makes them understand the relevance to some extent.
However, we have no view and no real saying in the CAR DESIGN department: AM is still the only standard there. This is , from the point of view of EM as the generic category, a strange situation. Why should math education be structured and organised friom the standards of AM? Will we turn all of humanity into 'small mathematicians', and to what end? What alternatives are there? How can

we develop this into a more 'naturalized', responsible and useful matyh education system, with adequate curricula?
For one thing, we could invite pedagogues who are busy in this area in other domains of learning like literacy and social education) and see what their knowledge and practice have to tell us. I think of initiative sof cooperative learning like Complex Instruction (E. Cohen, 1997, and amply developed in northern Europe, at my university center and in Scandinavia: CLIM and CLIP). Also intercative learning strategies will help(Pelech and Pieper). Applying these, or thinking math edi-uation along these lines will bring it closer to the world as lived by the pupil of today and in that sense 'naturalize' it. In developing curricula in that sense we will have to make political decisions: what is needed and what is relevant for survival (not for the glory of the professional mathematician)? What is democratically sensible? What is a good solid basis of understanding and in what ways can the learner develop on her/his own from there? Here, it seems that Math as practice (R. Hersch & P. Davis, 1981) is an intersting option. EM should get in contact with the pedagogues and with the people from Math as practice, I suggest.

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