# Ethnomathematics vs. Epistemological Hegemony

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## Introduction: a man at work

The considerations raised in this article are based on fieldwork in which I investigated the mathematical practices used by a home designer and builder in his work. In this article, I point out the existence not only of diverse forms of mathematics, or ethnomathematics, but also of diverse ways of doing mathematics. I argue that these idiosyncratic ways of mathematizing, whether pertaining to individuals or to entire cultural groups, should be recognized and legitimized in mathematics classrooms.

During a period of one semester, I 'shadowed' Miles, a home builder and designer, during the remodelling of a house. My purpose was to investigate and describe the ways in which Miles dealt with situations in his work that might give rise to mathematizations. Miles learned home-building and carpentry from his father. He started following his father to work at the age of six; by the time he was fifteen, he was his father's 'trim carpenter'. Miles has gone through a degree in painting at college. He now designs the houses he builds.

## Looking for mathematics

How are we to describe the ethnomathematics used by somebody or present in the product of someone's work? If the mathematics of other peoples may be different from the one(s) we know, how can we recognize it as mathematics? The paradox in ethnomathematical research identified by Millroy (1992) is based upon the premise that:

> it is impossible to recognize and describe anything without using one's own frameworks. (p. 11)

An alleviation of this paradox derives from the fact that our own 'framework' of what mathematics is has been forced into continuous adaptations, in light of the constant growth and development of the mathematics practiced by mathematicians. Steen (1990) points out that:

> mathematics has traditionally been described as the science of number and shape. The school emphasis on arithmetic and geometry is deeply rooted in this centuries-old perspective. But as the territory explored by mathematicians has expanded - into group theory and statistics, into optimization and control theory - the historic boundaries of mathematics have all but disappeared. [...] the guide to this growth is not calculation and formulas but an open-ended search for pattern. (p. 1)

He then characterizes mathematics as 'the science of patterns'.

Steen also talks about the *fundamentals of mathematics* or the *root system of mathematics* – "deep ideas that nourish the growing branches of mathematics" (p. 3). Among such ideas, he cites mathematical *structures* (e.g. numbers, shapes), *attributes* (e.g. symmetric, approximate), *actions* (e.g. visualize, classify), *abstractions* (e.g. symbols, logic), *attitudes* (e.g. wonder, beauty), *behaviors* (e.g. stability, convergence) and *dichotomies* (e.g. discrete vs. continuous, stochastic vs. deterministic). Note that this framework was advanced by Steen to describe the mathematics studied and created in universities and research centers. However, it seems broad enough to help delineate what I will recognize as mathematics in observations of out-of-school activities.

Another helpful framework is that proposed by Bishop (1988). Instead of focusing on the product of 'mathematizing', which he acknowledges may be different in different cultural groups, he has focused on the activities and processes which seem universal or common to every other culture, and which lead to the development of mathematics. He has identified six such activities: counting, measuring, locating, designing, explaining and playing.

I will use some of these categories to describe the way Miles 'mathematizes', based on my observations of his work and on his descriptions of the way he works.

### Measuring

Miles believes that he does not use much mathematics in his work. He says that all he does is "read some tapes, add, multiply, ...." He apparently does not consider 'reading tapes' a mathematical activity. Millroy (1992) would agree, classifying this type of activity as purely procedural, excluding it, thus, from warranting her label of 'mathematics'. I, however, found it interesting to observe what role 'reading tapes' plays in Miles' work.

In the situation with which Miles was dealing, accurate measurements were not only a matter of using a tool such as a measuring tape precisely. The materials and the environment usually presented extra constraints and variables that had to be taken into consideration. Factors such as the materials' fibers and proportions posed constraints to the way they were measured. Moreover, adjustments in measuring had to be done to account for variations in the material caused by temperature changes. Miles' expertise on these adjustments grew with practice. For example, Miles was especially careful after wooden trims which he had appropriately cut, fit and nailed 'shrunk' after some days, and had to be removed and replaced.

### Locating and visualizing

When trying to locate a point in the middle of a certain length, or the center of a shape, Miles rarely measured or calculated its position. He stood back, looked at it, marked the point and stood back again to check. If the location seemed right, that was it. I saw Miles use this procedure so many times that for me it became typical of him: stand back, twist his mouth or mutter if it did not look right, decide on a satisfactory point and proceed with his work. Miles used this procedure in finishing work such as placing towel hangers in the bathroom wall or nailing hangers to the bedroom door, as well as in the building of the structures of the house. Miles' description of how he placed the beam that supported the ceiling indicate how much intuitions and visualization skills count in that kind of work:

> To do something like this [pointing to the ceiling], make a V-arch come into a room, the considerations are: what supports all this weight across here? Because, just to be here [pointing], you know, a triangle is a pretty strong support, which means there is a lot of down pressure going into that corner there. But still, it's so long and so low, that there has to be support across here. So what happens is, from that point, from there right up to there, there is a very large beam, which is actually these three or four very big boards put together. I have another beam put across here. And then this beam ties into that. So everything you have to kinda think about: "Oh, how is this gonna sit? What is this gonna do? Where is the pressure gonna be?". And, I'm not an engineer, well, but I feel like I have an intuitive sensibility about it, because if you don't do this, well, things are gonna sag, or it is gonna fall down. Maybe that comes from just growing up with it, and seeing how things are put together.

In other words, Miles does not make calculations or measurements to locate the points where the pressure is going. He uses his intuition, visualization skills and knowledge about the behavior of shapes, in a holistic and subjective process

### Behaviors of shapes and structures

In the above quotation, we have already seen that Miles uses his knowledge about the behavior of certain shapes to predict the behavior of a larger structure ("a triangle is a pretty strong support"). Through explanations and drawings, Miles made evident that a lot of intuition about the behavior of geometrical configurations is involved in his knowledge about structures:

> A triangle is a rigid shape. But if its base is more that 40 feet long, it starts losing its stability and sagging.

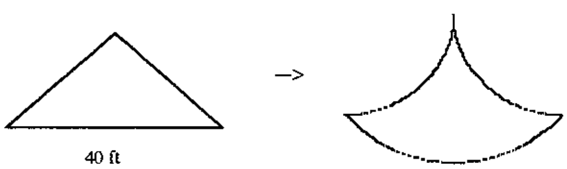


*Figure 1*

> So, for roofs 40 feet long or longer, we have to put additional triangles like this to offer more support.

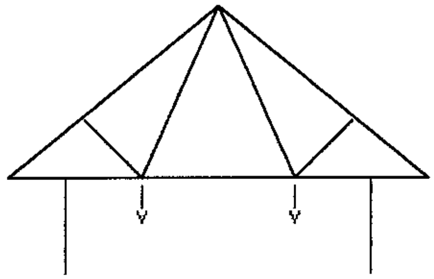

*Figure 2*

> Then the weight of this roof is also carried through the vertices of these triangles, and is supported by the walls. This is called a 'standard truss'. In a cathedral ceiling, we have what is called a 'scissors truss', which is a pretty stable configuration, because of all the triangles that are there.

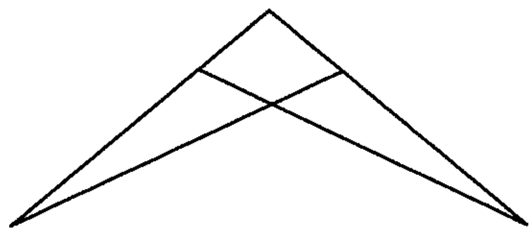

*Figure 3*

### Designing

This is the part of Miles' work which I found had the most unusual characteristics. It is also the most important part of his work for him. He considers himself a designer more than a home builder. In this sub-section, I will argue that, analogously to what has been called in computer programming 'programming by doing', Miles 'designs by doing'.

He had said at various times that he likes to let the space dictate what he was going to do with it. He said every space has its special characteristics, that offer both constraints and suggestions for design. He showed, for example, a platform behind the bathtub he was working on. He said that, since he was reforming and adding to a previously built house, because of the way the outside wall had been built, a space had been created between the bathtub he designed and the wall. He said that in situations like this, he has to be able to create and recreate, finding new solutions. In the case of the bathtub, he talked the matter over with the owners of the house, and decided that in the space he would build a platform that could be used to rest a plant or some other ornamentation.

These continuous negotiations with the space (and with the owners of the space!) were evident in many other points of Miles' description of his work:

I guess I've always been kinda 'design-oriented', visually oriented I liked, I enjoyed getting into something and designing it, and it was kind of an intuitive process I don't really think about precisely what I am going to do. I just have a general shape of, well, like this space: it is very different from when I started. I don't know if I showed you the blueprints. It was just going to have a simple slope up there. The window treatment was going to be very different, very simple. I didn't like it. I mean, it was just kinda something to go on, to start with. Sometimes I will do things like that, just so I can get through the permit process here. You know, have an idea in my head, and I will be talking with people, and I guess what happens is there is a constant give and take. [...] They agreed with the first design, it was fine with them, but I hated it. So I talked them into this

When I came into this job I had those blueprints, and that was basically what we were doing, right up to the point that I started to put the walls up in here. I remember going home over the weekend, just before I was ready to stand the walls up on the new part, and thinking how much I just didn't like the design. And I came back on Monday and said "I don't like this design. This is what I wanna do Do you guys agree with this?" And they thought it was great. I didn't have to convince them very much, fortunately, in that I thought it was a much better design

A lot of the process that happens is just seeing what fits where [...] It's really hard to make the form conform to the design

I asked Miles whether 'designing by doing' was a common procedure in his field. He suggested that it was not usually done because often the designing and the building are done by different persons.

**Some attitudes**

Some attitudes that Steen (1990) has said lay in the root system of mathematics are evident in Miles' work. One of them is the search for beauty, and another is the attempt to understand a reality. Miles also seems to avoid doing mere procedural work. Being able to create and conceptualize seem to be his main motivators. A mentioned above, Miles enjoys "getting into something and designing it".

I don't want a job I don't like If it means just coming into a job, slapping up some walls and putting a roof on it, according to somebody else's drawings, I mean, I get really bored with that kind of thing.

The search for beauty is evident when Miles is willing to start his work over because: "it just didn't look good"

## Miles' style of mastery

There is no doubt Miles masters the art of designing and building. The result of his work is appreciated and valued:

These people hired me because I do this kind of thing. The people before them also hired me because I design my own things. People call me in because they've seen somebody else's job and they've really liked what I've done And they want me to come and do it for them.

However, the way he builds a house is probably not the way most people think a house is built. I myself thought I would be seeing in my fieldwork many more calculations and precise measurements being done. Interestingly, home-building was used by a colleague at a mathematics education seminar to exemplify situations in which rigorous mathematics is necessary: "If precise calculations are not done, this building is going to fall!" I think this reflects what most people expect from civil construction But in Miles' work intuition and visualization play a much more important role than calculations, and yield as good, or even better, results.

This observation calls our attention to the existence of different 'styles of mastery'. Turkle (1984) distinguishes between two styles of mastery of computer programming in child programmers. She calls them 'hard' and 'soft' mastery:

Hard mastery is the imposition of will over the machine through the implementation of a plan. [...] Soft mastery is more interactive. Hard mastery is the mastery of the planner, the engineer; soft mastery is the mastery of the artist: try this, wait for a response, try something else, let the overall shape emerge from an interaction with the medium It is more like a conversation than a monologue. (pp 104-105)

Turkle's description of the way Kevin, a fourth-grader, programs the computer could be well used to describe the way that Miles designs:

Kevin is like a painter who stands back between brush strokes, looks at the canvas, and only from this contemplation decides what to do next. (p. 104)

She points out that this style of work can lead to "new and surprising results" In fact, Kevin's programs are admired and copied all through the fourth-grade class. But most importantly, she points out that computer programming is usually thought of as an activity that can only be successfully done if one uses the 'hard' approach.

Turkle and Papert (1991) use other analogies to characterize the programming styles of Alex, whom they also consider a 'soft programmer':

While the structured programmer starts with a clear plan defined in abstract terms, Alex lets the product emerge through a negotiation between himself and his material. In cooking, this would be the style of chefs who don't follow recipes but a series of decisions made as a function of how things taste Or we might think of sculptors who let themselves be guided by the qualities of the stone that reveal themselves as the work progresses. (p. 171)

The similarities between the two contexts, computer programming and home-building, and between the way that Miles works and Kevin and Alex program made me want to use Turkle's framework to categorize the way Miles works as a 'soft approach' to home designing and building. In both contexts, actions at one level (designing, programming) produce results at the other level (the configuration of the space; the results on the computer's screen). And in both contexts, 'soft workers' use these results to further modify what they had done at that first level

Turkle and Papert also mention that Levi-Strauss used the idea of *bricolage* (tinkering) to describe non-Western science - which he called 'science of the concrete' - to contrast it with the analytic methodology of Western science:

> *Bricoleurs* construct theories by arranging and rearranging, by negotiating and renegotiating with a set of well-known materials [ .. ] *Bricoleurs* use a mastery of associations and interactions For planners, mistakes are missteps; bricoleurs use a navigation of midcourse corrections (p. 169)

This discussion suggests that, more than paying attention to *what kind* of mathematics Miles does, it is important to note how he does it. This may be an aspect to which we still have to open our minds, to free them from the idea that mathematics always involves a top-down approach such as deductive reasoning. This view is quite widespread, and can be attributed to that fact that what is presented to us in schools is just the final result of the work of mathematicians. Not much is said about the process of discovery and negotiation that went on at length before the establishment of a mathematical result, nor is much said about the role that intuition played in the process.

## Has it got to be analytic to be mathematics?

The realization of soft and hard styles of mastery invites us to challenge the hegemony of abstract and formal reasoning in mathematics Turkle (1984) and Turkle and Papert (1991) have started the challenge in the field of computer programming. They point out the fact that, besides being a matter of personality, the use of one or the other approach is also a lot related to gender Girls tend to be 'soft programmers'. But Turkle and Papert emphasize that this does not prevent them from making significant technical innovations in their computer culture. They have also noted that many of these soft programmers characterize themselves as 'not good at math' But aren't they? The answer to this depends on how we settle the question raised in the beginning of this article: what counts as mathematics? What framework should we use to look upon mathematics?

Davis and Anderson (1979) argue in support of the creation of a *milieu* which is receptive to non-analytic mathematics. For them, a de-emphasis of the analog, experimental or intuitive elements of mathematics represents the closing off of one channel of mathematical consciousness and experience. In Davis and Anderson's (1979) discussion, whether non-analytic, or *analog* mathematics, as they call it, is or is not mathematics is not even an issue. The matter for them is one of professional prejudice

> The intellect looks after its own [. ] Although an analog solution [to a problem] may be clever, based on sophisticated and subtle instrumentation, it does not carry the accolade of the purely intellectual solution. (p. 114)

Turkle and Papert (1991) give a similar diagnosis to the situation, claiming there is a:

> pressure to believe the general superior to the specific or the abstract superior to the concrete [in the field of mathematics] (p 170)

The thesis of the hegemony of analytic mathematics being based on a hierarchy of intellectual values created by a class of professionals is strong enough to lead us to consider some kind of reformulation. Its strength lies in the numerous examples of fruitful, non-analytical mathematical practices, one of which was portrayed in this short article. And the call for a reformulation will have to bloom from within the profession of mathematics, maybe from those not-so-few professionals who sense a feeling of malaise in the field and necessarily pass through the practice of education.

I believe encouraging visual and kinesthetic intuition in mathematical problem solving and computer programming will bring much more of a balance into mathematics classes: both for the abilities that will be developed and for who will succeed in mathematics classes Recognizing that there are also successful soft approaches to designing, measuring, locating and other mathematical activities in different contexts, as with the example of Miles' home-building, can help open the field of school mathematics to people who have traditionally been discouraged from engaging in mathematics at school

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