MATH PHOBIA, MATH TEACHING, AND THE WORLD AS SCIENCE CENTER

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I am writing to you all, teacher colleagues, today, from within the Amazon forest. But I grew up French, in Paris. I was fifteen when I first entered a library. Public libraries were not current then. My mother who knew a librarian there introduced me to the Library of the French Academy. Not knowing what I was there for, I asked for Descartes' first book. I think that my choice came from having had to learn "Cartesian coordinates" and heard about "the Method" and being intrigued by the logic of saying "I think, therefore I am". I was going to meet in some way the human being whose name got attached to those things. I got the very first edition. Maybe I had in my hands the very book that he presented to the Academy. I browsed through it, and stopped at his drawings of light rays going through drops in a rainbow. Those drawings were attempts at representing something that Descartes was trying to understand; it was his original thought process that I was getting close to. As I read what he put down in words and deciphered his scribbles I was accompanying him and recreating it all for myself. Many years later, in another special library, the Library Tower at Yale, I came across a text of Voltaire describing how he and his mistress were weighing iron bars when heated up white hot, and when cold, trying to find a difference. I already had co-written the textbook Introduction to General Relativity by then, and I wished we had put in it Voltaire's attempt at weighing energy in the 18th Century, doing for real one of Einstein's thought-experiments! The point of this musing is that this continuous learning I have been alive in was not formal, although it happened in the most formal-looking places. It was simply being in touch with realities created by others, with original investigations recounted by their very authors, situations that satisfied my own normal curiosity, just like Jules Verne satisfied my imagination beyond those realities. Furthermore, all of this diffuse learning took place within my native culture, in my mother tongue.

So it never crossed my French mind to be afraid of theoretical-looking or mathematical-looking things. My own remedy against the tediousness of doing rather repetitive formal math exercises in post undergraduate French schooling was to find geometrical solutions to algebraic problems, entering into creative competition, shouting out "elegant" solutions from the wooden benches at Lycée Saint Louis, with the now French mathematician Adrien Douady. Somehow, we never were afraid of math. Our French culture oozes organization, formality and logic. Our very language demands a precise, unique systematization, correctness in everything from accent to orthography. There are strict rules in grammar and in table manners. "It's this way, because it's this way", said my grandmother when she did not find arguments in a discussion with me as a child. So the French children are more familiar with overall cultural formalizations and therefore enter the formalities of "math at school" without estrangement.

It appears to me that there may be something specifically 'Anglo' in that "fear of math" affair. This may feel ridiculous at first, since England had Newton while France had Descartes. But there is a serious difference: while Descartes wrote everything in French, Newton had to write his math/theoretical things in Latin (you know, for political survival in a Church dominated world; he had to obey its laws, and he was afraid of its power). So Newton's math work was born distant from everyone, I mean from people like you and me of that time. And today, in the global Anglo world, Mathematics is still mostly for people linked to one Cambridge or another, colonizer or colonized. On the other hand Newton did write about the experimental physical world in everybody's language, English that is, not Latin, in his "Optics" books. Maybe this reflects in the fact that English-speaking educators are not as "fearful of physics" as they are of math. The typically North-American 'empirical' approach to physical problems does not extend into math problems. And we breathe this difference in our classrooms.

There, the purely formal aspect of math dominates our lives. The prime formalizers are not physically present but they rule us all: they are the 'Authors of Textbooks'. They imprint us with the formality of the schooling process. They are no "authors" at all in the sense that Descartes or Newton were. They define and dominate our teaching avenues. They are sons and daughters, intellectually, that is, of previous textbook writers; at times this tendency runs in a family that entered the trade within the State controlled production. In Brazil there are lineages of textbook authors, a data bank of individuals "recognized" by the Ministry of Education. And today they rarely deviate from the US dictated approach to standard textbook mannerism. The whole world still suffers from the drawings with intersecting circles that claim to present "ensembles", an example of basic French abstraction envy, reduced and falsified into "New" math by submissive bean counters and textbook writing technicians the world over. Today nothing mathematical is lived directly, truly, within one's desires and needs, the world over. Except within some aboriginal or indigenous corners of humanity, in tiny cracks in what I will still call, as in May 1968, "the System". And I will share with you in a minute my own experience within one of these indigenous openings into living mathematics. But overall, we are witnessing the concentration of power in an elite that defines itself as textbook educators, each generation more formalistic than the preceding one, each generation merely reorganizing the formalities devised by the previous one; they produce manuals always organized by grade, presenting supposedly grade-appropriate concepts (as if I chose to read Descartes in terms of the grade I was in at the time!), presenting successions of topics, creating pedagogical rules and sequences, Piagetizing curricula. They pretend that learning is logically sequential, they linearize us all; and teachers, in their turn, put the kids in line, exercise after exercise, chapter after chapter. The textbook writers and the self-called Professors of Education, with capital P and E, perpetuate the drilling structure; they are the barking "sergeants" of the educational boot camp called schooling.

School math is simply a pain. Through official book-following, Math has become associated with putting things, and thoughts, into categorical boxes; and teaching consists in opening up a series of boxes, following a path through a curricular grid. We must travel through sequences of hierarchically organized topics, a bundle of chapter titles and these, as time brings on new fashionable labels, get elevated to a status called framework. We live in a prison metaphor. Our problem is that one does not enjoy living or learning within a frame, within preset borders. One does not enjoy teaching when one has to execute a program just to fulfill the program, filling the kids' brain to the brim. Pure quantity, measurable quantities: we are doing that type of math all the time; and we are tired of it although we obey, as

mathematical automats. Al these unpleasant associations that end up building up into fear, maybe at times panic and, then, once pushed back into our subconscious, repressed because we do not want to look at it in the face any more, build up a chronic phobia... Is that a substitute for lacking executable desires? We can't live by quantity alone: "Did I cover that topic? Did I finish that section last time? Can I pull over that box on this page? Can I assign that bit as homework?" We are talking heads, speaking math-like administrative 'educationese' language in our own heads. The model lesson plan we are to imagine at breakfast should look like a series of cereal boxes that we'll empty on the blackboard, in lines and columns. We'll follow a presentation matrix and some of us might do it with Power Point. Someday we'll have Power Line to work with. Some self-called educational programmers will prepare all this for us; we've become programmable too. We are being mathed-out, and we and the kids are right to want to stay alive, and not like it! It ain't living; it is frigid, formalized to death, the death of everyone's curiosity and creativity. I am playing here with the language of schooling, because playing is living; It helps me see what is being said and what is then set into print as teaching orders, in the name of a supposedly necessary organization for all teachers to walk into, in step, climbing a mathematical ladder of universal knowledge.

Somehow I did not have to live things that way in France. From a certain point on, usually in the upper grades, each teacher insisted in giving "his" course (all my math teachers were men) and you had to take notes from his own authorship exposed on the blackboard. Math learning then, was from the real talking and writing of a living person, not tied up to the formidable orderliness of a printed volume.

At the same time, in my youth, the Algerian kids whose parents tried to survive economically and physically by taking refuge in France from the colonial war in their homeland, would only (and this 'only' is fundamental) meet math as formal stuff in stiff textbooks, not ever in their mothers' tongue. This is why I now want to talk with you about this issue as I see it from a specific corner of the Third World, from very far away from "the belly of the beast" that you live in. But, first, let me show you one of my own "Beautiful Contradictions" that the poet Nathaniel Tarn talks about: I must confess to you that I just published a MATH TEXTBOOK! The interesting detail about this achievement is that I cannot read it, and none of you could read it either; and very few people could even recognize the mathematical notation used in it. The title that its collective authors chose is: "A guide to keep investigating the way we 'people from the anaconda snake' count and measure things". They, whom we call Tuyuka, have not decided on a name for what we call mathematics. Do they need to formalize that? They know what they do when they create an ordering for their fishing nets according to the size of the mesh (that they produce by knotting a line around standard hardwood slats whose widths are measured in fingers, in finger widths that is) and the corresponding types of fish that they catch, and/or not catch. There is a lot of math, my friends, in elaborating the contents behind these sentences! In this book, you also find detailed drawings of pineapples; the women of the community were very happy to investigate the families of lines that you can count on the pineapples that they cultivate in their manioc gardens. They presented their findings to everyone else in that house that the white man had basically forced them to build and called "school" but that they then appropriated, with a little help from their honest advisors, those who are working at the service of their culture: First, the anthropologist who does not think of "getting her degree in the white world" any more, but accompanies the indigenous teachers in their effort to alphabetize the kids in their father tongue (excuse these technicalities, but without

them, I would be giving you a false impression of simplicity); Second, the linguist who helped them decide how to make their language be more alive, become literate and owners of literature, by first writing it down, everybody participating, writing without strict orthographical standardization: reading back is not difficult for those who know the language; it may feel difficult for the white person looking from outside and wishing for strict rules, as if we were again doing something where only one way and one answer are permitted, that thing that would be just like textbook math! Third, yours truly, who proposed that counting and measuring was just part of expressing oneself with specialized parts of one's language, with a few symbols just like those that represent sounds in words, within one's way of thinking about one's life. Tuyuka Indians organized the results, in their language, of their counting lines on pineapples, discussed, chose symbols and noticed the rule among what our culture calls the Fibonacci numbers...

I seem to be very far gone from our fearful topic. And yet, it is its absence in Tuyuka life today that must interest us here. They looked for patterns in the world around them and in the world of the tools that were developed by their ancestors. They uncovered the math hidden in their choices of patterns on woven baskets, and asleep in the weavers' unconscious. They discovered their ethnomathematics, what we can call here the math of their ethnic group, defined by the language that the group expresses itself in. And they are just as at ease within it as they are with their 'ethnoreligion'. It is fun to research one's own culture in all its aspects, and do that with the kids, and call it learning and maybe, to be understood by the textbook writers, teaching. It was neither frightful nor painful; those ideas did not apply. None of us was being drilled into something; and there were no more teachers as "prison guards"; this expression was used by one of the Tuyuka teachers who was forced to teach in Portuguese, by the white rulers of colonizing education, to ethnically different peoples, during 30 years. As he described to his colleagues and me how he had just helped a bunch of kids count the leaves spiraling around the stem of a cassava plant, he said suddenly: "I was a prison guard for 30 years, but now I see the kids being happy."

“When will we all stop being prison guards?” I ask. Someone, 35 years ago, chose to do it right here in California, opening the doors of the Palace of Fine Arts without any formal inauguration of what became the Exploratorium. And what I and Tuyuka teachers did together resembles very concretely what we still do, inspired by Frank Oppenheimer, in our Science and Math Centers: the place is full of real, material things, things familiar to the visitors or students who can explore and discover some organization, some order, some relations; or marvel at some explicit order that we have prepared for them to play with (like symmetric objects or drawings that the visitor constructs and deconstructs, discovering invariance and the variety of symmetry rules). The Tuyuka did just that with their fish nets and their basketry techniques. Patterns on woven objects require multiples to fit into a whole. Looking for rules in the branching of strangely regular plants revealed the concept of fractal growth. But all of this only made sense to them and flowed in their interactions and teaching because we did it from within their culture, their life, their own language. And they kept discussing and finding joy in these discoveries, and sharing a little with me in Portuguese when they paused; and then I could at times tell them something about how other civilizations discovered, played with and used such concepts. I was glad, at that time, to have done a lot of multicultural math with our teacher colleagues at the Exploratorium in the 90's. From Tsalagi weaver Kim Shuck's 'corn numbers' to Inca quipu databases, I told stories of what I had learned from other cultures. The Tuyuka then chose the Mayan notation to represent their numbers because their counting, when listened to in their

language, gives special roles to units (the Mayan dot), five (the Mayan bar) and 20 (the Mayan base and vertical positioning choice). Here is a photograph of a poster made by four kids detailing their counting system and its notation, as they count fish.

Could there be fears, anxieties or phobia in this intellectual adventure? Five years ago, no Tuyuka had ever written a word down in their language. Their process of literacy is a true cultural literacy, and it is theirs. In our Science Centers we also do technical literacy and, when we allow ourselves to think deeper we do and live cultural literacy overall. And no-one is afraid.

What corresponded to US fears when I first went into Tuyuka territory was an initial apprehension acquired through "contact" with the Brazilian world; in fact, the reasoning that led me there in the first place was quite contorted. In the official Brazilian world of formal education math is used to select out people, the globalized technique that consists in grading and examining and that all of us are forced to participate in our schools. Indigenous Education, as imposed from the white political world of State or Municipal Secretariats of Education, tries to reproduce this white man's schooling technique. But some indigenous groups, using the Brazilian Constitution's recognition of an indigenous right to a "differentiated" education, and helped by individuals from dedicated NGO's, succeed in defining their own way of doing education through a recently created category of individuals: indigenous teachers, paid by the official white world. Those newly selected teachers were almost all "educated" by the various types of missionaries that invaded the Amazon basin in the middle of the 20th century; in mission schools, they were forbidden to use their own language and they were supposedly trained in Portuguese, Mathematics, Geography, History with the same books, as any Brazilian kid. They resisted quietly and dosed through it all, never acquiring the formal skills of the white man. Today they remember and have a chance to look for alternatives. But they never heard of anything else in mathematics besides "the four operations" and this is explicitly what they asked me to come teach them. When I arrived I first asked them to recount their contact with learning math and they all confirmed that they "did not learn it". It had grazed then without hurting and thus they had not had time to become fearful. So I proposed to look for their own stuff of life when some repetitions, regularities or special organization occurred. And we were off into their own adventure in discovery. No question of fear because there were no a priori difficulties, no rules to follow, no abstractions required. We were not going to live through formalities but enjoy intellectual life in discovering organization in the real world, their real world.

Now that I have said all this I understand better why we created Science Centers. Remember why Frank Oppenheimer created the Exploratorium, to give ordinary people a true access to the joy of discovering, of exercising their intellectual capacity on their own in the midst of a rich mix of natural phenomena. And remember that the greatest achievement of the Teacher Institute at the Exploratorium is having its alumni not be able to drive fast at any time, because they keep finding new interesting things in their field of view, and they go on observing, and seeing and thinking as human beings, alive, and not mere car-drivers. Our aim is that high. We are the antithesis of school formalism, although we are very organized in the seriousness of what we do. We offer people some possibilities of doing, living and feeling math, discovering that math content is finding patterns. ("Patterns" was the original banner announcing the area of math exhibits at the Exploratorium). Science Centers can use their own words, create categories of activities, and make up games without referring to directors' grids, matrices or frames. The people assembled here today

are museum educators and classroom teachers who know about science and math centers and know the difference between what can happen there and what is enforced in the classroom. My proposal, then, to all of you, would be to "have no fear" and transform your classroom into a living discovery center.

There it will be possible and enjoyable to do math by researching one's own world, as my experience with my Tuyuka friends taught me. You develop the concepts you need as they appear and you know what they have to do with the real world. Our kids have a real world they live in; and however politically incorrect a trip to the supermarket might be, it still is a truthful way to find numbers in common use, combine them, see how they change, discover real things about what economics are. Such an activity does not create fear of math. Claudia Zaslavsky has proposed a lot of activities and studies for the early grades and Marilyn Frankenstein for later education. Inheriting their proposals and their determination and applying them into our Science and Math Centers and classrooms, we can truly "get on with our lives". Science Centers are not to accept any more being considered as marginal additional resources for the standard formalized unappetizing school menu, or reduced to one more offering among field trip distractions. They are a methodological example for enjoyable math teaching.

Friends, there is a job to be done, there is a world of creation and joy to be lived together with all the kids, if only we insist in our efforts to accompany the learners' own discoveries, if we insist upon a real concrete respectful way of treating the learners. We can be self-righteous about the success of Science Centers, their formal success. So, have no fears!

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