

Trick or Truth: the Mysterious Connection Between Physics and Mathematics – FQXI Essay contest, 2015

FROM PARENTS TO CHILDREN, by Teresa Mendes

I will start this essay letting you read a recently discovered letter from Nicolau Xavier Mendes, my grandfather, written in 1935, in India, in Portuguese language, and addressed to his two sons:

"To my two sons, Rui and Alvaro.

THE UTILITY AND BEAUTY OF MATH.

Since the ancient times, all who knew Civilization, cultivated mathematics - some led by practical needs, others attracted by the pleasures of the spirit. And because mathematics has subtle inventions that serve both to facilitate the industries as to satisfy the curious, mankind soon realized its usefulness and its beauty.

Mathematics is a more perfect science than all other sciences and has numerous applications:

In astronomy, it is through mathematical calculations that one predicts the movement of the heavenly bodies; in physics, mathematics overcome the experiments and reduces the work we need to do the know the results; in finance teaches us how to calculate interests, annuities, exchange rates and rents; in agriculture, facilitates the geographical work; in engineering, helps to determine the strength of materials; in Navigation, help and guide the sailors; in the military arts, solves the shooting issues, etc.

This way one can realize how useful to man the study of mathematics is. It's not only the utility that streams all its interest: it contains a large sum of Perfection, Harmony and Beauty.

Leonardo da Vinci, the greatest exponent of Italian painting, confesses the pleasure of math, saying:

"If sunlight produces the greatest joy in the bodies, the clarity of mathematical truths produces the greatest joy in people's minds."

It is because mathematics has, more than in any other science, multiples occasions to admire the greatness of the human spirit; because it is highly aesthetic and because it contains within itself the foundations of Art.

The great Leibniz says: "Art is a high expression of arithmetic."

Indeed, all forms of art live in between the number and the shape. Painting has its geometry in the sketch and perspective; Architecture and Sculpture subordinate laws of their aesthetic to proportion and symmetry; Music and Poetry search within the number or the measure the best of their attractions ... the rhythm.

There is no need to study and devote one selves to higher mathematics to enjoy its beauty. In the plains of elementary mathematics studied in high schools, there are also plenty of opportunities to meet its charms.

All depends on the way we teach and the way we learn.

The branches of elementary mathematics are three: Arithmetic, Algebra and Geometry.

Each branch has its characteristic interests.

In the method of Arithmetic, one can observe the curious relations of numbers, so curious and so perfect that Frederick Gauss - the German mathematician - said: "Mathematics is the queen of sciences, and the arithmetic the queen of mathematics."

It is in Arithmetic, that one especially notes the spirit of order and proportion. In theorems, statements, operations - all savoring the order and proportion, or in short, the method.

It is also through arithmetic, that men have for the first time the awareness of reason, when they know the results of their first accounts. And at that time, one begin to feel the incalculable pleasure of calculate.

Elementary Algebra is a symbolic language that has all its elegance in the simplicity of its style. Each equation is a prose passage; the unknowns are the questions that have their answers in the equation's solutions.

To put a problem in the equation form is to write in algebraic language the conditions of a question raised in the colloquial form. To solve the equation is to seek the solution of the problem: - and here is the merit of this language.

Algebra describes how you can establish parallels - is an attic view, which strives for accuracy and clarity. And there is all its charm.

Edgard Quinet, poet and philosopher, professor of Mathematics at the Polytechnic School of Paris, was so surprised by the beauty of Algebra that he considered it superior to all human languages and the language of God in the spirit.

The algebraic method has over the arithmetic one the advantage of being simpler, more attractive and more general. That is the reason why Algebra, allowing progressing faster, widens the horizons in the field of numbers and develops in mankind the power of abstraction, by covering general truths, not settling on useless details.

Of all the branches of elementary mathematics, says a teacher, it is geometry that more pleasures reserves to scholars.

In simple check of a property, or the statement of a theorem, the young people experience great satisfaction, each student is the little Archimedes discovering constantly new principles and deducing new consequences. A knowledge acquired by their own efforts, or in fact demonstrated by the logic of a child reasoning gives them the feeling of intellectual personality.

What joy Isaac Newton must have felt when found to be mathematically precise the calculations that led to the brilliant discovery of his law of gravity.

But there is more than the pleasure of discovery that geometry offers to scholars. Those who penetrates in the logical spirit of the science appreciates the close correlation of their theorems, linked to [...] forming the grand building [...]

*My dear children [...]
as the [...]*

[Last page torn...]

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I read this letter, last week, a letter from a father to his children, for no apparent reason, from my grandfather to my father that was only 6 years old. And it was for the first time read. 80 years after being written. What a chill. This letter from my grandfather to my father was a windfall. Who knows how my grandfather would have ended his letter; but his love for mathematics, passed on to his children, does not need any more words.

FROM MATH TO PHYSICS ... AND EVERYTHING IN BETWEEN.

My father did not write, yet, a letter to his three daughters, at least I think not. But if he had written it, Rómulo de Carvalho would certainly appear in this letter, as several books of this Portuguese teacher, my father's former teacher of Physics and Chemistry. His books systematically appeared in each daughter's and grandchildren's homes.

The first book of Rómulo de Carvalho I read, I must have been about 15 years old, and served me to get a good grade on an test (with consultation) in the subject of Physical & Chemical Sciences and Philosophy. Two very different teachers decided to innovate proposing a joint exam. 1975 was a cool and exciting period for teenagers of our Portuguese history, where a political revolution occurred and democracy was born, in Portugal. I found that book,

browsing through in my father's library, a book called "What is Physics?", that had all the answers to questions that I thought I needed. It had, and it is part of my fond memories.

Meanwhile, maybe not all Portuguese know that Romulo de Carvalho was also a poet, Antonio Giedeão, but all know one poem, used in a beautiful song "The Philosopher's Stone" that I let you enjoy here [1].

With Romulo de Carvalho I also learned that the tears of the black women were the same as mine - water and sodium chloride; also learned from the pleasure of hearing my father's stories about his classes, the enjoyment of teaching and learning science.

My father taught me many things: the pleasures of mathematics, physics, music, sports, bridge, engineering, Indian food, honesty, uprightness, how to love a woman for a lifetime, and the courage to create new things and innovate, like companies, or how to emigrate and return, how life is about change and adaptation.

Now is my turn to transmit my passion for science:

In my youth, Math was a game, a fun game. The most entertaining game of high school, as much fun as the revolution for democracy, the thrill of competing in gymnastic championships, the challenge of tutoring for pocket money and the emotions of first loves. Today Calculus is almost a relic of my memory that trembles in front of a Schrödinger equation. Today I only can add properly using Excel. The lesson here: if you don't practice, you will forget how to do it ...

But Math accompanied me during all my life. It was the Logic that stayed with me - from *modern mathematics* that my father forced me to explain, while he taught me the "simple rule of three". Algorithms, queues, data analysis and systems, simplex, but also the math of musicality: tapping the 5-6-7-8 that starts a dance step, a tango figure, a salsa clave or learning the difficult flamenco claps.

THE UTILITY AND BEAUTY OF PHYSICS

In Physics, Romulo de Carvalho left me Newton, Galileo, Archimedes, the atom, the planetary system, galaxies, the very large and the very small, all Sagan and Mendeleev, Science Museums and Discovery Channels.

Without quite knowing how that happened, I followed a Chemistry major: I

studied and researched; my first job was teaching young people; I also know what a laboratory feels like and the drama of the researcher's life. But in Chemistry, everything is easy; everything is logical, it all makes sense. Quantum Mechanics was a chapter: some quantum numbers, orbitals, something weird like uncertainties and exclusions, we would never had to use again. Teachers never gave it too much attention ...

For many years, Quantum Mechanics was what television programs and holiday books showed me. I never really understood, but I didn't question. The lesson here: we normally don't question scientists.

But now ... it is different.

Today, I think Physics need all our attention, even if we are not physicists.

Today I find myself thinking about my children, thinking about the future we leave them. I'm not comfortable to belong to that generation of adults, that watches our young people, at least in my country, so pessimists about their future, that their only hope in thinking about studying and working abroad, as if it will change anything.

But what could change everything?

What could really change everything would be a major breakthrough in the scientific arena – specially in Physics, because a major breakthrough in Physics will certainly create the opportunities for engineers to come out with new technologies, and new technologies will allow sustainable economic growth of economies and support a better life for all mankind, as History taught us.

Physics today is struggling ... in its own mess: no clue on what gravity is at a subatomic level, absolute incompatibility between the two major pillars of modern Physics, Quantum Mechanics and Relativity ... the role of Math in Physics taking the place of God as the creator of the universe – a mess in the foundations of Physics.

But Physics can change ... there is now an opportunity – correct the foundations.

I believe that in the beginning of the twentieth-century Physics took a wrong path, based on the principles of quantum mechanics instrumentalism, whose hegemony today is perpetuated because it is very difficult to "disprove" experimentally. Sure, when everything is possible, when all explanations however impossible they are, even the ones that are not "falsifiable", are taken seriously for decades and decades, by the most prestigious and serious researchers, '*something is wrong in kingdom of Denmark*'. While Quantum Mechanics joined the pleas of Local Realism, the results have been spectacular, now that physicists decided to ignore those limits; no concrete results have

been achieved, for a too long time.

For me it is time for Physics to return the road that can provide Mankind with new technologies to simplify life and create economic value. I do not see any future in Quantum Mechanics.

So I, against all odds, I fight. I fight for a future, for a better future, for all children, but especially for you - Mafalda and Duarte, who I love with all my heart. I see it as a responsibility, a mission, but also a thrill, perhaps the hardest task I have ever set myself to do.

I fight, against the twentieth-century physics, in favor of a new physics of the XXI century. I fight for a scientific revolution, which scientifically is an absolutely natural and credible idea. I fight to restore the Local Realism paradigm in Physics of the quantum phenomena, that I'm sure will change the world of Physics, as well as the lives of all people that live on this planet.

It took me ten years to realize, but I do believe that, over the shoulders of giants, I can also make a difference, as a simple marketer. I just need other Portuguese on my side, to have a louder voice, because it is not easy to begin a scientific revolution when physicists are so busy with their lives that they are not listening, nor checking their foundations.

A scientific revolution is a battle of ideas; so detailed and specialized that only physicist will have the skills to debate and find a solution. What non-specialists can do is to make the world understand where the problem is, so that physicists have to pay attention.

TRICK OR TRUTH ...

About the connection of Mathematics with Physics: it is powerful one, and can be dangerous one. Probably it is where the problem of quantum mechanic lays - the religious belief that mathematics is the language of the universe and not a very useful human invention, because it can accurately predict ... anything. The problem comes when physicist believed that whatever mathematics predicts, sooner or later, will be proven experimentally. And people believe in scientists.

I do not believe in this religion, because mathematics is not the reality. Math is a powerful tool that human ingeniously invented to facilitate our life and enchant us with its beauty.

Physics studies the universe that is neither black nor white - is only realistic and local. :)

The physical world has its limits: the interactions have the limit of the speed of

light, as Einstein once said, (and also said that he never believed that quantum mechanics was a complete theory); and reality has well-defined properties independently of if we are looking or not. Physics studies the universe, from the very small to the very large, and there is no difference between the very large and the very small - only the mathematical tools we use to explain and predict can be different, because sometimes, good approximations are sufficient to solve the problems we have in our practice. And there cannot have one Physics for the subatomic world, another Physics for the macroscopic world, as advocated by defenders of today's mainstream physicists, or if they advocate it, they will have to define where and why is there a frontier.

It is not the first time [2] and probably will be not the last, that I appeal to the physics community, and more specifically the FQXI community, to seriously discuss the Local Realism paradigm: I assure you, it is a paradigm that to this date has not been falsified and therefore is a line of research that deserves to be supported and funded, an issue that obviously adheres completely to the mission of FQXI Institute.

I also think FQXI should also take an active role in informing the thousands and thousands of Physics & Chemistry teachers of the secondary schools and Universities around the world, that they are teaching it wrong, probably by lack of information, when they are teaching their students to believe that Local Realism has been experimentally rejected.

(And no, 1982 Aspect experiments were not conclusive, so they did not reject Local Realism ... nor the following ones, until now. There are still, in 2014, proposals from specialists in quantum foundations for the final "loophole-free experiment"... [3, 4]).

Physics can be a beautiful science, but only if one knows how to respect the physical limits of our universe. Physics explains the mysteries of the past and provides forecasts for the future, while surprising us with the possibilities of our own future through the imagination of those who are curious enough to want to know more and more.

When Physics relaxes and stops following the principles that make it a science, we should worry. And we must never confuse Mathematics and Physics.

As my grandfather Nicolau wrote: "In physics, mathematics overcomes the experiments and reduces the effort we need to know the results".

That's all for now, on the relationship between physics and mathematics.

But, because this essay has the title From Parents for Children, I would like to add that to Mathematics and Physics I joined Innovation - the ability to take risks, and Marketing - the ability to design products and services, economically feasible, taking into account the needs of others, and also Empathy - to not to

forget that, on a daily basis, things do not need to be economically viable to continue to make sense.

About the meaning of life, I advise you to listen the physicists because they better than anyone, and much better than our politicians or powerful leaders of the financial worlds, look at the universe with curiosity and commitment to understand how it works and many of them have a unique ability to convey that passion [4]. Even If they do not check their foundations, they can give you very interesting insights.

Physics, normally will also offer us very interesting predictions about our future, predictions that all business and governments should pay attention, because they lead to the technologies of the future. I regret that today's Physics does not do that job, nothing, non-realist or non-local, will come to the marketplace. Today's big bet of Quantum Mechanics, entanglement it is just a prediction, not a real property. And without entanglement, there will be no quantum computers, no quantum teleportation, no quantum encryption. Therefore, in my opinion (and I doubt it is only me with that opinion) the physicists are using the wrong tool - Quantum Mechanics, shooting ideas everywhere without any limits that adhere to this universe we live in, limits that now has a name: it is called Local Realism.

And now I, like my grandfather and my father before me [...] I will leave the last three lines open, to be completed in the future [...]

My dear children [...] with the Portuguese [...]

with a new Foundation [...]

your mother [...]

[Kids: read also the Portuguese version, ok?]

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[1] "The Philosopher's Stone" ,Poem by Antonio Gedeão.

[With translation of the poem for English language]

<https://www.youtube.com/watch?v=ACm6RZx4lbM>

[2] "Physics needs a Paradigm Shift," by Teresa Mendes

<http://fqxi.org/community/forum/topic/2246>

[3] Loopholes in Bell Inequality Tests of Local Realism, Jan-Åke Larsson

<http://arxiv.org/abs/1407.0363>

[4] Bell inequalities under non-ideal conditions, João N. C. Especial

<http://arxiv.org/abs/1205.4010>

[4] Neil deGrasse Tyson response to a question from a 6 year old on the meaning of life, <https://www.youtube.com/watch?v=BgMBGD6MZKc>