The seventh wonder
The crisis of science education

Science is the key factor of technology and technology is the foundation of our existence in nature. Strangely, the education of science starts with nature and not technology.
This contradiction is already present in science itself because the laws of science are regarded as laws of nature that simply have special applications governing technology.
I believe that all this will alter and it will turn out that us and technology was already part of nature's language from the start. But these strange thoughts will not be explored in this article.
The importance of science education is unquestionable and it is also accepted that this education is failing.
People, even educated ones do not understand basic scientific principles!
The promotion of science is only using superficial remedies like popularizing science as such in the media or encouraging kids toward science as an abstract goal again.
The internal conflicts that block understandings are taboos.
The first and most important internal conflict is the role of mathematics.
Is mathematics a science at all? There is no point of arguing about terms, the point is that science needs math. Strangely, math needs science too.
The separation of math as a subject taught on its own in schools is a major cause of the problems. Many have suggested so called integrated science education, where math is developed faithfully to the history of math, as a tool of science.
The most important manifesto about the insanity of math on its own was written by Richard Feynman. It was especially important because it attacked the tertiary level, in fact the physics education at universities. The obsession with derivations was his actual target. When I read his article, did I just realize the tragedy that happened to my own brother who had to drop out of the electrical engineering department because he could not handle the abstract rubbish they required. He still became an excellent engineer.
Since Feynman's article the situation became much worse!
The derivation mania creped into high school education!
All this coming from me a theoretical mathematician should sound strange, but it's even stranger. This is so because just as physics has its modern twentieth century reformulation that is pretty well known, math also has a New Math. Even a continuing analogy exists. Just as new physics has two major fields Relativity and Quantum Mechanics, New Math is also based on Logic and Set Theory. But here in New Math a third new pillar emerged too which could be called Effectivity or Computability as it has been renamed probably correctly. This at once connects it to computers at least.
Just as New Physics is avoided before tertiary level, New Math is avoided too, though a formal usage of sets and even logical symbols did penetrate high school education.
So, my contradictory anti math sentiment is deeper because I fell in love with New Math very early. But I was tutoring math for all my life and it had major influence on me.
Only now at an older age did I come to recognizing the major causes of the problems.
So I try to lay these facts down as follows:

A major difference in math and physics education is that while physics is only requiring proper visions of what the laws mean, in math there are simple “abilities” that have to be in our actions. So, we are talking about algorithmic abilities, to be able to do certain processes. The most elementary level of these of course is counting.
The three “R”-s are including this as third, arithmetic.
But actually the three “R”-s follow two earlier abilities, walking and talking.
On the other hand arithmetic itself is a bit confusing internally because it usually includes the knowledge of the times table. But this should be separated!
Unlike counting that automatically induces the counting in steps even backwards, multiplication is not an intuitive algorithm.
So, to be very detailed we have six abilities that are universally accepted as musts:
Walking, talking, reading, writing, counting and knowing the times table.

Clearly, the times table as a mechanically memorized formal knowledge stands in contrast to the earlier true abilities. We use simple multiplications every day when we are shopping and they obviously influence wider visions too but still, this is a hidden relation.
There are two not well known approaches built on this special role of the times table.
The first is gone now and tried to avoid the mechanical learning, rather make kids discover multiplications by themselves. It was a total failure. Some kids became successful but some couldn’t multiply even at sixth grade.
The second is the complete opposite, it expands the times table into counting in head with more digit numbers. This is a success. Kids who obtain these abilities become more confident and to be a good magician with numbers will never be a disadvantage.
And yet this is not a road to mathematics!
But is there a simple road to mathematics? Yes there is!
Before I reveal this road though let’s contemplate on the word “road” itself.
Roads in general are the algorithmic abilities that underneath their simple processes that everybody can learn, will provide us with an arsenal of hidden visions and even attitudes!
Roads should not be marked by teachers. They are simply the black and white musts that everybody not only must but indeed can master. Just as we don’t stamp a baby because he or she learns to walk or starts to talk a bit later, similarly all road abilities have varying practice time needed to conquer them. These delays are not negatives. They have to do with processing the underlying hidden factors subconsciously. So in fact, the “slow learners” can actually be the true geniuses, just as people who learnt to walk later could still become sporting champions and ones who learnt to talk later could become the best actors.

Beside the Roads there are two other categories in education, the Gardens and the Maps.

The gardens are areas that we wonder into and apply our visions concretely.
The maps are external or above views that simply tell how the big fields relate.

The clear separation and conscious knowledge of what we are doing, walking a road, wondering in a garden, or looking at a map, is the most important start.

Of course, the first true step in the revolution that I propose is the admission that there are roads beyond the basic six. I clearly specified three such new roads that could alter human learning and solve the misery that education is right now.

But I will only reveal the first and most elemental of these three because it was actually not my recognition and without it I could not conceive the whole Road Approach.

After the second world war in the soviet union an order was given that math education has to be elevated already at elementary level and the job was taken up by Larichev.
He published a collection of few thousand elementary math examples. Humbly titled as Collection Of Algebraic Examples, it became an added problem book to the text books.
In truth, it is a text book on its own because the problems are so gradual that going thru them one by one guarantees two things. Firstly that we can not fail in solving them and secondly that after we go through them we entered mathematics as such.
This sounds pretentious but it is the truth! There is such thing as “as such”. There is a fundamental wall of abstraction that frightens and repels the outsiders and Larichev penetrated that wall with hundred percent success rate. That sounds not only pretentious but straight out as a miracle. So there you go, now the title makes sense.
But miracles are denied! I denied the miracle of Larichev for decades.
Then I embraced it, then I practiced it, then I analyzed it. So now I know exactly why the word problems are the road to mathematics. Simply because they smuggle in the use of variables into our subconscious. But such smuggling can only happen when a full reality is supporting it. So the full psychological picture is complicated but luckily this is unimportant because now after embracing, practicing and understanding the importance of word problems, I finally came to the most important part, promoting it.
But breaking down the walls of mathematics is an intention that will at once encounter the walls of ignorance. And here this word “ignorance” is meant in the ancient deep context as the most complicated material binding force.
In practice it appears as simple stupidity and prejudice.
I only encountered one other person who came to this same realization that the word problems are a particular yet universal Road into mathematics. His name is Andrei Toom and he’s been fighting a war with the world of official education systems for decades now, without any success. I am not even sure if he is still alive. I will send a copy of this article to find out.
At any rate, now I can say that the truth of our claim (Toom’s and mine) can not be accepted by external derivations or smart ass arguments. Only the practice of teaching verifies it but it does so clearly that anybody who witnesses it will be amazed.
I started intensively tutor math again here in Australia only when my son Daniel attended the Newtown high school in Sydney. The failing students that I brought up to become the bests in their classes and their happy parents were the living witnesses. At the start I still tried simultaneous fields and only gradually realized that the breakthrough is already achieved by just going through the word problems. Then the rest is easy.
These personal successes can easily stray one away from the fundamental problem:
Why don’t they use this wonder in schools?
This then becomes a political question and our personal ego satisfaction turns into anger.
And indeed I was called by some as the “Angry Samaritan”.
I can live with this title.
This was the first part of my article. The second will dwell into a particular physics educational mine field the atmospheric pressure. This is also a breakthrough field for very different reasons than the word problems are in math.
To start physics with the atmospheric pressure before even explaining elementary concepts like planets, stars, forces, gravity is not obvious at all. And yet this is a simple necessity that becomes evident once again we start the practice, teaching kids.

Then we can realize that actually this phenomenon indeed involves all the intuitive details. Forces, gravity and much much more!
The raw fact that atmospheric pressure exists and is big can be started by the historically also first demonstration, the 1657 Magdeburg Vacuum Plates of Otto Von Guericke.
The classroom versions are smaller and instead of horses the strongest students can fail to separate the two hemispheres that are merely attached to each other by their smooth edges. One of them has an opening and a tap that can be closed after we suck out the air from inside with a pump that of course must have a valve in it.
The didactical trap in this experiment is that we already know that suction is causing force from even the earliest childhood and we practice it every day when using a straw.
So to say that it is not the vacuum that holds the plates together rather the external air pressure on them is really just a new explanation and does not initiate an actual feeling.
In fact, it would be much better to start with the straw then and tell that actually it's not our lung that sucks up the coke rather the atmospheric pressure on top of the cup.
Or to play with syringes can come to the same point with even more details.
But all these are lacking a fundamental blast in our plausibilities.
This can be obtained by the "Cup and card experiment" but unfortunately this magic trick is deprived from its true potential due to the false explanations that follow it.
A cup of water is covered with a card and then carefully turned upside down.
The water remains inside and we actually feel the weight of the water inside.
This is crucial and so the best is to use plastic cup because then we really feel that it is the water that we hold even upside down when there is no connecting force that should keep the water inside. Of course, the card as necessary closing is a diversion in our paradox but since itself is only placed and not glued or attached, thus our subconscious at once corrects this diversion and recognizes that the water and the card still should fall down.
A much deeper diversion is if we don't use a full cup and we see that the water still remains. This is closer to the Magdeburg plates situation but there is no sucking out of any air. The truth of course is that the water is dropping a tiny bit but the card and the rim of the cup can take that excess water and so suction occurs and then calculations can verify that even such small percentage of suction provides enough force to conquer the relatively small weight of the water. But all this is details of reality that goes away from the true point of the experiment. The abstract world of intuitions. So it is abstract but not formal. And that is exactly why its awakening should be so crucial.
So, the deception that we use a full cup and thus suggest that this is somehow important is a necessary initial lie. A strange abstraction then can still connect this to the Magdeburg plates by saying that since there is no air between the water and the cup thus the suction of the "nothing" does the force. At once we could then apply backwards this to the plates themselves and imagine that true plates rather than hemispheres should be used. So could two perfectly flat plates stick together so that we can not separate them? Of course they could and we experience such sticky situations in every day life already. A broken glass piece easily sticks on the window and only a little water is needed to smoothen them. But here this is again a diversion from external pressure or vacuum to surface tensions and the like.
The return to our upside down cup that thus involves so many lies is still vital.
Firstly, because of the fundamental intuitive axiom inherent. Namely, that we definitely can not hold the water. Amazingly, this is the initial paradox, the whole magic trick and yet the thousands of internet explanations avoid this very fact!!!

The most idiotic explanations merely say that the atmospheric pressure is actually that holds the water.
The one level less idiotic explanations say that there is a huge atmospheric pressure on the bottom so it is able to hold the water easily.
Of course the common failure in these is that they dodge the basic paradox “what the hell are we holding?”. Or are we and the atmosphere both hold the water? This would make the atmospheric pressure as a mere explanation even more phony.
But this second explanation at least starts to unveil the truth, that more different forces are present. The truth of course is that more here means not two, the big atmospheric from the bottom and the small water weight, rather four:
Bottom atmosphere pressure, water weight, top atmosphere pressure, and finally our holding force of the cup.
The cup is actually pushed up with the big atmospheric force, say 50 kilo minus the water weight, say 0.1 kilo. So in total with 49.9 kilo. That would make the cup fly up fast but from the top the cup has the same atmospheric force down, 50 kilo. The total of these three of course would be 0.1 downward, so the cup would move slowly down.
Luckily, our hands is feeling this downward force and tries to balance it.
This is what we feel, the total of the three forces not the weight of the water.
The size of this total is of course indeed exactly the weight of the water!!!
Once the child understands this, that forces add and subtract with such precisions yet the sizes are merely a mathematical feature of the reality of the forces themselves, he or she entered the true domain of physics. Plus now the existence of the atmospheric pressure became a reality. A real force that we actually hold. Even though, it is only a tiny unbalanced part of the big forces.
After this, the experiments can have a purpose. To truly verify what we observed, and to find out how big the atmospheric pressure is.
The natural idea is to use more water, that is use taller cups.
If we tell the child that we have “insider knowledge” and so we know that we would need a ten meter tall cup to conquer the atmospheric pressure then we can even ask how else we could increase the weight of the liquid. And indeed children will realize that with heavier liquids. Then we can show that mercury is more than ten times heavier then water and so definitely a one meter tall cup would do.
At this point can we introduce a new “trick” that avoids all the ugliness of the card and the non totally full cup problem too. Namely, that instead of turning a full cup upside down, we can submerge a cup in any liquid, there turn it upside down and carefully lift it above the surface so that its rim is still submerged. The cup remains full as we can demonstrate it easily with a small cup. Then we can also show that a bigger cup that wouldn’t fit under the tub can be simply filled and covered properly with not a card but any stopper that then can be removed submerged. This then can be done with even a meter long glass tube filled with mercury and placed into a tub of mercury. And voila, after the stopper is removed under the mercury in the tub, the mercury in the tube will fall back to 76 cm leaving above vacuum. Then we can show the real point:
The mercury always falls back to 76 cm regardless the exact length of the tube above!
So the amount of vacuum is irrelevant, simply because it is not sucking up the mercury!
The mercury’s weight is pushed up by the atmospheric pressure coming through the tub and originating on its surface as the actual weight of the atmosphere!
But all these words have only true meanings if concrete plausibilities are accompanying them. And the cup and card experiment is the way toward this!
There is a secret world behind all these struggles to truly understand anything.

The beginning of course is to accept that there is a difference between true understanding and formal verbal arguments.
This is ignored and even denied at the present because the final test of acceptance today is the discovery of anything new. This is the only measure of truth. So excellence is used to replace understanding.
Well, excellence indeed guarantees understanding but understanding exists for all!!!!
So, the excelling ones should promote understanding on it own too.
These go to the heart of the matter!
We live in a world where excelling is the only meaningful aim, to be more than others to have more than others, to exploit others.
And not teaching well is the worst form of exploitation!