DigiMathArt – Connecting Math and Art through Programming. A Method of Creating New Neural Networks

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Abstract

Learning should be a natural, pure and joyful experience – even in schools, if we take into account that the old English scōl*,* scolu*, came via Latin from the Greek* skholē*, which means leisure, philosophy, lecture place (according to the Oxford Dictionaries). Many people think that Math, or Programming, or Art are tough jobs, that require special talent or dedication. They are taught, in schools or otherwise, that they use only some specific types of intelligences, and the others are simply switched off – which is not true, as neurosciences try to prove for some time, since neuroimaging took its turn in the investigation methods of the brain function. Here comes the DigiMathArt, an experience that involves many regions of the brain – both from right and left hemispheres – a method that captivates and engages in further approach by its unique concept – using Math to create Art forms through Programming. Kids are thrilled to create, and crave to learn more in order to generate new forms and colours – fractals are the most complex. Most of the pupils involved are girls, who discover the world of programming through art. The development of special neural networks and the general brain development are studied by comparison to the classic learning style of the same math concepts.*

1. Introduction

Since the era of rationality emerged, with Descartes well known *cogito, ergo sum*, the idea of splitting wholes into parts, and studying them in order to understand wholeness, became the main form of inquiry. There is no doubt that this revolution in the way of thinking of the human kind had major impact on the development of the scientific method, which is still considered the only reliable. New disciplines arrived – replacing the classical liberal arts (or liberal pursuits – from lat. *liberalia studia*), rooted in the basic curriculum (*enkuklios paideia* = education in a circle) of the late Classical and Hellenistic Greece. Martianus Capella described the seven liberal arts in his 5th century AD *Marriage of Mercury and Philology,* and this is the moment they took the canonical form. The four so-called "scientific" arts were known as *Quadrivium* – music, arithmetic, geometry and astronomy (or astrology) – and the three arts of humanities – grammar, logic and rhetoric – were called *Trivium* [1]. After Christianization, *Trivium* became *Studia humanitatis* and engulfed history, Greek and ethics (or moral philosophy), poetry regaining its important place [2]. This humanism curriculum became the educational foundation for the European elites during the 16th century, for the political administration, the clergy, and the professions of law and medicine [3], and persisted until the middle of the 20th century. Right now, the main academic areas that may be associated with the liberal arts include languages, literature, mathematics, natural sciences, philosophy, psychology, social sciences, arts (music, performing, fine arts), religious studies. Lots and lots of us consider they are good or bad at least at one of these disciplines…

Since the advent of Quantum theory, the human knowledge is on the way of finding its whole potential on a scientific basis. In order to create awareness in each student, even in ourselves, as mentors, new types of curriculum are needed. Such a curriculum would start from the native capacity of observing and making connections, and further lead to developing conscience and consciousness as well.

Our suggestion of such a curriculum includes – as long as *Art* is considered, in our proposal, the level of excellence in any approach:

- *DigiMathArt*, a holistic study of mathematics, programming and computer graphics;
- *Art of Knowledge*, a holistic study of sciences in historical, geographical and social context;
- *Science of Art / Art of Science*, an interdisciplinary approach for first grades, that uses fine arts, music and performing as a "gateway" to science;
- *Art of self-awareness*, a journey to our inner worlds, by means of the appropriate words. The aim is to define, and create, eventually, new concepts that pave the way towards neurosciences.

2. Description and methodology

This study is focused on DigiMathArt, a new method of teaching and learning that uses computer graphics and programming in order to make the mathematics concepts easier to understand.
The curricula of DigitMathArt is structured on modules according (but not limited to) to the age:

Introduction **(age 6-12)**	**I. Functions and equations – Digi Flowers** **(age 8 – 14)**
Theory: Point coordinates Natural and integers Numerical basis Sequences Areas, volumes Units of measurement Fractions, decimals Algebraic operations Equations Elements of Euclidean geometry Basics of C++ programming	**Theory:** Real numbers. Radicals Equation of line Linear and non-linear functions Elements of trigonometry Trigonometric functions Operations with functions Parametric equations of the circle Quadrics Compound functions Analysis. Limits of functions C++ programming **Applications:** Digital flowers
II. Matrix and Complex numbers – Fractals applications **(age 10-16)**	**III. Vector, Analytic and Differential geometry – Optics applications** **(age 12-18)**
Theory: Matrix Geometric transformations Complex numbers Analysis. Limits of sequences Quaternions C++ Procedural programming **Applications:** Fractals: Koch snowflake, Dragon curve Mandelbrot and Julia set Mandelbulb	**Theory:** Vectors 2D/3D Analytic geometry 2D/3D Analysis. derivatives, differentials Differential geometry Object oriented programming **Applications:** Optics: Lights, shadows Reflection, refraction

Table 1 – modules of the DigiMathArt curriculum

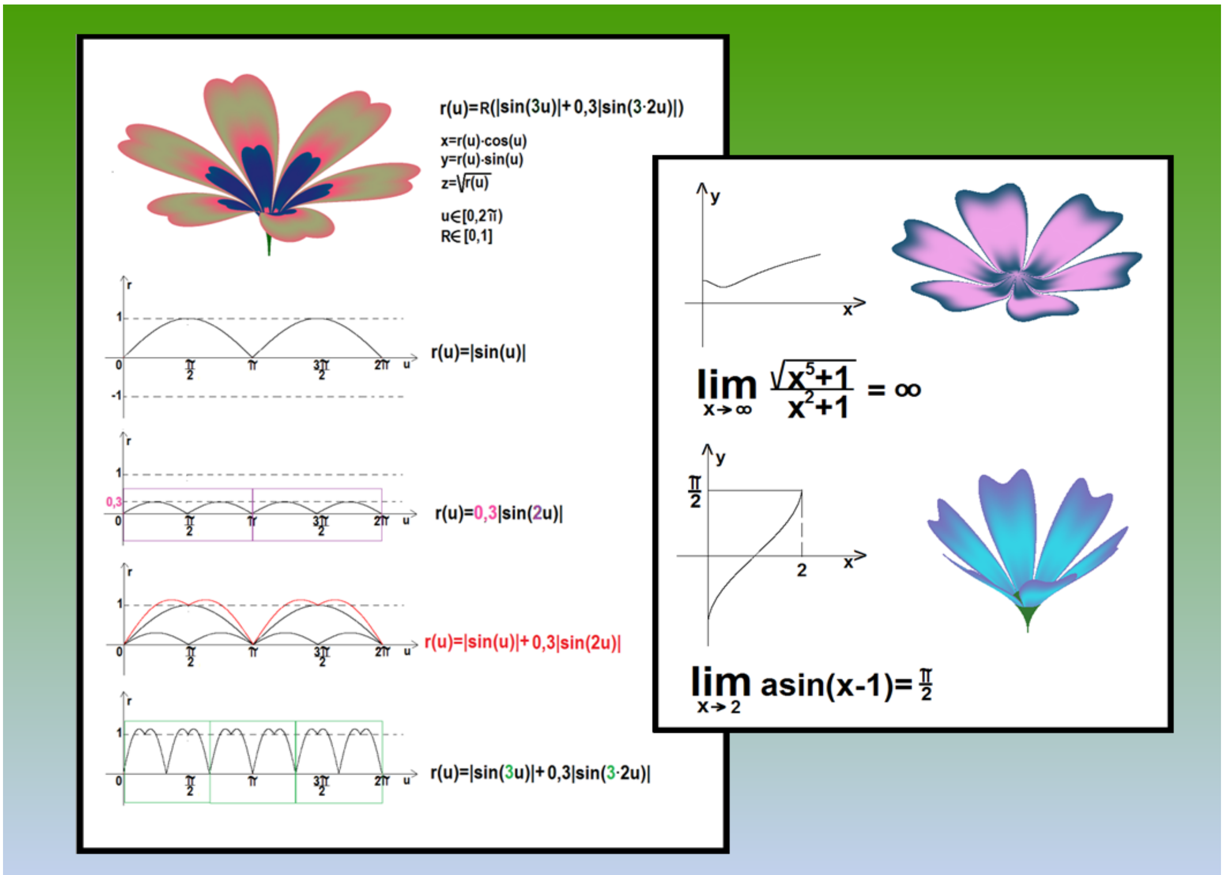

Fig. 1. Trigonometric functions (left). Limits of functions (right).

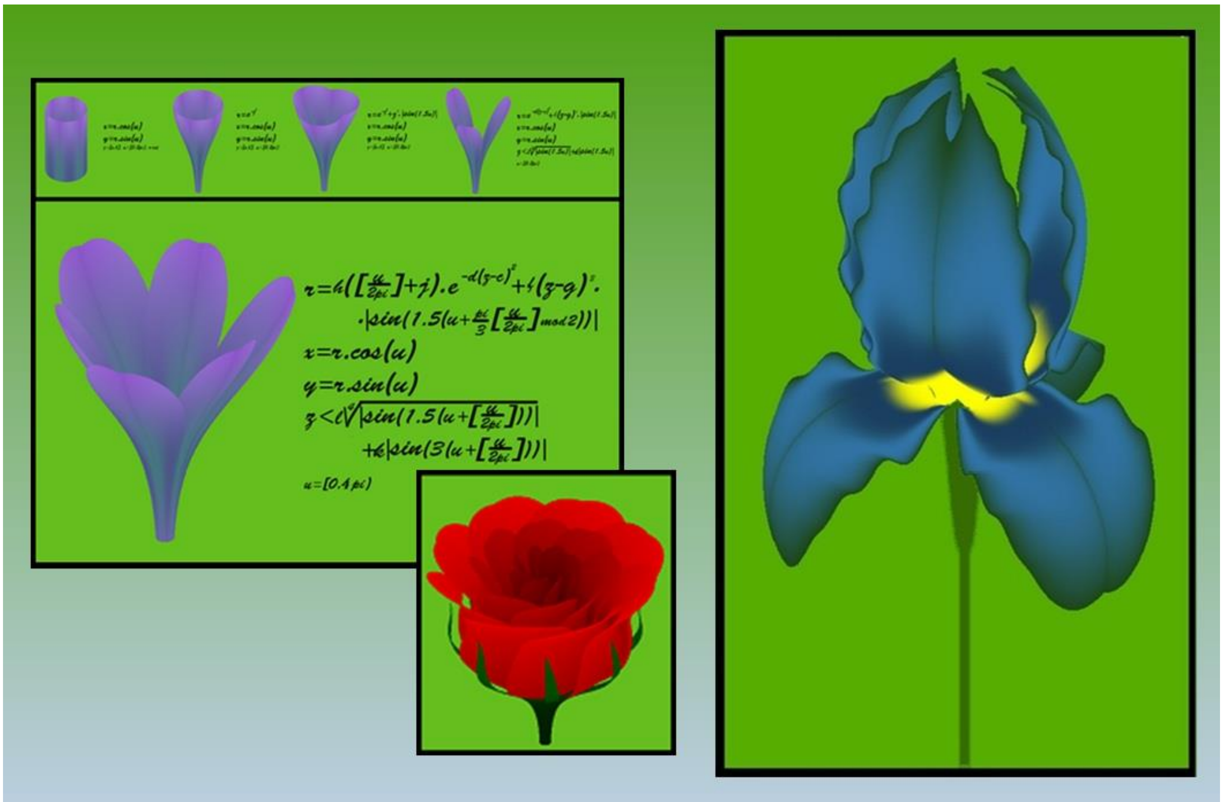

Fig. 2. Parametric equations of the cylinder (left). Geometric transformations (right).

The study is carried on a group of 24 students aged 6 to 14 enrolled in public and private schools, but home/unschoolers as well. This activity is performed since July 2013 on request, at the Re-Design Centre of Resources for Holistic Education. First, DigiMathArt was designed to accommodate groups of 6 or more students. Following the huge gaps between different kind of education, thinking, and of the completely new approach in mathematics, a period of transition was needed – each pupil had to switch from the classic, repetitive way of learning to intuitive concept generation. Then they have passed a classical examination in order to be assigned to a group.
At this point, the only evaluation of this method of teaching and learning goes by means of the national standardized tests. The pupils enrolled in the public and private systems of education who are trained with DigiMathArt method perform as high as possible when tested, and the home / unschoolers manifest a better ability to integrate and comprehend math concepts not only in math, but in other activities that involve critical thinking and 3D concepts.
The activities at the Centre for Holistic Education occur in a free manner, each pupil chooses the activity and the place to perform, and its team, as well. “Day-dreaming” is encouraged, as long as most of the education process takes place in a garden.
In order to study the effect of such an approach on the cerebral cortex, EEG and neuroimagery techniques are to be involved as well – the growth of the gray matter of the cortex and the development of neural tracts by DTI (a version of MRI – magnetic resonance imaging – used for visualising the brain white matter, which contains the axons of the nerve cells) is in progress.
Another important aspect that has to be mentioned is the recent discovery of a team from the Bar-Ilan's Cognitive Neuroscience Laboratory supervised by Prof. Moshe Bar, part of the University's Gonda (Goldschmied) Multidisciplinary Brain Research Centre. They are the first to demonstrate how an external low-level electric stimulus can literally change the way we think. The study demonstrated how the increased mind wandering behaviour produced by external stimulation not only does not harm the ability to succeed at an appointed task, but it actually helps. Bar believes that this result might stem from the convergence, within a single brain region, of both the "thought controlling" mechanisms of executive function and the "thought freeing" activity of spontaneous, self-directed daydreams. "Interestingly, while our study's external stimulation increased the incidence of mind wandering, rather than reducing the subjects' ability to complete the task, it caused task performance to become slightly improved. The external stimulation actually enhanced the subjects' cognitive capacity." [4]
The experiment was designed by Prof. Bar's post-doctoral researcher Dr. Vadim Axelrod, and consisted in treating volunteers with transcranial direct current stimulation (tDCS), a non-invasive and painless procedure that uses low-level electricity to stimulate specific brain regions. During treatment, the participants were asked to track and respond to numerals flashed on a computer screen. They were also periodically asked to respond to an on-screen "thought probe" in which they reported, on a scale of one to four, the extent to which they were experiencing spontaneous thoughts unrelated to the numeric task they had been given. "Over the last 15 or 20 years, scientists have shown that – unlike the localized neural activity associated with specific tasks – mind wandering involves the activation of a gigantic default network involving many parts of the brain," Bar says. "This cross-brain involvement may be involved in behavioural outcomes such as creativity and mood, and may also contribute to the ability to stay successfully on-task while the mind goes off on its merry mental way." [5]

3. Conclusion

Despite the huge paradigm shift in physics, we still persist in our Cartesian point of view, splitting wholes into pieces and naming them in order to understand the whole, we still think in terms of “mental” and “physical”, we still insist in laying foundations in order to build a world “as we know it”, but which is already obsolete. David Bohm, one of the first to challenge the Cartesian model of reality, developed the theory of implicate and explicate order [6]. *Science, Order, and Creativity*, written by Bohm and Peat in 1987, discusses the role of orders of varying complexity in the perception of a work of art. This is an attempt to bridge the gaps between the Lego bricks of information we try to put together in order to get knowledge. But knowledge is something else but the sum of its parts.
Why do we need education? One answer is: to get a holistic approach to the (uni)verse we live in – or build out. This is why we need to change the paradigm of education as well. Here follow a few proposals:

- Mathematics should be the backbone of any attempt to understand nature – in all its forms, visible or not. And the “receipt” to make mathematics affordable and fun for any mind, is to incorporate it in the mundane activities – in our daily learning processes. DigiMathArt is an attempt to use fine arts, programming and mathematics in order to create complex connectomes that may be the brain highways to understanding.

- In our actual world, the most effective way to boost learning and understanding is to swap the direction of approach – from general to particular, from the whole to its manifestations. Studying vision, for example, means not only the anatomy of the eye, but optics (lenses), reflection / refraction, electromagnetic fields and spectrums, biochemistry, and so on. A comparison of the vision systems is also necessary, strengthening our perception as manifestations of the same energy that "built" the world.
- Nature is the ideal classroom. Getting rid of the buildings named schools. There is no learning style, there are only attempts to escape the cages we are forced to live and learn in – no matter if it's exquisitely painted or decorated. Remember the kittens grown in striped cages – once outside, they couldn't hold their balance, they couldn't find their water and food – placed aside them.
- Knowledge – which is quite something else but the sum of information – is the final outcome of education. To get it, we need to make connections, to exercise the fundamentals particles of our structures / fields to experience frequencies they never "heard" of. Two hundred years ago, Johann Gottlieb Fichte, an influential philosopher of that time, set a goal: "education should aim at destroying free will so that after pupils are thus schooled they will be incapable throughout the rest of their lives of thinking or acting otherwise than as their school masters would have wished… The social psychologist of the future will have a number of classes of school children on whom they will try different methods of producing an unshakable conviction that snow is black. When the technique has been perfected, every government that has been in charge of education for more than one generation will be able to control its subjects securely without the need of armies or policemen". We live the time when this goal is no longer available or acceptable...

References

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[3] *Charles G. Nauert, Humanism and the Culture of Renaissance Europe (New Approaches to European History), Cambridge University Press, 2006, pp. 172-173.*

[4] *Source:*
http://www1.biu.ac.il/indexE.php?id=12923&pt=20&pid=4&level=1&cPath=4&type=1&news=2336

[5] *Vadim Axelrod, Geraint Rees, Michal Lavidor, Moshe Bar. Increasing propensity to mind-wander with transcranial direct current stimulation.* Proceedings of the National Academy of Sciences*, 2015; 201421435 DOI: 10.1073/pnas.1421435112*

[6] *David Bohm, Wholeness and the Implicate Order, London: Routledge, 1980, ISBN 0-7100-0971-2, p. xv: In the enfolded [or implicate] order, space and time are no longer the dominant factors determining the relationships of dependence or independence of different elements. Rather, an entirely different sort of basic connection of elements is possible, from which our ordinary notions of space and time, along with those of separately existent material particles, are abstracted as forms derived from the deeper order. These ordinary notions in fact appear in what is called the "explicate" or "unfolded" order, which is a special and distinguished form contained within the general totality of all the implicate orders.*