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Children and Robots

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One way to explore the relation of artificial intelligence and human consciousness is to look at the way children build robots and program them. It seems that when children construct a robot as a new toy or a new instrument not only they are putting together “atoms and bits” using physics and information technology, but they also attribute to their creation some “mental” properties. I will try to briefly analyze this phenomenon and the acquisition of the new robotics skills in our lives.

Animism, artificialism and roboticism

Jean Piaget described some 80 years ago the mélange of “animism” and “artificialism” in the cognitive development of young children in his celebrated book *La représentation du monde chez l’enfant,* 1938 (*The child conception of the world*). For Piaget animism “is the tendency that the child has to ascribe life and consciousness to inanimate beings” and artificialism is the idea that “nature is directed by people or at least gravitates around people”.[1]

Today, millions of children around the world have access to robots, and many acquire the skills to construct and program them since primary education. We can coin the term *roboticism* as *the belief that the robot is an autonomous object with liberty to make decisions*. As such, roboticism could be understood as a new synthesis of animism and artificialism. When children think that a robot is an “animated artifact” they are in fact putting together both believes. On the one hand, they have *constructed* an artifact that is working as they have predicted, on the other, they have given instructions that are followed *automatically* by the robot, without human control. This mixture of dependency (rules) and autonomy (freedom) is quite unique. At the time of Piaget, in the pre-digital era, it was impossible even to imagine such a combination in the hands of children. Children have now constructed an object that becomes in a certain sense “independent”, the robots work without human help. Of course, the child has prescribed the kind of work the robot performs by means of a set of rules in a well-defined environment; the robot’s apparent freedom is limited by this particular environment and rules. My thesis is that early hands-on experience in the construction and programming of robots may lead children to discover the real power and limits of artificial intelligence. But we would need more field research and extended cognitive studies to disentangle the new composite of beliefs that may continue into adulthood in relation to the robots.

A personal history: playing with turtles

My experience with children and robots started in the nineteen-sixties when Seymour Papert promoted the revolutionary project of deploying computers in the classrooms and began to explore the way children learn to program and construct/control a robot. I met Papert in the early 60s at the Center of Genetic Epistemology directed by Jean Piaget in Geneva. At that time he was developing his cognitive theory of *constructionism,* as a complement to Piaget’s theory of *constructivism*. In Piaget’s words, *constructivism* is the “formal obligation of constantly transcending the systems already constructed to assure non-contradiction” (Piaget, 1961) In contrast, Papert’s *constructionism* was more focused on the dynamics of developmental change than on the logical stability of mental structures or stages. Both authors were clearly opposed to instructionism in education. Papert left Geneva for MIT, where he became with Marvin Minsky director of the AI Lab (1967). I would like to pay now a most sincere tribute to my dear friends Seymour and Marvin who passed away this year, we owe them so much.

With Wally Feurzeig, Papert created LOGO, a programming language inspired by LISP and in the 80s he introduced this computer language in schools. He became professor at the MIT Media Lab, founded by Nicholas Negroponte, but, unfortunately, his master Piaget died in 1980 and couldn’t see his formidable breakthrough in education. Together with Horacio C. Reggini, we soon followed his example in Argentina, where we created la “Asociación Amigos de Logo” to promote the practice of Logo in elementary and special education schools. From the very beginning Papert fully supported my work with disabled children with the help of computers. His seminal book, *Mindstorms (1980*) was followed by Reggini’s *Alas para la mente. Logo: un lenguaje de computadoras un estilo de pensar* (1982), a book that had a great impact in our Latin American region. Logo

was used in many different school activities; one of the most popular was to make designs on the computer screen using elementary geometric procedures that move a pointer, a small triangle that was called a “turtle”.

The name “turtle” has an interesting history in cybernetics and was inspired in the (analog) robot created by the neurophysiologist William Grey Walter (1910-1977) in the 40s.[2] Grey Walter’s “tortoise”, had three wheels, light and touch sensors, steering and propulsion motors and two vacuum tubes analog processors that allowed the robot to explore and avoid obstacles, and to simulate positive and negative phototropism. It was named *Machina Speculatrix*,[3] and was used to simulate some brain mechanisms and simple behaviors. Gray Walter elaborated these ideas in an influential book *The living brain* (Norton, New York, 1963) that became a source of inspiration for many of us.

Following this trend the first robot programmed by children in the 80s was a Logo “turtle” (designed by Paul Wexelblat). The turtle was a very simple and robust robotic vehicle, a product by Terrapin Co. (terrapins are small semi-aquatic turtles) equipped with two wheels, electric motors, a transparent shell, a ring as a contact sensor and the whole robot connected to a computer.[4] Children were taught to write modular and recursive Logo programs with few simple commands such as forward (number), back (number), turn (degrees, left, right), pen down (to write the trajectory on the floor), pen up (stop drawing), etc. My first work with children and robots began with these charming Logo turtles in a variety of settings, working initially with disabled kids in a hospital and in some elementary schools. Incidentally at that time very few physicians or clinical psychologists were using computers. One landmark event, perhaps the first of its kind in the world, was the communication by computer we could establish among deaf children of Argentina and the United States. This ended with the communication gap established by Graham Bell when he invented the telephone and excluded ipso facto all deaf people from the system, a cruel paradox because he was a dedicated teacher of the deaf… Another unforgettable experience in the early 80s was to watch our turtle being moved in Buenos Aires by Logo commands from Boston via modem and telephones lines, well before Internet. Today the control of robots at a distance is a most common event, also in schools.

It was interesting that the robotic work with children started with turtles and not with androids/ humanoids robots… Roboticism was not “about humans” in the first days of robotics. Today things are changing rapidly and androids capture the imagination of children (and adults). There are so many androids in the market today at children’s reach. But there is an essential difference between *buying* a robot and *constructing* one. Both modalities can be used in the classroom or at home, but only constructing gives *transparency* to the inner organization of the machine, which is hidden in the manufactured robot.

A source of inspiration for all of us is the work of the Laboratory of Lifelong Kindergarten of the Media Lab at MIT, directed by Mitchel Resnick, creator of Scratch, a most useful programming language to use in elementary robotics with children. MIT is one of the leading places that launched the LegoLogo equipments for children where Lego blocks are provided with microprocessors. A recent development by Mariana Umashi Bers, also a disciple of Papert, now at Tufts, is the ScratchJr software (free download on iPad and Android Tablets) that is making possible to program robots without even knowing to read or write, what she calls KinderLab robotics. The job is done using solid objects with various symbols for SPIN, SING, STOP, and so forth, that can be put together as a “solid sentence” that commands a small wireless robot called Kibo. It is all about “learning to code” by doing.[5]

The same idea is at the core of the spirit of the foundation *La main à la pâte*, which promotes inquiry-based learning, including learning by “doing robotics”.[6]

Perhaps one of the most remarkable recent variations on robotic turtles is the “tortuga Butiá” made in 2012. It is essentially a “moving laptop”, a laptop mounted on wheels, a clever invention of the School of Engineering in Uruguay that can be easily built, uses free software (Turtle Art) as well as free hardware.[7] Therefore every device of the laptop, videos, photos, sounds, and a multiplicity of sensors, are already incorporated in the (laptop) robot and may be used freely without extra costs. In Uruguay every student and teacher in public schools (some 700,000) own their own laptop, the famous green XO produced by OLPC, *One laptop per child*, the program launched by Negroponte in 2005. Many children and adolescents are now able to transform their own XO into a robot which can compete with other robots and play all sort of games. Such a rapid transformation is bridging the technological gap between diverse socioeconomic populations, in particular in rural and urban deprived environments (Cobo and Mateu, 2016).

In Uruguay there are more that 1200 digital labs in public schools, well equipped with Lego/Logo (some 5000 kits) to construct robots and using Scratch to code. Among the very recent improvements we should mention the 3D printer that children are starting to use in order to produce solid pieces to build robots of the most diverse kinds. In November this year a national competition of robotics (180 teams) will demonstrate the creativity of students with this new tool.[8]

In conclusion*, the construction of a robot* is certainly the main path to understand how the machine works, and opens an immense space for invention, creativity and design starting with the first school years. This is a new cognitive skill that will have profound social, economical and moral consequences. This robotic experience, which is today available to millions of children, opens a new field of research for the neurocognitive and social sciences.

We could say that the Nobel Prize in Chemistry 2016 awarded jointly to Jean-Pierre Sauvage, J. Fraser Stoddart and Bernard L. Feringa "for the design and synthesis of molecular machines" rewarded a nanoscale kind of robotic turtle to play with, this time in the frontiers of molecular science. And when we play we learn, at all ages and in all disciplines.

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End Notes

[1] Battro, A.M. *Piaget: Dictionary of Terms* (Preface by Jean Piaget. Translated and edited by Elisabeth Rutschi-Hermann and Sarah F Campbell). Pergamon, New York 1973. *Artificialism*, 4 developmental periods: I) nature is directed by people or at least gravitates around people", II) *mythological artificialism* "appears from the moment when the child asks questions about the origin of things or answers questions which we put him", III) *technical artificialism*, "the child continues to attribute to man the general arrangement of things, but limiting his action to the operations which can be technically achieved", IV) *immanent artificialism*, "nature is the heir of man and manufacturer like a workman or artist….it considers things as the product of human manufacturing, much more than it attributes to the manufacturing activities".

Animism: "is the tendency that the child has to ascribe life and consciousness to inanimate beings". "The child ascribes to things moral attributes rather than psychological" I) *diffuse animism* is the general tendency of children to confuse the living and the inert", II) *systematic animism* is the group of explicit beliefs which the child has. The clearest of one of them is that children believe that the heavenly bodies follow them".

[2] http://www.rutherfordjournal.org/article020101.html

[3] http://www.extremenxt.com/walter.htm

[4] https://www.terrapinlogo.com/

[5] Video: https://www.youtube.com/watch?v=jOQ-9S3lOnM&list=PLXzFU_7W4n0t5suyfWPX6R-zUpd1MQ876

[6] C. Calmet, M. Hitzig & D. Wilgenbus, 2016. www.fondation-lamap.org

[7] Videos: https://www.youtube.com/watch?v=6leWvweMEMc

https://www.youtube.com/watch?v=vP6DAdGnmaA

https://www.youtube.com/watch?v=fXRRd5M_Zzs

[8] Videos: https://www.youtube.com/watch?v=hkERD8Oylzw

https://www.youtube.com/watch?v=ztM7_AwXJWs

https://www.youtube.com/watch?v=Na-lSM90oVA