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Fab Lab Kids: experimental workshop on manufacturing digital educational toys

Paulo Eduardo Fonseca de Campos, Heloisa Maria Domingues Neves and Alex Garcia Smith Angelo

Paulo Campos Eduardo Fonseca is an Architect and Doctor of Architecture and Urbanism. He is a professor and researcher at the School of Architecture and Urbanism of the University of São Paulo (FAUUSP) and Coordinator of the Design Program. He researches design production and contemporary architecture and its transition from traditional production systems to current digital means of manufacturing.

Heloisa Maria Domingues Neves is an Architect and Master of Communication and Semiotics. Student of *Fab Academy* of the *Center for Bits and Atoms* - MIT. She is interested in the areas of *Open Design*, Collaborative Design, Digital Manufacturing and Fab Labs.

Alex Garcia Smith Angelo is an Architect. Researcher at the School of Architecture and Urbanism of the University of São Paulo (FAUUSP). He studies the digital manufacturing technologies applied to Architecture and Design. He is interested in the inclusion of digital manufacturing and knowledge networks as part of public policies in education.

Abstract

This article describes the conceptual and theoretical process of an experimental workshop on digitally manufacturing educational toys in conjunction with the community of the city of Guarulhos. The project was coordinated by DIGI FAB (research group on digital manufacturing applied to design and architecture at FAU USP) in partnership with Fab Lab Costa Rica, Lab Fab Lima, Fab Lab Barcelona and the Department of the Environment of the city of Guarulhos. The main objective of the project was to experience learning-by-doing, network learning and learning through the use of new technologies such as manufacturing and digital electronics through the theme of environmental education. The result was satisfactory, pointing out some flaws that will be discussed in the article and treated as points to be methodologically better worked out in future activities, but mainly, the project demonstrates successes in relation to network learning and learning-by-doing, and to the clear appropriation of the workshop by the community.

Keywords: Education, Knowledge Networks, Digital Fabrication, Environment.

1. New paradigms for material production providing new ways of learning

The Technology and Information Revolution, or TIC as it is named, created new means of communication instrumentalized by a significant number of innovations such as the personal computer, the Internet, new materials, new means of production, among many other technical and scientific discoveries, creating a new kind of socialization in continuous expansion. According to Gershenfeld (2005, p. 13) we passed a threshold of this revolution that leads us to think of the binomial bits and atoms through a more fluid and permeable border, to the extent that a world of atoms is being increasingly personalized through the ever more accessible bits and machines. Faced with this, and believing that this revolution eventually also revolutionized other areas, it is important to highlight the value of the concept of networks and cooperation and of the construction of experience-based knowledge (it being understood in this experiment as experience through electronics and digital manufacturing). According to Castells (2011, p. 566):

> inclusion / exclusion in networks and the architecture of relationships between networks, enabled by information technologies that operate at the speed of light, shape functions and processes prevalent in our societies. Networks are open structures capable of expanding indefinitely, integrating new nodes, provided they can communicate within the network, i.e., share the same communication codes (for example, values and performance goals).

Based upon the network concept described above and upon the recurrent practices of TIC, we can reflect on new cooperative practices that emerge by combining knowledge networks with digital manufacturing. This alliance enables us to exchange information and the fast and accurate materialization of digitally shared solutions. The focus is not only on the improvement of virtual environments, but on a balance between the virtual network and possibilities of materialization. According to Gershenfeld (2005, p. 18), it will be through digital manufacturing that we will make tangible the virtual worlds we create.

Continuing a step further, we can say that this paradigm shift also changes the way one can absorb knowledge. The set of digital techniques available for network communication and manufacturing could provide feedback between theory and practice, learning-by-doing, simply proposing an intellectualist and individualistic nature of knowledge, but a process that takes place in the relations between subject and world, being relationships of transformations resulting from the balance between cooperation and realization of knowledge. Given this, it is believed to be possible and desirable to form technical knowledge networks that have as an assumption and commitment the spread of a new kind of knowledge, which is embodied through the materialization of solutions with the use of digital manufacturing. For this to happen, projects of this nature emerge, in an effort to understand the limits and benefits that these technologies together can offer us in terms of innovation.

Within this framework lies a workshop held by us, and whose results are presented in this article. Briefly, we strove to make it such that the concepts discussed above could be implemented through a group of students who for one day received information about digital manufacturing, electronics and the reuse of wood, in order to build for themselves an educational trash bin/toy coupled with an electronic counter, which in turn aims to quantify objects to be stored to be recycled. Among the processes presented to students, we can cite: collaboration and virtual learning, object customization, the visualization of a process of milling wood in a CNC machine (computer numerical control) and the soldering of components on circuit boards.

2. Knowledge networks grounded in a new way of teaching

The Fab Lab Kids project carried out in Brazil is the result of a larger project that is configured in open networks of information and knowledge. It is part of one of the Fab Lab network projects. Fab Lab is an abbreviation for fabrication laboratories, which are present in many countries around the world. They have a more conceptual foundation, since the project was born at MIT (the Massachusetts Institute of Technology)[1]. Within the network, there are some collaborative projects and a number of initiatives for the exchange of projects and experiences among the labs. The labs around the world, through a common system of video conferencing used in meetings, training and day to day in laboratories, are regularly in contact with each other to exchange experiences. Each Fab Lab has an locally defined emphasis according to local problems. In India, for example, there are projects to develop electronic panels that facilitate the generation of energy, while in Costa Rica there are plans for solving problems related to wireless Internet technology for agriculture, education and medical production[2]. Some Fab Labs are open for the public to produce their objects, as well as for professionals who want to develop products. Brazil has been gradually including itself in this network and soon intends to have its first ever Fab Lab installed. The Fab Kids project, the experiment in question in this article, is envisioned as a first step to implementing this partnership.

Thus explained, therefore, the connection between those involved, we will cite the following three closest partners in the formation of the network that was assembled for the Fab Lab Kids Guarulhos experience.

2.1 The Fab Lab Kids project by Fab Lab Barcelona

[1] Site "Center for Bits and Atoms": http://cba.mit.edu/.

[2] Site with list of Fab Labs : http://fab.cba.mit.edu/about/labs/

Fab Lab Barcelona[3], linked to the Institute for Advanced Architecture of Catalonia – IaaC, is now one of the leading digital manufacturing laboratories taking part in the worldwide Fab Lab network. Fab Lab Kids, created by Fab Lab Barcelona, is an open project with activities for children and young people 10 to 16 years old. In the laboratory, for two and a half hours a week, groups of children and young people, separated by age, develop with the support of chaperones, activities aimed at awakening creativity and designing innovative products. In short, we seek to highlight the need to invent, to create something that has to do with human development. Children have more unimpeded creative ability to invent, and creativity is closely linked to their emotions, and therefore their development can increase personal growth and the expansion of their talents. According to its creators, Fab Lab Kids is a creative laboratory that promotes the development of intelligence, creativity and imagination of children and youth. It is a place to stimulate thought and where innovation takes place, a place where educational and recreational activities for children and adolescents are performed with a focus on design and digital manufacturing[4].

2.2 The "Construction and Learning Camps" project by Fab Lab Costa Rica/Lutec

Under the guidance of Professor Milton Villegas-Lemus, Fab Lab, Costa Rica or Lutec Luthiers de la Tecnología was created in the 2000s, headquartered in the second-largest public university in that country, the TEC-Technological Institute of Costa Rica[5] (Instituto Tecnológico de Costa Rica) in the city of Cartago. Villegas-Lemus (2011, sp) defines as one of the foundations of his thought "recursive constructivism", which is the union of two concepts, one from the area of sociology and the other from the area of computation, and he still defines the laboratory activities directed at children as follows:

> Construction and Learning Camps are initiatives within and outside the university, in schools and rural communities, with children aged 9 to 11. Student volunteers are encouraged to participate in the project. In these Construction and Learning Camps, children create their own toy designs and also develop product prototypes. (Lemus-Villegas, 2011, S.P.)

Lemus-Villegas concludes affirming that after years of experience with the Camps, he came to the conclusion that the best way to seek an alternative to the traditional educational structure would be to implement a program that would attend to the children after school hours, incorporating as a main part of the method proposed the idea that the students themselves would present their projects to parents and to the university students who monitor the program.

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[3] Site "FabLab BCN": http://fablabbcn.org/

[4] Site "Fab Lab Kids": www.fablabkids.org/programa-2009-2010/

[5] Site "TEC Tecnológico de Costa Rica": http://www.tec.ac.cr

2.3 Fab Lab Lima, the garbage bin/educational toy project

The designer of the garbage bin/educational toy is the designer and director of Fab Lab Lima, Victor Freundt. One of his lines of research is the development of children's characters based on popular culture and the intelligent and creative use of technology by children, encouraging them to create their own toys and games.

The "Tacho" family, a name given by the designer to the line drawings created in the workshop, was chosen to encourage new and unusual student designs for objects for children, and also so that students become familiar with processes of collaboration and personalization.

3. The Fab Lab Kids pilot Project – experimental digital toy manufacturing workshop by the City of Guarulhos

Based in the theory outlined above and guided by the case studies already carried out in Barcelona and Costa Rica, the Fab Lab Kids Workshop emerged. As a proposed methodology, we decided to extensively employ the concept of collaboration through a partnership with Fab Lab Costa Rica, which actively participated in and throughout the workshop, exhibiting their projects for the Guarulhos students, helping them with the difficulties encountered and making final comments on the projects undertaken. The objective of this networking was to mitigate geographic and cultural barriers, which might somehow contribute to broader learning. Moreover, the Costa Rica group has extensive experience with the workshop and we all learned from them in one way or another. With respect to Barcelona, the relationship was more to understand how the project is done and how we engage students pedagogically with the topic of digital manufacturing and electronics, although we also benefitted from the online participation of the coordinator of that program. For its part, the cooperation with Fab Lab Lima occurred with the goal of participating in the project[6] developed by Victor Freundt, who provided us the base drawings of the garbage bin/educational toys (which we explain in detail below) so the children could personalize and adapt them so they could be implemented with the digital counter (also better explained later).

The immediate objective of the workshop was to introduce to a group of 18 children, between 7 and 12 years old from the city of Guarulhos, environmental issues and their possible connection with the use of electronics and digital manufacturing. In turn, it can be said that the workshop had as a main purpose the encouragement of creativity, thought, innovation and

[6] Victor Freundt : http://fablabbcn.org/2011/10/victor-Freundt-graduado-en-el-fab-academy-barcelona-gana-premios-de-diseno-e-innovacion-en-peru/

idea exchange with other Latin American cultures, as well as providing practical experience in group work.

On the part of the researchers who conducted the workshop, the inclusion of digital manufacturing as part of public educational policy is one of the objects of study of the Research Group DIGI FAB from the Faculty of Architecture and Urbanism of the University of São Paulo which investigates, among other issues, the implementation of educational and cultural initiatives through digital manufacturing tools. From the initiative of that research group, in collaboration with other laboratories in the worldwide Fab Lab network and in the best interests of the Municipality of Guarulhos, in addition to private sector companies, it was possible to conduct the pilot project. The event was held in December 2011 at the Virgínia Ranalli Environmental Education Center (Centro de Educação Ambiental Virgínia Ranalli), on a Saturday from 9:00 to 18:00, and included local facilitators and participants via Skype (monitors and small presentations).

Figure 1. Poster presentation of the project. Source: Authors.

3.1. The ecological garbage bin made of recycled wood.

The object developed by the students was "Tacho", a garbage bin/ wooden toy, sent by the project coordinator of Fab Lab Lima especially for the workshop, so that in this first stage children could have access to an object to be customized and which made use of digital manufacturing techniques. Because we had a very short time for the workshop, children did not witness the whole process of cutting the pieces, receiving the pre-cut parts and having them personalized and mounted. However, during a break, a technician fabricated a part of the trash bin in front of students and answered questions that emerged, showing how the

parts were manufactured from the digital design to the sending of the file to the CNC milling machine.

Figure 2. CNC milling machine demonstration, author's photo. Source: Authors.

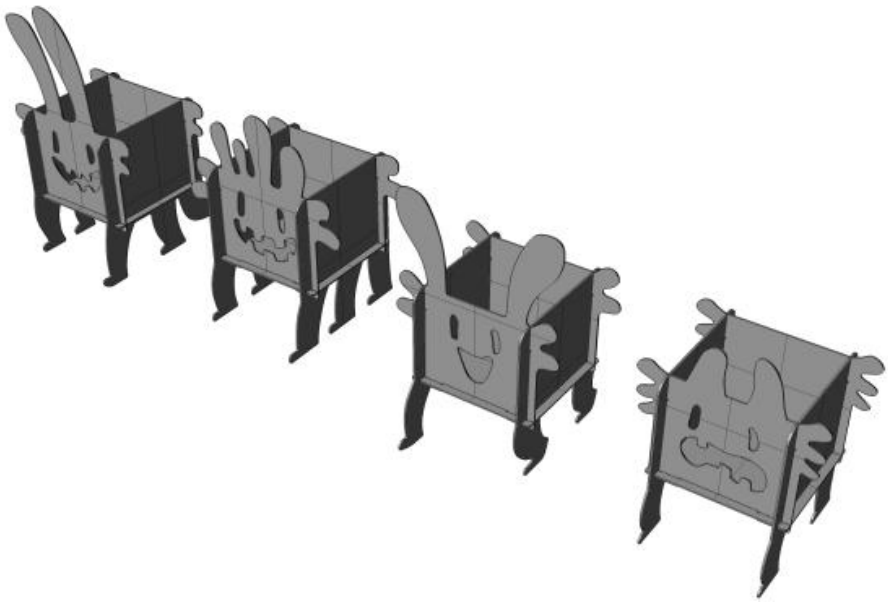

Figure 3. Types of garbage bins, designed in Rhinocerus/McNeel (designer Victor Freundt). Source: Authors.

The wood used was extracted from raw timber, donated by the Ecological Sawmill of the City of Guarulhos and converted into sheets. This process was also shown to children through pictures.

Figure 4. Ecological Sawmill of the City of Guarulhos, 2011. Source: PMG.

The wooden sheets were then delivered to the company responsible for its CNC cutting, already in the digital manufacturing step of the process. Digital files containing the parametric garbage bin designs, for manufacturing, were sent by Fab Lab Lima.

Figure 5. CNC technoflexorouters. Source: Authors.

Figure 6. "Raw" timber and the ecological garbage bin. Source: Authors.

Figure 7. Fully assembled garbage bin. Source: Authors.

3.2 Fab Lab Costa Rica's/Lutec's Electronic Kits

Kits containing electronic components and circuit boards, to be assembled by children in this first workshop, were developed and submitted by Fab Lab Costa Rica/TEC-Technological of Costa Rica - LuTec, under the supervision of Prof. Milton Villegas-Lemus. These electronic components are the same used in the Construction and Learning Camps developed in Costa

Rica, as already mentioned. The kits are made up of circuit modules with a digital counter and a light sensor. Attached to these modules were batteries, LEDs and cables that children at a workshop set up by welding and simple fittings.

The general principle of operation of the electronic components installed in the Ecological Garbage Bin, after assembly by children, consisted in the activation of a digital counter, such that an object falling into basket would interrupt the beam of light between the LED and the light sensor.

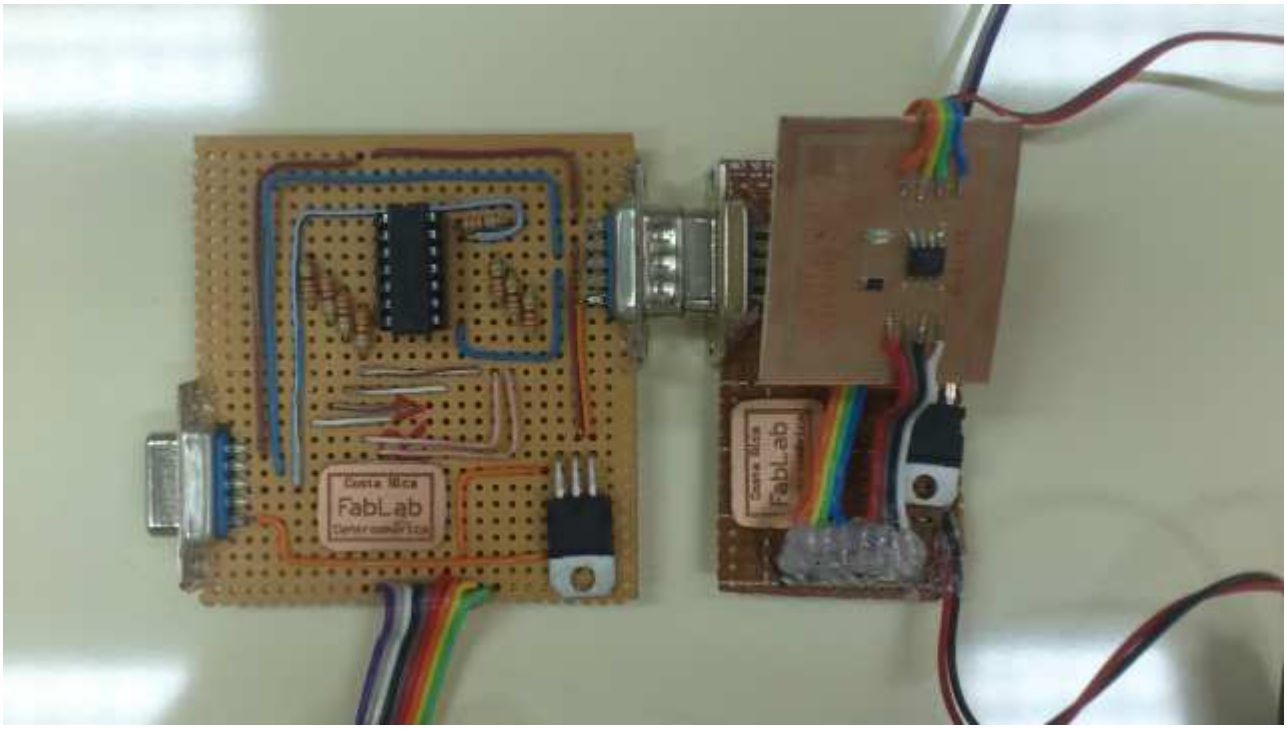

Figura 8. Electronic kits sent by Fab Lab Costa Rica. Source: Authors.

3.3 The Workshop

After a brief initial presentation of the dynamics of the workshop by members of the Department of the Environment, from the USP Department of Architecture and Urbanism and Fab Lab Barcelona, whose contribution was effected by video conference, the children began to customize their Ecological Garbage Bins. Each group of children adopted a tutor in Costa Rica, responsible for their guidance and monitoring by video conference.

Figure 9. Students introducing themselves to Fab Lab Costa Rica. Source: Authors.

Figure 10. Personalization of the Ecological Garbage Bin/Toy. Source: Authors.

Figure 11. Personalization of the Ecological Garbage Bin/Toy. Source: Authors.

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Figure 12. Personalization of the Ecological Garbage Bin/Toy. Source: Authors.

Figure 13. Presentation for the tutors from FAB LAB Costa Rica. Source: Authors.

After customizing the project, the children assembled the garbage bins and began the assembly of electronic components. The children assembled, welded and tested the operation of each electronic module presented by Lutec staff from Costa Rica, under the supervision of

local facilitators. The assembly of the kits involved the direct participation of the Costa Rica team, who explained step by step how to assemble the kits by video conference, assisted by two cameras to capture the different angles for better understanding of the operation. Meanwhile, the facilitators from the DIGI FAB USP Group and Fab Lab Lima's Professor Benito Juarez coordinated each group.

Figure 14. An (electronic) instance of learning-by-doing. Source: Authors.

Figure 15. An (electronic) instance of learning-by-doing. Source: Authors.

Figure 16. An (electronic) instance of learning-by-doing. Source: Authors.

Figure 17. An (electronic) instance of learning-by-doing, with functioning modules and the garbage bins in the background. Source: Authors.

Figure 18. Customized garbage bin/toy without the electronic kits. Source: Authors.

For a better student understanding of the project as a whole, there would be a joint discussion in the classroom on how best to engage the device in the trash bin/toy. However, with the short time remaining and the workshop's late schedule, we did not have the joining of parts necessary to synthesize the various components of the workshop into a single project. There was only a brief finalization made by the Brazilian and Costa Rican organizers.

5. Reflections on the Pilot Project

The workshop had a positive result as it fulfilled its main objective, which was to try to learn by doing, network learning and learning through the use of new technologies such as manufacturing and digital electronics. The project also had a positive impact on the

municipality of Guarulhos, winning the first prize for Best Citizen Technology in 2011 from the Department of Information Technology of the city of Guarulhos[7].

As points to be further elaborated in the upcoming workshops, we can say that despite the proposed thematic approaches: digital manufacturing, electronics, environment and education through knowledge networks, experience has demonstrated the clear importance of the further development of techniques for integrating technology into the creative process, since the customization and assembly of the kits afforded technical learning, but did not met the expectations of in-depth creative learning. Campos (2005 apud Campos, 2011, p.101) teaches us that:

> Papert seeks to draw our attention to the fact that if you dive into learning situations rather than look at them from a distance, if we have a greater connectivity with them rather than being separate, they become powerful for our learning. Involvement, the full self-application to what we are learning is, in theory, the key to real learning.

In a further evaluation, the experience of the workshop was not fully complete in that there was no direct participation of children in the development of the object, that is, if there had been direct interaction providing a problem, or conditions for the discovery of one and encouraging its solution through technological tools, the activity would offer greater scientific gains for students, again citing Campos (2008, pp.13-14)

> It is noteworthy that the action of the trainer, regarding the difficulties of his apprentice in computing environments, requires intense planning, based on consideration of all stages, where the trainer/developer acts on the questions of students, promoting the autonomy of new knowledge construction relating to the problem in question. We mean that when using technology as a mediator, we must plan its use in a way that enables students to build knowledge, not only through the computer, but through the relationships established with colleagues, teachers and all possible sources of knowledge.

And in a reflection on the role of computers in this process, Blikstein (2011, p. 11) teaches us that:

> And given the complexity of science and industry today, those who do not know how live in cognitive symbiosis with machinery (and their networks) will not have much chance of surviving. This is exactly where the computer comes into education. Forget the computer as an Internet access terminal. Forget the computer as a multimedia machine. The true value of computers in education is to enable students to create models – i.e., to learn science as science is done today.

In this theoretical and practical context, successful experiences and saving for structural and conceptual comparisons, the workshop lacked in that it did not allow a greater creative interaction among students. However, these identified faults will lead us to improvements for future activities, since the cornerstone was laid and this ended up creating an open field for

[7] Site: http://www.telecidadania.blogspot.com.br/

experimentation on the themes described above, and in a manner much closer to the community, thus leaving the strictly academic world – a world in which we understand the university to reside.

Video 1: http://vimeo.com/33193676

Video 2: http://www.youtube.com/watch?v=x8_FIiOjGqs

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