74. Sustainability and Fabrication Laboratory applied to Architecture: Neil A. Gershenfeld and How to Make (Almost) Anything.

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Abstract Communication addresses the issue of 'The Digital Fabrication Revolution' postulated by Neil A. Gershenfeld. The objectives pursued are basically two: 1. Analyze the new 'teaching contents' of a Fablab, with such powerful tools like Arduino regarding prototyping as well as the practical application of them in sustainable architecture and 2. Analyze methodology of these new spaces and its impact on teaching Architecture. To do this, we reflect on the present and future potential of the growing network of laboratories scattered throughout the world digital manufacturing. It is reveal or clarify the success of a formula that involves building "almost everything" also sustainable architecture, technology base, and to establish relations with a current focus of Smart Cities. The main consideration is to analyze, in a special way, the impact of these new approaches in the formation of future architect associated such training both collective production, as educational resources come into play, given that it is a global phenomenon, with a network of about 60 official centers in the world. On the other hand, the research seeks to highlight the importance of machines in relation to the present and the future of sustainable societies, with the premise that cities of the future will be built primarily by machines, as a step in the prefabrication constructive.

Keywords Gershenfeld, Prototipado CAD/CAM, *Open Hardware*, Arduino.

1 Introduction

One of the first milestones of technological innovation is the proposal first pro-set personal computer called Memex. Its architect was the engineer and scientist American Vannevar Bush, who in his article titled As We May Think, published in 1945 in The Atlantic Monthly, proposed a dispositi-vo electromechanical which he called Memex and had previously developed at MIT as photoelectric technology model microfilm. It was a mechanized warehouse of information that "exten-

ded memory", hence its name, consisting of a desk with a keyboard and a series of levers and could be consulted quickly and flexibly. Other important milestones that help better understand the technological revolution of recent decades are the creation of MIT`s Architecture Machine Group (1967) of the hand of N. Negroponte and L. Groiser, and the subsequent founding of the MIT Media Lab (1985) by N. Negroponte, along with Jerome B. Wiesner.

Somewhat later, in 1998, Neil A. Gershenfeld, director of MIT's Center for Bits and Atoms, raised customization manufacturing with its already famous maxim How to Make (Almost) Anything addressed to an interdisciplinary group of students. Later he created in 2001 the first Fab Lab at MIT, in collaboration with Bakhtiar Mikhak, The current network of Fab Labs scattered around the globe come to address the need of emerging technologies in remote and less developed countries, where people resource-poor they can improve their quality of life. The promotion of citizen innovation, in order to transform reality and promote greater social inclusion, begins to consider, increasingly, as an objective of sustainability at the international political level and in recent years very prominently in speaking countries Hispanic, but also, increasingly, in companies and universities as well as in numerous regional and national public administrations.

In this sense, digital technologies enable self-organization networking and promoting the development of collective intelligence, both locally and globally. This utopian active community participation prefigures thus a proactive citizen profile, immersed in articulated network and require greater collaboration by fostering synergies communities, but also promo-watching generation of collaborative platforms. The distinctive feature of these is-spaces of collaborative work (incubators, hubs or citizens laboratories) is the commitment to research and innovation, the hand of digital technologies and Web 2.0, with an organizational approach bottom-up, from bottom up, although having the philanthropic collaboration of both public and private companies. This facilitates the co-production as an engine of social transformation as recommended in the Oslo Manual (Anon 2006) bringing together people with varying degrees of expertise and promoting horizontal and inclusive contexts, whose greatest interest lies in the number and diversity of participants, such as medialabs, citilabs or li-ving lab, among others.

It is open space in which citizens engage in innovation projects and not in places for the exclusive use of experts, given that bring together people with different disciplinary orientations in a shared learning process. As far precedents can be cited the Homebrew Computer Club 1975 (Faggin et al. 1976) or the MIT Media Lab (MIT), founded in 1985, with later labs like MindLab in Denmark or MediaLab Prado and BarcelonaLab in Spain.

In these participatory and open spaces characterized by self-management, mutual support and collaboration and in which the use of hardware and free software, shared repositories and free licenses is encouraged, lines of work of interest arise for community are based on networks of exchange and in which user profiles are choosing between art, technology and science. For example, international networks unconferences or unconferences like BarCamp, involve a model conference

open space that is used primarily in communities of technological innovation. Another example of innovation is the use of concise presentations format 20 x 20 PechaKucha maintaining a high interest of participants.

2 Media Lab model

Technological innovation in the context of the Europe 2020 strategy (Cal Barredo 2011), with examples like the Transcreativa project (SUDOE 2014), addresses the need for prototyping through technological mapping, prototype development and job creation for young, for the sake of achieving smart, sustainable and inclusive growth that fosters scientific excellence, industrial leadership and societal challenges (Rosenberg 2000) and all this also in relation to higher education (Anon 2015b). In this regard, R & D + i promotes concepts such as Behaviour or Social Technologies Mining in CCIs (ICC) medinate collaboration and networking.

Media labs or Media Labs, with a genealogical history of more than three decades, are places of surgi-two in a row of the technological revolution (Villar Allé 2014) that combines media and digital technology cultural and interdisciplinary cooperation. Thus, the term Lab renders obsolete the traditional terms of workshop or studio. However, despite the dis-course community or collaborative art, emerged in the late sixties, was especially critical with the individual or subjective art, processes of collaborative work do not always achieve the objectives of group interaction or open to the public sphere and enable the sharing of artistic experience. Thus, the relations between art, science and new media is evident in the so-called Electronic Art, a generic label that encompasses others such as Computer art (Cheok 2010), Algorithmic art (Shanken 2002), Generative art (Oliver Gingrich 2012), Cybernetic art, Kinetic art, etc. In this respect it should be mentioned as milestones the Cybernetic Serendipity exhibition held in London in 1968 and Les Immatériauxs (Blistène 1985), held in Paris in 1985.

Regarding a possible classification of centers Media Labs, one can speak of four main types: professional character cultural, civic, academic and. Among the former include the ZKM (Karlsruhe, Germany), place that was organized in 2005 the exhibition Making Things Public (Nielsen 2005), in which new forms of citizen participation dealt with a parallel project basis Internet data entitled "Fair Assembly" devised by Steve Dietz. In the typology of Media Lab civic MedialabPrado (Prada 2009) Madrid highlights, in which projects are approached from different optics training, creation and dissemination.

Also with a cultural approach include the Floating Lab Collective`s Re Museum (Corbett 2008) in Washington, with the collaboration of various communi-ties that bring their projects in esperimentales spaces open to multiple disciplines.

3 Maker Lab and Fab Lab

The Maker Lab and Fab Lab are prototyping laboratories. In the case of Fablab the figure of the manager is essential to get the in-ternational connection thereof (Eychenne & Neves 2013). A Fab Lab or Fabrication La-boratory is a laboratory prototype of physical objects embedded in a worldwide network of Fab Labs distributed worldwide (Anon 2009) and agglutinated in the Fab Foundation, it created last by MIT's Center for Bits & Atoms Fab Lab Program.

The realization of prototypes required skills of ELECTRONI-ca and CAD / CAM by users Fablab. Besides physical machines, the biggest attraction of these areas is the proposed opening to the world, with free access and low fares and collaborative work or peer (peer-to-peer) web 2.0. The first laboratory of its kind, the Center for Bits and Atoms (CBA) was founded in 2001 within the MIT by the National Science Foundation (NSF) and directed by Neil A. Gershenfeld. It was an ambitious research center whose primary objective was the digital revolution, namely personal digital manufacturing, looking democratizing new technologies by machines capable of producing anything at any scale.

Its important international diffusion makes the Fab Labs collaborative innovation platforms that facilitate the connection between people and organizations. On the other hand, the idea of digital technology laboratory is associated to advanced users, although the term Lab is also associated with the use of Information Technology and Communication at the Media Lab (Oliver 2001) concept goes to nominate at expresses media laboratories. Gershenfeld raised the proposal digital manufacturing (Gershenfeld 2008), with the precedent of the Media Lab (Brand & Gubern 1989), as an alternative to the purchase of existing objects and the consequent technological and social implications of this idea entails, that of " . how to make (almost) everything "with tools used in CAD-CAM the author highlights the difficulties of experimental Labs Fab in places like Ghana and India, to try to make too expensive tools or are not available, all with help from . software open streaming through the network code However, there are many types derived from this first laboratory model, and include other labels, among which the most related to architecture are the Living lab (Liedtke et al, 2012), City Lab (Andersen & Eidhammer 2015). in all cases emphasize explicitly the aforementioned ideas collective work (Hardin 2010), self-organization and commons in active participation and collaborative highlighting the ideas of altruism and human cooperation.

Thus, the power Fablab philosophy a methodology that energizes innovative and multidisciplinary projects with potential to market their services. On the other hand, networking plays a key role in the exchange of ideas or bit of information. The prototype, the central element of pro-innovation process involves a direct and rapid experimentation, which tra-duce cost savings. In addition, collaborative and interdisciplinary work is going associated with the complexity of a project, which may involve different user profiles with different approaches or strategies, what has been called 'collective intelligence'. An additional attraction is the degree of realism of the proposals or their proximity to the actual demand of society, enhancing the exposure of manufactured products.

For the specific case of the Fab Lab ETSA Sevilla, with like-minded architects

like Santiago Cirugeda (Cirugeda 2007), it is expressed the concern about being at the height of the times. In this sense, the trajectory Fab Lab is illustrated by the example of fabbing CC Project in 2011 with the collaboration of the City of Caceres in the Ribera del Marco Plan program. The banking pergola image was also designed from sketches of the residents of the area and is intended as a framework for urban gardens. This is just one example among the many projects of digital manufacturing Fab Lab Sevilla (Pérez de Lama Falcon et al. 2014) and the Center for Innovation and Design (IND) of the School of Architecture of Seville (Gutiérrez Rueda García et al. 2010). Another project of great interest is entitled The Caterpillar (Narvaez Pastor Rodriguez & Martin 2013), a caterpillar pavilion made in 2013 and has been followed in the Archimedean Pavilion 2016 (Fig.1).

Fig. 1 *Archimedean Pavilion* (2016). Project FabLab Sevilla. Photograph of the author.

On the other hand, in the spaces Fab Lab and continuing in the specific field of architecture, arise, for example, product design ephemeral and new forms of interpretation of furniture, both indoor and urban architecture, while digital manufacturing aid just as design nteractivos or smart environments such as proposals bioclimatic houses. With open as Arduino (Fig. 2), a platform Open Hardware based on a plate with a microcontroller that has, for example, sensor modules environmental parameters standards. On the other hand, the development environment Arduino facilitates use of electronics in multidisciplinary projects in which communities share code running electronic routines; thus, the electronics is incorporated into the manufactured prototypes, which are equipped with electronic circuits which simulate movement.

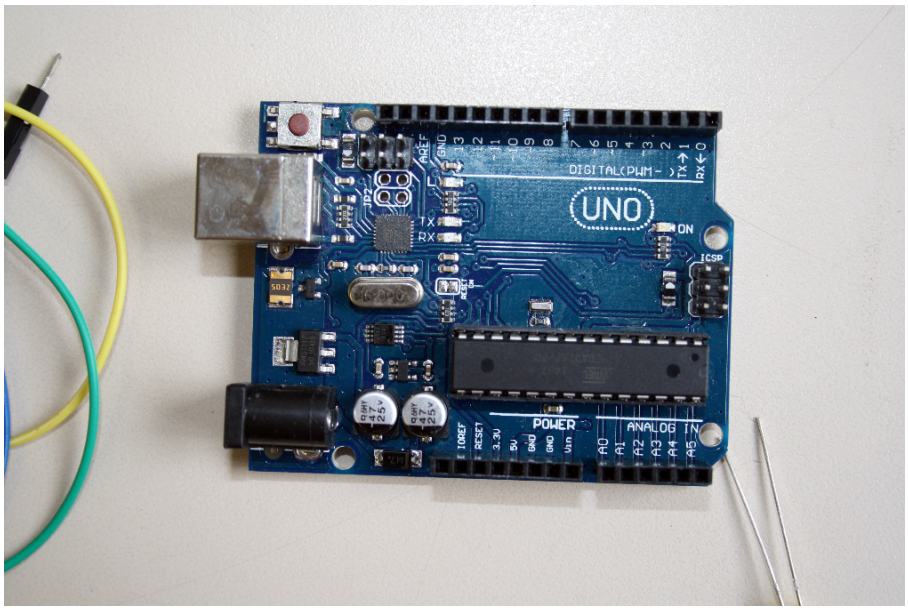

Fig. 2 Open Hardware Arduino. Photograph of the author.

So, thanks to the open manufacturing convergence between electronics and computing enables electronic devices to build non-expert users. The integrated development environment is free to download Arduino, which is the advantage of the use and development without license. Examples of pro-projects that can be addressed are related to renewable energy proposals, interactive street furniture or security devices. Thus, in the field of home automation, hand electronics, Arduino design can help improve the energy efficiency of domestic households (Sack 2006). In this regard, automation is particularly relevant in the case of elderly or physically disabled or diminished cognitive abilities people, which certainly contributes to improving the quality of life and greater autonomy.

On the other hand, there are many proposals of ephemeral architecture or limited, such as structures for faith-rias stands or events, made with cheap materials (Minguet 2005) and nove-dosos designs useful life. In the same line could be cited, for example, the design of furniture from recycled material (Pario Perra & Gandolfi 2011). Another facet is the generation of 2D nanoarchitecture or small-format pieces obtained from cutting machine CNC, which are then assembled to generate 3D structures larger. cardboard, wood, plastic, metal, PVC, etc., from the point of view of materials, a wide range is approached In another vein, play a key role events related to both meetings as participatory and dynamic digital manufacturing workshops and training courses in 3D design, prototyping, cutting techniques or electronics.

4 Living Lab, City Lab y sostenibilidad

The term Living Lab appears closely associated with W. J. Mitchell (Mitchell & Valderrama 2000) with its Smart City (Mitchell 2007) project and there is also a European Network of Living Labs (Almirall 2006). It is within the MIT where Professor Mitchell (Mitchell 1997) raised a research methodology and validation of prototypes of various intelli-people houses looking for the interaction of users with sensors on re-signal environments and putting information technology and communications at the service of citizens (Mitchell 2003).

The growing problem of overpopulation of cities (Falconer & Mitchell 2012) involves efficiently resolve the problem of infrastruc-tures supply of cities in a chord urban planning with the Age of Big Data (Offenhuber & Ratti 2014). On the other hand, it is Nece-sary develop sustainability strategies seeking urban planning respectful with the environment (Anon 2015a), taking advantage of information technology and communications to improve the quality of life and reduce costs. The controversial concept of Smart Cities and Smart Communities Online (Lopezmalo 2012) has led to numerous theoretical discussions in political circles of urban planning worldwide since the technology is not well understood in all sectors that make up the city. The multiplicity of stakeholders in the complexity of the functioning of cities generate interdependencies that determine the built result. By contrast, smart cities, articulated as complex systems with multiple layers, are an opportunity to integrate the infrastructure of the city to raise effective management with strong economic, social and environmental impacts (Tanzer & Longoria 2007).

Later the idea spread to different countries, especially in northern Europe (Keiding et al. 2009). He began to apply to other in-lathes as mobile services or various projects between univer-sities and companies and based on the search for innovation and quality of services to citizens as I2CAT (I2CAT 2015) in Catalonia or Testbed Botnia (Almirall et al., 2012) in Sweden. On the other hand, the Multistakeholder supposed participation in the process of different actors in the value chain, as a networking process made from equal. On the other hand, validation of products is done in multicontextos (Villar Alé 2015) and in real environments, so users are the real protagonists of innovation projects, the latter understood as a social process.

Scientific and technological parks assume innovation policy, although they are in need of a critical mass to take an innovation much more focused on the user. This is especially true with the use of information technology and communications, and the aim of achieving the convergence of technology, market and society. In this regard, the Living Lab is carried out both validation and development cycle of a product or service based on cooperation and emergertes multiple environments and interdisciplinarity.

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