DOI: http://dx.doi.org/10.5007/1807-0221.2017v14n26p152

Extensio UFSC | Revista Eletrônica de Extensão

FABLAB PRONTO3D: LEARNING WITH PRACTICE

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Abstract
The recent development and use of digital fabrication techniques for architecture, product design, engineering, construction, among many others, has caused impact changes on design processes since its beginning until final construction. New construction methods have been developed with the use of those new techniques, spreading many ways of possibilities hardly achieved before. Nowadays, spaces called FABLABs offer a range of procedures and equipment that provide the manufacture of scale models, prototypes or final elements in different fidelity degrees. This paper shows the possibilities and activities being implemented, with the use of technology, at PRONTO3D - Prototyping and New 3D Oriented Technology Laboratory, at UFSC, that belongs to PRONTO3D Network Labs, in Santa Catarina State, since 2013.
Keywords: Digital Fabrication. Materialization. Design Process.

FABLAB PRONTO3D: APRENDENDO COM A PRÁTICA

Resumo
O recente desenvolvimento e utilização de técnicas de fabricação digital para a arquitetura, design, engenharias, construção, dentre outras, têm causado mudanças de impacto no processo de projeto desde seu início até sua construção final. Novos métodos de construção estão sendo desenvolvidos com o uso dessas novas técnicas, abrindo um leque de possibilidades dificilmente alcançadas anteriormente. Espaços nomeados como FABLAB's hoje, oferecem uma gama de técnicas, procedimentos e equipamentos que proporcionam a execução de modelos, protótipos ou elementos finais em diferentes graus de fidelidade. Este artigo mostra as possibilidades e atividades executadas, com base nestas tecnologias, no PRONTO3D – Laboratório de Prototipagem e Novas Tecnologias Orientadas ao 3D, na UFSC, que faz parte da Rede PRONTO3D, no estado de Santa Catarina, desde 2013.
Palavras-chave: Fabricação Digital. Materialização. Prática Projetual.

FABLAB PRONTO3D: APRENDIENDO CON LA PRÁCTICA

Resumen
El reciente desarrollo y utilización de técnicas de fabricación digital para la arquitectura, diseño, ingenierías, construcción, entre otras, han causado cambios de impacto en el proceso de diseño desde su inicio hasta su construcción final. Los nuevos métodos de construcción se están desarrollando con el uso de estas nuevas técnicas, abriendo un abanico de posibilidades jamás alcanzadas anteriormente. Espacios nombrados como FABLAB's hoy, ofrecen una gama de técnicas, procedimientos y equipos que proporcionan la ejecución de modelos, prototipos o elementos finales en diferentes grados de fidelidad. Este artículo muestra las posibilidades y actividades ejecutadas, basándose en estas tecnologías, en el PRONTO3D - Laboratorio de Prototipado y Nuevas Tecnologías Orientadas al 3D, en la UFSC, que forma parte de la Red PRONTO3D, en el estado de Santa Catarina, desde 2013.
Palavras clave: Digital Manufacturing. Materialización. Práctica Proyectuala.

INTRODUCTION

Since the introduction of computational tools in architectural, industrial design and engineering design processes in the 1980s, a real revolution in the way of thinking, creating, producing, and manufacturing has been completing every decade. The first CAD (Computer Aided Design) systems had the noble mission of two-dimensional (2D) representation and three-dimensional (3D) modeling, in which visualization was the major justification for using this new technology. For several years, design practices that involved the use of mock-ups or scale models were replaced by virtual tours and walk-throughs with textures, scenery, vegetation, and people that filled the eyes of students, professionals, and customers. As a result, project exploration and understanding skills were quickly assimilated and improved, and the execution of physical models became increasingly disused.

However, facing the need of editing or manipulation of design, the rearrangement processes for new visualizations were often delayed, due to a lack of 1) support and interaction by CAD software and 2) programming experience of professionals. In addition, the 2D-3D-2D connection was not fully supported or facilitated; software were more of an electronic drawing board than proper a design aid.

By the beginning of the new century, the evolution of CAD software, in terms of technology and functionality, led to the use of Parametric Design, in which user's control is more interactive, direct and conscious. Software is no longer exclusively created by programmers who have little, or any design project experience, whatever their field of expertise is, architecture, product design or engineering. The evolution of software has developed in the professional of these areas programming skills, seeking their own design needs, taking control of their actions.

Architects, for instance, use software to create complex forms that contain several information and the potential that these new technologies bring to production and design project management has revolutionized the way we produce, evaluate, manufacture and build architecture. However, this led to a moment of reassessment of the mechanisms inherent in such unbridled use (Pupo, 2009). Historically, two-dimensional drawings have been the medium of communication in architectural, engineering and industrial design projects for a long time. Even so, they are no longer considered as solutions that can guarantee a spatial understanding, both in conceptual and representation phases. The three-dimensional representation and the physical model provide a greater success in this communication, establishing proportionalities, perspectives and functionalities inherent to the project, which perhaps could not be evidenced in a virtual representation.

According to Pallasma (2013, p.15), in several areas of knowledge, "human consciousness is an embodied consciousness," which makes the human being connected to the world through all the senses. For the author, together with the prevailing architecture of the eyes, touch is understood as experimentation and understanding of the space in which one lives, where all the tactile experience is multisensory. He also complements that, in these last times of computerization, the touch is the most forgotten sense, but it is the sensorial mode that integrates the experience of the world with the individuality.

> "Even in the age of computer-aided design (CAD) and virtual simulation, traditional scale models or mock-ups are unrivaled features in the design process of a product designer or architect. The physical model or the three-dimensional model speak up with our hands and bodies as powerfully as our eyes, and the process of constructing a model simulates the process of constructing the final work "(PALLASMA, 2011, p.60).

Thus, the materialization of form helps design thinking in its full spatial totality (PALLASMA, 2011) constituting a tactile and multisensorial reality of the imagination. It is undoubtedly an experience that is embedded in an intimacy that cannot be achieved by means of electronic mockups or even any computerized simulation, simply because in these cases the surface of the monitor still has a tactile screen.

Therefore, combining the new forms of Parametric Design with the new technologies of materialization of form, architects, designers and engineers have developed new "vocabularies" not only for the final production of the products, but also for physical models, thanks to a variety of tools and techniques that have emerged to complete the traditional, empowering the entire design process. Digital Fabrication is one of them. Several techniques used in the production of physical models bring 3D modeling, produced with the advancement of software, in the transformation of virtual images to physical model. Digital Fabrication today is a great ally for a better spatial understanding, together with technologies that use raw materials such as gypsum, resins, plastics, among others, for making models, constructive elements or final pieces, in shorter deadlines when compared to traditional techniques (PUPO, 2009).

Most of architects, designers and engineers have already incorporated CAD (Computer Aided Design) as a drawing tool, now seen as common procedure even where it would not be necessary. Its extensive use has already overcome the simple representation barrier and new forms of application have been explored. The use of CAM (Computer Aided Manufacturing), which is associated with Digital Fabrication, includes heavy machinery used for the execution of constructive elements to be sent directly to construction set. This type of equipment, especially numerical control machines (CNC), were, in the past, almost exclusively used in mechanical engineering, but now have been widely used in other areas, producing constructive elements that will compose physically the idealized project.

FABLAB's

Facing all this diversity of possibilities and new interactions for design processes, as well as for the representation of form, a new concept of approaching applied technology is being explored and quickly used and assimilated worldwide. These are called FabLab's (an acronym for Fabrication Laboratories) that are spaces equipped with high technology for materialization of form, and fully accessible to any layer of society, academic or otherwise. FabLab's are laboratories that enable everyone to transform their ideas and projects into reality, with access to information and means of invention through digital fabrication.

The idea has initiated as an extension project created by Professor Neil Gershenfeld, director of the Center for Bits and Atoms of the Massachusetts Institute of Technology (MIT) in the United States. The FabLab's are currently an international community of more than 1,000 laboratories in hundreds of countries, whose objective is to share the knowledge acquired in the experiences of each unit. These laboratories also share equipment and processes, as well as digital files and solutions, thus forming a solid network for the exchange of ideas.

Each FabLab has a different focus. There are those who are more focused on solving local basic problems, working on joint projects with governments and universities, while others have a more practical approach, providing free access to machines and equipment so that everyone may develop his or her own personal project. The laboratories are MIT-certified and prepared to offer operational, educational, technical and logistical support beyond what is available in a lab, like a community resource, providing access to individuals as well as scheduling groups of any age. FabLab's have an evolving set of equipment (Figure 1) and can make (almost) anything, allowing ideas and projects to be shared across the network.

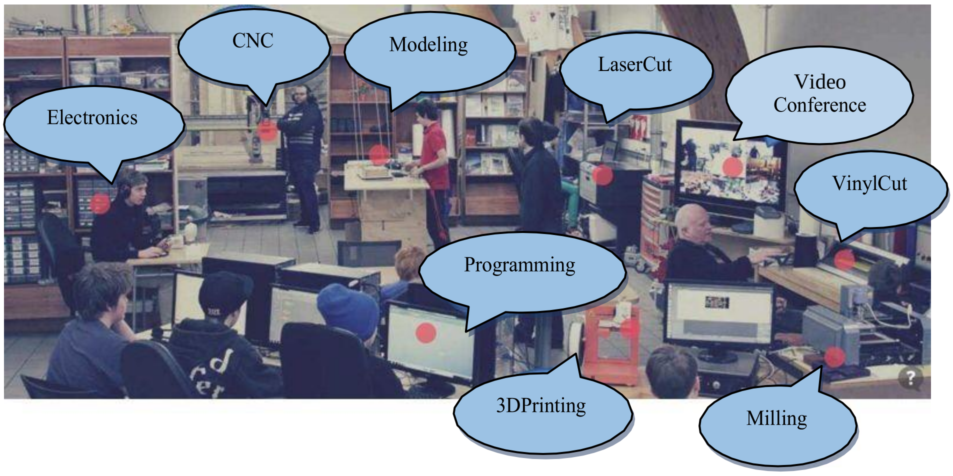

Ilustração 1 – Basic configuration of a FabLab
Fonte: Adaptation FabFoundation (2017)

PRONTO3D NETWORK

Created in 2013, PRONTO3D Network - Prototyping Laboratories and New Technologies Oriented to 3D - is a network of digital fabrication laboratories that aims structuring strategically located centers in the state of Santa Catarina, Brazil, currently with branches in the cities of Lages, Criciúma, Chapecó and Florianópolis. The implementation and financial support was from FAPESC and FINEP and each laboratory started its activities in 2013 with a 3D printer, a large CNC Reuter and a laser cutter. With the objective of attending a range of academic courses in the areas of teaching, research and extension, as well as society in general, the activities cover all areas involving the creation, development and production of models, prototypes, mock-ups and real-scale products with the use of state-of-the-art technology, helping the different stages of the design process.

The mission of PRONTO3D Network includes 5 key points: 1) To offer its researchers an appropriate infrastructure, 2) To train a team of facilitators for the dissemination of applied technology, 3) To offer incentives in the form of scholarships and internships, 4) To perform effective efficient work and 5) to provide collaborative work across the network. In order to achieve fullness in activities to which the network proposes, PRONTO3D Network labs are equipped with characteristics such as efficiency, versatility, collaboration, creativity and playfulness, which works as its DNA.

The branch in Florianopolis, which is located at UFSC, has the management of the Design course and has attended courses such as Design, Architecture, Material Engineering, Mechanics, Electrical, Museology, Physiology, Administration, among others, in the most diverse forms of action. Today, among the equipment and technologies available, the laboratory has 4 3D printers, a laser cutter, a Reuter CNC of large format (3x2m), a Reuter of subtraction and printed circuit and a thermoforming equipment (this one developed in the own laboratory). Florianópolis branch has been certified by MIT as a FabLab in January 2016 and has become part of the international network of digital fabrication laboratories since then.

MATERIAL E METHODS

This section will identify and describe some of the work developed specifically at the Florianópolis branch, at UFSC, as well as some of its activities in the fields of teaching, research and extension.

The possibility of incorporating these new means of production into the research and development of new products brings new perspectives of advances and innovation in the learning and assimilation of knowledge. The paradigm shift on the learning process is understood and based on research and experimentation. Papert's pedagogy (1991), for example, differs from traditional pedagogy when 1) emphasizes learning rather than teaching; 2) encourages personal development of the student through the construction of knowledge through research and not simply the transmission of knowledge from the teacher to the student; and 3) applies learning by making it (hands on) in their activities. This type of exploratory reasoning must be present in the minds of young researchers whose aim is to explore new possibilities and reach the creative development of innovative products and processes. And this is the dynamics of the many activities at PRONTO3D: the experimentation (Figure 2). The expression "hands on" turns the assimilation of concepts, contents, criteria and limits to be explored in a practical and playful way.

Figure 2 – Students working in their researches
Font: PRONTO3D files

Creativity is explored with the help of the technologies available in the FABLAB, which are described below.

LASER CUT

Undoubtedly, it is the most widely used technology by students and researchers because its ease of use, with two-dimensional drawings (which will be later assembled after the cuts) and for accepting a very wide range of material types. Figure 3 illustrates some works designed by students of the design course in which the design theme was "lamps", emphasizing the investigation of materials that could be used in this technology, as well as applied in lighting elements.

Figura 3 – Laser cut work
Fonte: PRONTO3D files

At the same time, the exploration of cardboard in its varied weights and textures could be tested in creating models of seat surfaces (stools), in small scale, using a design technique that can explore form, by means of interlocking. This is a technique that fits pre-designed cardboard slices and distribute them according to the thickness of the raw material. Figure 4 shows some examples of this technique, developed in PRONTO3D, using an open source AutoDesk software called 123DMake..

Figura 4: Trabalhos com a técnica *Interlocking* e corte laser em papelão
Fonte: Acervo PRONTO3D

In fashion and modeling, the use of fabrics that had a favorable performance for this purpose, could be tested in real-size models (Figure 5), using the laser cutter as a design tool and final proposition.

Figura 5: Laser cut modeling example
Fonte: PRONTO3D files

3D PRINTING

There are a variety of 3D printing technologies today, additive techniques, which segment their use for the execution of small-scale models and prototypes and can print a three-dimensional model, coming from a digital file. Some of those equipment use different materials, like (1) Selective Laser Sintering (SLS) uses laser technology to sintered powder resin, (2) Stereolithography (SLA) uses liquid resin that is sintered by laser, (3) 3DP uses gypsum powder sintered by a Binder (Glue) and 4) Fused Deposition Modeler (FDM) that uses thermoplastics (such as PLA - Polylactic Acid and ABS - Acrylonitrile Butadiene Styrene). The most widely used technique today, due to its affordable price of equipment and supplies, is FDM, which uses filaments of thermoplastics that are melted and layered to form the object. Some objects developed at PRONTO3D can be visualized in figure 6.

Figura 6 - 3D printing examples(FDM)
Fonte: PRONTO3D Files

CNC (*Computer Numeric Control*)

Subtractive technologies are those that sculpt or cut materials such as wood, polyurethane, Styrofoam, aluminum, among others, by using milling cutters from digital designs. The materialization of the shape occurs with the removal of material until the shape is obtained by CNC equipment which are numerically controlled by a computer (x, y and z coordinates). These are considered of great size equipments, with different possibilities of number of axes. PRONTO3D has two equipments of this type, one with dimensions approximately of 2 x 3m in which it is possible to obtain real-scale prototypes or even forms for later concreting, and another smaller one used to obtain printed circuit boards. Figure 7 shows some real-scale works produced in the laboratory.

Extensio: R. Eletr. de Extensão, ISSN 1807-0221 Florianópolis, v. 14, n. 26, p. 152-165, 2017.

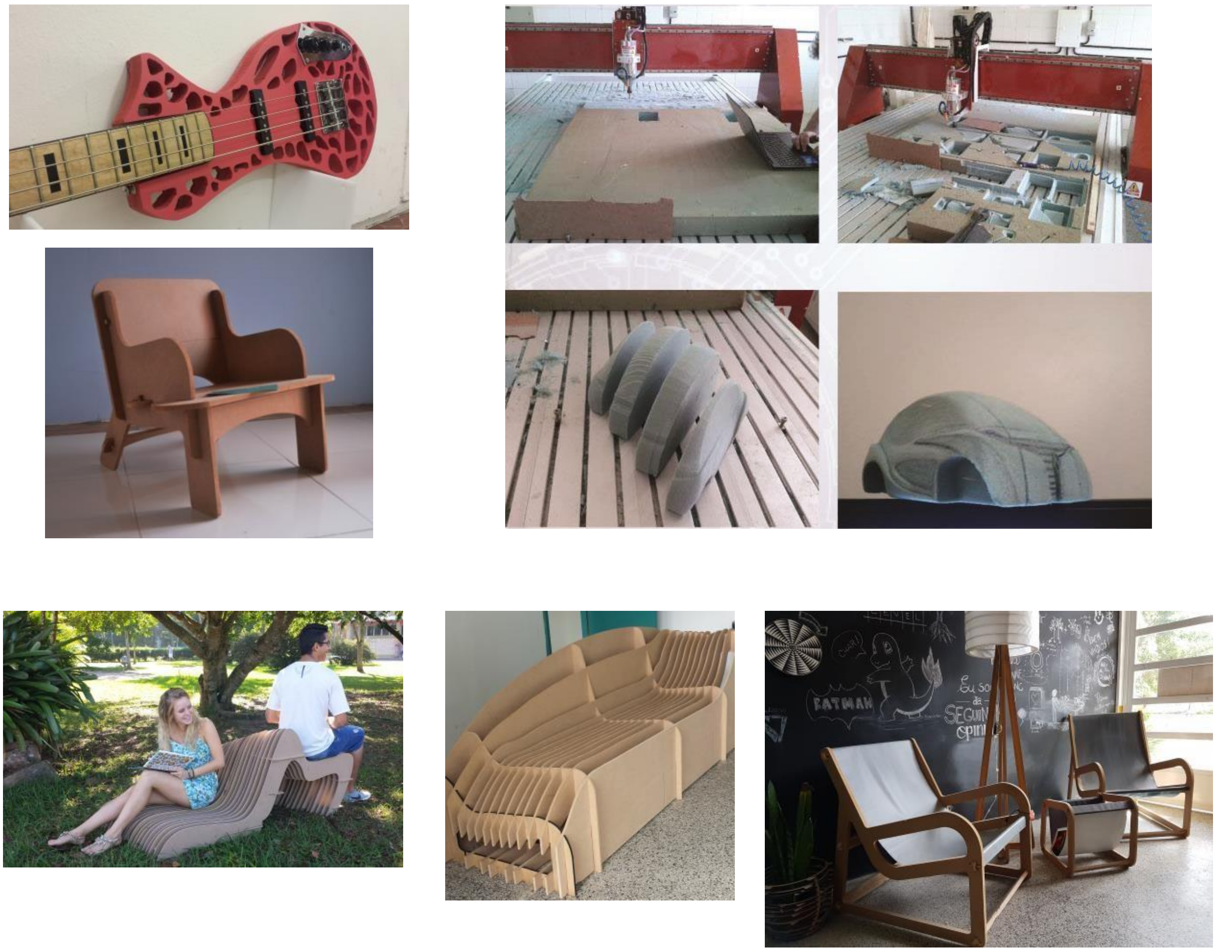

Figura 7 – CNC work
Fonte: PRONTO3D files

RESULTS AND ANALISYS

All the technologies, activities and possibilities presented here are absorbed in several extension activities promoted by PRONTO3D in Florianópolis. Among them, PRONTO KIDS is highlighted, which involves the execution of workshops, held in the laboratory, for children between 6 and 12 years of age, in partnership with schools of basic education. The objective is to show children the use of digital technology, aiming the dissemination of technology allied to the creativity that emerged at this age, which is shared by learning and easy assimilation. The first activities in this category, were with a group of 15 students from an Elementary School within UFSC campus, in which children had contact with laser cutting technology in the execution of elements that identified the learning processes previously obtained in the classroom. In the first edition, which took place in May 2016, students in the literacy phase had the challenge of assembling a dinosaur toy, previously cut in laser technology, in which their pieces had marked (also in laser) the sequence of the alphabet that should be respected for the success of the assembly. The activity was playful, interactive, participatory and informative to encourage the conscious use of technology for the materialization of the form (Figure 8).

Figura 8 – PRONTOKIDS 1
Fonte: PRONTO3D files

Following the same workshop pattern, two other activities with children were carried out in the laboratory, with different themes, dengue awareness and a study of endangered animals. In the first one, students also had contact with laser cutting technology in the assembly of a dragonfly (Figure 9) and in the second, the technology was 3D printing, in which students had the opportunity to see their own two-dimensional drawings materialized (Figure 10) on three- dimensional objects.

Figura 9 – PRONTOKIDS 2
Fonte: PRONTO3D files

Figura 10 – PRONTOKIDS 3
Fonte: PRONTO3D files

The extension activities in PRONTO3D are not limited to those described here, but they expand to diverse audiences, with different interests, but always focusing on "learning by making", aiming materialization of form as a design, spatial and cognitive task.

Since the beginning of its activities in Florianópolis, the laboratory has already attended more than 600 academic works, as well as non-academic community through extension projects, in training programs and works to raise awareness of the use of new technologies in common activities. Focusing on manufacturing technologies, each semester the lab offers space for about 15 students as scientific researchers, compulsory internships or even volunteers whose research permeates the application of technologies of digital fabrication.

FINAL CONSIDERATION

The activities and works described in this article illustrate the dynamics of learning and assimilation of content applied in the laboratory, in which "learning by making" is a primordial requirement in integrating the technology of form materialization with design process. The understanding of technology as a new tool and support to the creation of ideas, solutions and design innovation, brings new fronts of work, with quality, innovation, creative solutions, as well as facilitates in the practice of the collaborative design, shortening paths and frontiers of innovation.

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