

# Reprogramming Practice

## *Revising design thinking through digital fabrication*

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*Questioning the importance and impact of design thinking methodologies in the architectural design studios is a backbone of architectural education in twenty first century. 3D printing and digital manufacturing are disruptive technologies that are changing architects and designers daily lives. These trends require new skills, based on a deep understanding of digital continuum from design to production, from generation to fabrication. This continuity transcends the merely instrumental contributions of a person-machine relationship to praxis, has begun to evolve as a medium that supports a continuous logic of design thinking and making. Design thinking methodologies associated with digital fabrication emerged as a leading technological and design issue of digital research and design. As designers, we are witnessing a no frontier between computational design and digital fabrication. For this paper is taken into consideration the work of two architecture studios that share a unique background on new methodologies by embracing the digital technology in their own practice. Their work reflects on new design methodologies facing the expansion of digital technology in architectural practice. This paper discusses the possibility of new design thinking methods driven by digital fabrication.*

**Keywords:** *Design thinking, Digital Fabrication, AEC, Collaborative Design, Architectural Practice*

### INTRODUCTION

Technology advancements have a profound impact on design thinking in architecture, professional practice and architectural education. Computational design thinking (Leach & Yaun, 2017) and innovative approaches in digital fabrication bring new demands for rethinking of architectural practice (Morell, 2015; Dye & Samuel, 2015; Hensel & Nilsson, 2016; Ak-

samija, 2016). Only an inclusive approach can engender the understanding required to address the many issues raised by the fourth industrial revolution. This will require collaborative and flexible structures that reflect the integration of various ecosystems and which take fully into account all stakeholders (Schwab, 2016).

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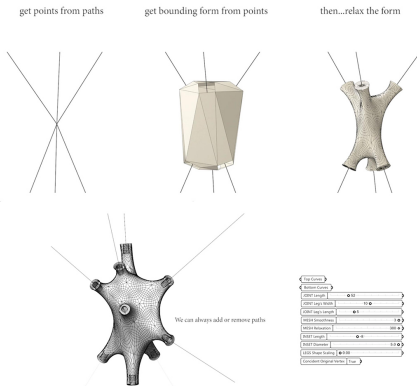


Figure 1  
Left – Digital  
Crafting Collection,  
2012, gt2P;  
Right-Lexus design  
award 2018:  
DIGITALAB's  
generative system  
links low-tech  
materials and  
high-tech  
processes.

industry is in a state of flux fueled by transformative shifts in technology and design (Menges et al, 2017). Financial incentives around new economics of production, increased efficiencies afforded by streamlined communication and the automation of labor-intensive processes are already underway (Corser, 2010; Gramazio & Kohler, 2014; Bernstein & Deamer, 2010).

In this context, the architects have a momentary opportunity to give a direction to this shift that will set the foundation for the next generation of architects.

Technology research should not be bound by constricting disciplinary standards, constrains or ideologies lest we limit its potential. Yet to explore this unprecedented potential requires not only a technical grasp of digital fabrications' capabilities and limitations, but also an in-depth understanding of the disciplinary consequences of technology research.

The rise of design thinking has to do with a greater understanding of the methods and process developed in the design (Cross, 1984). Processes have been established (analysis -> ideation -> prototype -> iteration -> implementation), and tools have been defined (brainstorming, rapid prototyping, desktop walkthrough...) in order to transmit and

generate truly collective processes.

This deeper understanding has led to an explosion of applications and a broader collaborative process. One of the major principles in design thinking is that the process is constantly changing: it never repeats systematically, and we must be actively creative with the process itself (Rowe, 1987).

If architecture follows the path which the design has begun, then it will produce a wide range of improvements and modifications in both directions.

Architecture is facing problems or situations in which a plastical, formal or spatial approach is not enough; we must improve and adapt the tools and processes to approach creatively different issues. On the other hand, the act of participating and creating design processes from the architectural knowledge enables to introduce new tools in the processes.

The design thinking model extends its tools and methods that came essentially from product design, user experience, design services, among others, and architecture can face problems with a holistic approach, allowing architects to act in situations which previously were unknown (Menges, 2011).

Design thinking promotes a human-centered and an open-ended approach, seeing failure not as a mistake, but as an opportunity to learn (Makstutis,

2018). As Penn (2015) argues architectural professional practice is a body of knowledge in part the result of training, but is largely a result of practical experience. It comprises both explicit and tacit knowledge - learned not through theory, but through a process of reflection on experience; by watching others, and trial and error, coupled to actively thinking about why some things worked well and others failed.

IDEO (product design) and OMA/AMO (architecture) are large structures with many types of projects, both have depth in an intense way in the creative process and have reached a similar conclusion: the creative processes of design (especially collective) are applicable to a variety of situations, even in antagonistic disciplines such as politics, management, marketing, etc. (Cross, 2008).

In this context, the subject of this study is the necessity, importance and impact of the design thinking methodologies, which plays a complementary role rather than support in the architectural design studios which is a backbone of architectural education (Burry et al. 2010; Wagner et al 2010; Wiertelarz, 2016; Gu & Wang, 2012).

For this paper is taken in consideration the work of two young architecture studios that share a unique background on new methodologies by embracing the digital technology in their own practice. Their work reflects on new design methodologies facing the expansion of digital technology in architectural practice. This paper explores the possibility of new design thinking methods driven by digital fabrication.

The outcome of this study, results in a taxonomy projecting a new design thinking process based on the methodologies adopted by the architecture studios in study. This preliminary taxonomy presents a new concept where digital fabrication is the common aspect along the design process, performing as support and an integrated aspect of the process.

## METHODOLOGY

The study adopted a methodology to reveal possible new design thinking methods driven by digital fabrication based on the analysis of the work of two architecture studios.

Both young studios were selected to enroll in this study due to their work developed in the practical context that is expanding traditions of making towards new techniques that integrate manual craft, computational design, digital fabrication, and advanced robotic technologies, often in hybrid relationships. The two studios in study in this research support this concept.

DIGITALAB and gt2P are architecture studios “born” in the digital environment and are dedicated to explore digital design and fabrication, or as they call themselves: they are digital crafters (domusweb, 2018) (dezeen, 2019) (figure 1). They both focus their work on the continuous process of research and experimentation in digital crafting, promoting new encounters between the technologies for projecting and the richness of the local expressed in traditional materials and techniques. With digital fabrication, they were able to turn the attention to the physical nature of architecture, by opening up new aesthetics and functional perspectives and address the digital in architecture as a radically contemporary building culture.

DIGITALAB is a Portuguese multidisciplinary architectural office, creative lab and design studio, focused on both generative design and digital fabrication, by merging analog and digital technology in order to come up with computationally generated designs and structures. It is a young practice led by Ana Fonseca and Brimet Silva that develops projects in several fields: product design, art installation, interior design, architecture and digital research. DIGITALAB is committed to employing new technologies in the production of forms and spaces, exploring strategic combinations between generative processes (Computational design) and digital fabrication technologies (3D printing, CNC, laser-cutting, and robotics). Their main goal is to explore the potential of digi-

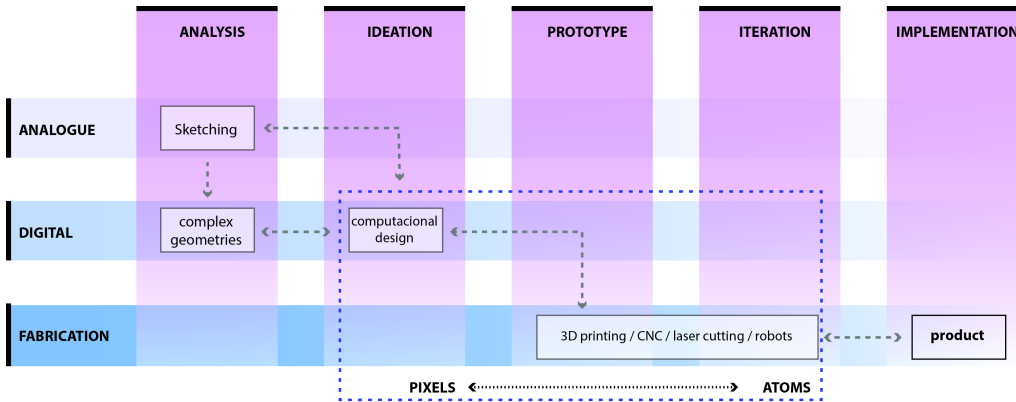


Figure 2  
DIGITALAB  
workflow diagram

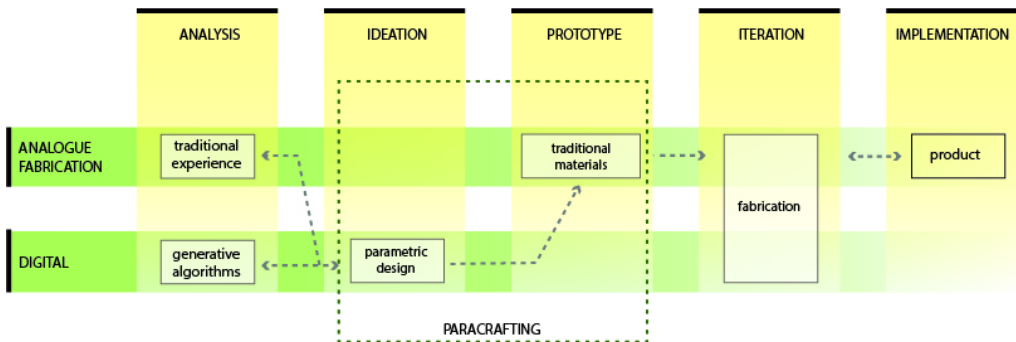


Figure 3  
gt2P workflow  
diagram

tal tools as creative weapons to transform pixels into atoms, and virtual processes into physical objects and environments.

Gt2P - Great things to People is a Chilean collective involved in projects of architecture, art and design and with an experimental approach that combines digital fabrication, traditional craft and materials. They are driven both by their cultural heritage as well as a dedication to parametric design, or paracrafting - wherein they devise physical production systems and then play with variables within those systems (such as time, temperature, volume,

etc.) to manipulate materials in unexpected ways.

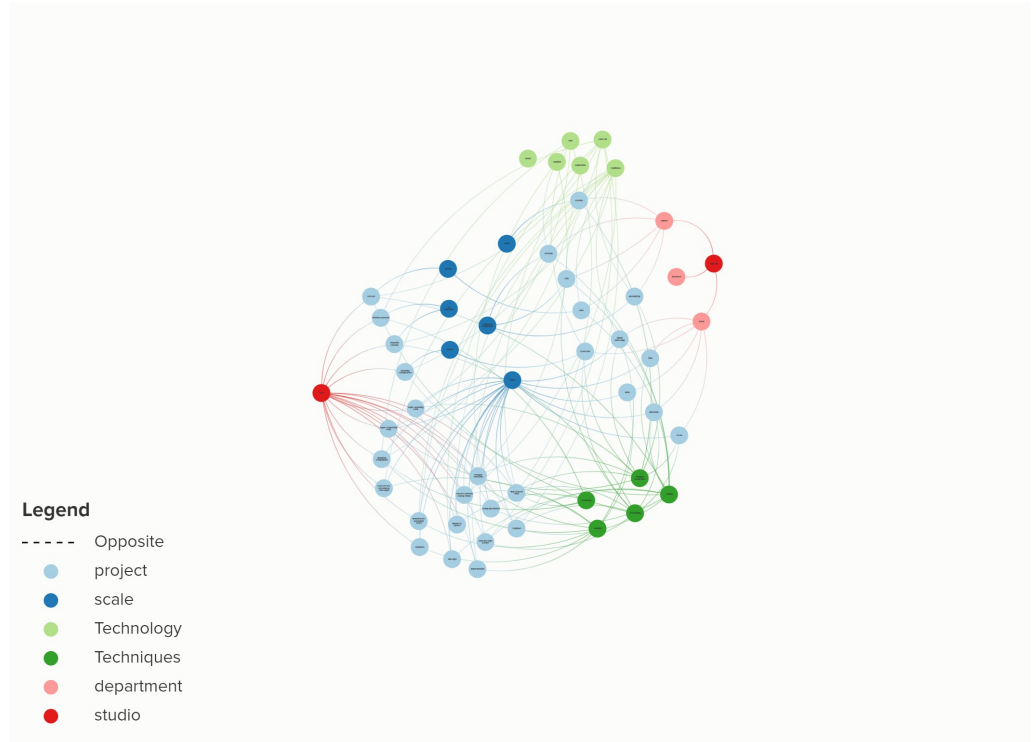
The taxonomy design encompassed 2 stages: (1) getting inspired - analyses the studios workflow and online interviews; (2) Learning by doing - analyses a group of projects of each studio.

### GETTING INSPIRED

The first analysis is based on the studios workflow, and as a result, we produced two diagrams explaining the processes of each office.

DIGITALAB is organized in three major departments: form, space and research, being each one of

Figure 4  
Preliminary  
taxonomy relating  
DIGITALAB with  
gt2P group of  
projects



them focused on different scales but they all share a common interest: employing new technologies in the production of forms and spaces, exploring strategic combinations between generative processes and digital fabrication technologies (figure 2).

Their workflow is based on the idea that pixels become atoms, meaning that from matter and materials, comes materialization. Starting from the sketch they develop the concept and test it on the digital environment with the support of complex geometries and computational design. From there it starts the process of developing the final product between generative design and the implementation of digital fabrication. It then allows to explore materials and processes until the final result.

Gt2P refers to their approach as paracrafting. This is the way that the studio experiment with parametric design, focusing on production processes that often incorporate analog fabrication as well as traditional materials. This frees parametric design from its usual connection to computers and it contextualizes their work within the national landscape and culture. This way of systemizing ideas and processes through variables also allows them to create entire object families, rather than isolated objects.

Their work methodology has two dimensions (figure 3). First, they seek to systematize knowledge and observation, whether of natural, artificial, geometric or spatial, phenomena, through generative algorithms. Here parametric design is a tool to guide

the planning of projects that they carry out, enabling the integration of its stages of design, development and production. Their workflow bounces between the analogue and the digital supporting each other along the design process.

On the other hand, they have discovered an artistic dimension that connects them with their cultural heritage, through the incorporation of traditional experience and knowledge that feed and qualify the generative algorithms or DNA that they create. At the end, they expose the unexpectedness of manual processes and local materials as a way to value what they are in what they do.

## LEARNING BY DOING

To support this investigation, it was taken in consideration several projects from each studio: from DIGITALAB were taken as a reference eleven projects dated from 2015 to 2019; regarding gt2p, we had as reference nineteen projects developed from 2010 to 2019. As criteria we took into consideration 4 parameters: scale, processes, tools, and craft vs. digital.

We took into consideration the scale of projects (if it's an objects, a building, a system or a temporary structure), the used techniques (complex geometries, folding, tessellation, forming, sectioning), the tools or the technology used to develop the projects (traditional techniques, laser cut, CNC, addition or robots) and even comparing the use of crafts or the digital environment in the projects.

To help us organize and visualize the information in study, we used Kumu as a tool to produce a relationship map (figure 4).

This preliminary taxonomy presents a new concept where digital fabrication is the common aspect along the design process, performing as support and an integrated aspect of the process.

Looking over the data collected, it is clear to state that both studios take digital fabrication as an opportunity to explore further and complement the crafts potential. The range of projects in analyses shows that they work in different scales, and with time they have found a way to make design work as a business.

They have realized that it is in diversity where their real value or contribution is by breaking boundaries in practice and by combining symbiotic techniques.

The produced design thinking diagram helps the main investigation by understanding and supporting the belief that digital fabrication is not only a tool, but rather an integrated strategy in collaborative digital processes that can allow a better communication along the design process.

By analyzing and evaluating the work achieved by these two studios, we can relate and comprehend how two independent offices have been developing their unique way of working and thinking with the support of digital technologies.

There is no doubt that the profession is expanding traditions of making towards new techniques. It is clear in their work that digital fabrication is a technology used not only as a tool to produce the final piece, but mostly a way of thinking that supports the entire process along the design thinking process.

## DISCUSSION

In this paper we argue that design thinking in the architecture studio may benefit from digital fabrication, to foster a more profound understanding of these processes among architects. Digital fabrication is being coalesced in design studios in order to optimize the traditional workflows they're already familiar with. This technology doesn't necessarily replace the existing tools, when implemented well it simply evolves existing workflows.

This paper is part of a study that investigates the architectural design process and starts from the premise that we should expand the study of design methods to include other approaches. It considers digital fabrication not only as a tool, but as an integrated strategy in collaborative digital processes that can allow a better communication along the design process. It presents the development of design methodologies in order to contribute to a greater understanding of the methodology for design projects with caution to the fact that each one reflects the period in which it was developed.

The emergence of complex technological and environmental problems, challenge the professionals to seek novel practices of collaboration and exchange that deliberately overcome and dissolve traditional disciplinary boundaries. This collective approach to working with technology is not only revolutionizing how things are designed and made, but is fundamentally transforming the culture, politics and economics of the creative industries as a whole.

If the first robotic age - the age of industrial automation - vastly improved our physical productivity, the second robotic age will surely come to distinguish itself as a driver of creative capacity. The present moment is ripe for connecting technology with imagination and materialization, inspiring new fundamental discoveries and opening new scientific frontiers.

Based on the work produced by DIGITALAB and gt2P we can understand how digital fabrication enables new relations and allows a high-tech and low-tech approach where craftsman practices is mixed in with technological processes.

The development of a preliminary taxonomy allowing understanding the role of digital fabrication on design process in architectural practice along with a discussion of their capacity to question the basis of education and the conceptualization of architecture.

## CONCLUSION

This paper intends to discuss the relationship between making process in design-led research and other aspects that are challenging architectural practice.

Design thinking methodologies associated with digital fabrication emerged as a leading technological and design issue of digital research and design.

Integrating digital fabrication into design thinking contexts is by no means a straightforward process. This study reveals that design thinking in the design studio can benefit from digital fabrication as an integrated part of the work setup. Design thinking supports the studio work, in which failure, iterative processes, and continuous reflections on fabri-

cation materials are integral parts of the process. Our observational studies, design thinking theory, and research experiment accounted for in the paper set out a trajectory for more thorough studies of how design thinking may be integrated into creative and reflective processes of digital fabrication in the design studio.

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