DIGITAL TOOLS, ANALOGUE MINDS

A Project-based Framework for Understanding the Dialogue In-between

ALEKSANDRA RAONIC1 and MILOS RAONIC2
1Xi’an Jiaotong-Liverpool University, China
1aleksandra.raonic@xjtlu.edu.cn
2RAUM, Serbia
2milos@raum.co.rs

Abstract. This paper is situated in a specific research by design setting, where the realised work of architecture has been generated with digital tools operated by analogue minds of designers. It examines the relationship between the two entities, the designer and the tools, in an attempt to understand their specific roles better, trusting that this can lead to anew ways of enhancing the design process. Through revisiting the processes, methods, techniques and tools employed within various design-cycles of the project, authors present their own/designerly/ experience, pointing to both the potentials and limitations of the digital tools used. The attention is drawn to the importance for a human designer to have a critical awareness of the true nature of the computational systems and the capacity of both to adapt to the given context, in order to be able to embrace them and use to their full potentials.

Keywords. Project-based learning; design exploration; digital tools; design cognition; low-cost conditions.

1. Introduction

In the professional context of the contemporary architectural design practice digital tools have become widely trusted modes for supporting the design process in all of its phases. Designers and engineers nowadays extensively operate within the digital realm, relying on computers primarily as design generating engines, as tools for exploration of design ideas and their testing, and as means of communication and efficient data transfer to all other active participants in the design chain. The name computer aided design itself suggests that computational systems are to be regarded as complementary to designer led process, assisting a human designer in conducting the actual design thinking and design production. To what extent
a computer has the capacity to aid the designer, and what would be a degree of its autonomy within that process are some of the concerns raised and addressed within this paper.

Founded on the theoretical grounds that have already given recognition to designer’s perceptual and cognitive abilities as the keystones in the generative processes of creating innovative design solutions, whereas the generative role of the digital techniques is accomplished through the designer’s simultaneous interpretation and manipulation (Kolarevic 2004), this paper explores further the relationship between the two in a project-based setting. It aims to identify aspects and areas of the design process in which the use of particular digital tools might play the most prominent role in complementing and assisting human designer’s design thinking and actuation.

![Figure 1. 2D and 3D representation from the winning competition entry: a wireframe perspective drawing of the proposed market design and the site plan of the proposal showing the rotunda in the middle of the market and the alley of trees within the market area.](image)

The paper presents a newly built and recently put in use Central Green Market project designed by the authors during the period of 2012-2013 and finally realised in 2015 (RAUM, 2015). By exposing their particular designers' experience during the creation of the Central Green Market, authors intent to demonstrate the level of compatibility of the computational design methods with the cognitive and perceptual design approaches within various design stages. The paper focuses on the initial, exploratory stage of the design and only briefly informs about the later stages of the design that are concerned with its technical resolution, leaving these to be tackled in the future. However, this paper wants to make explicit that despite the fact BIM was not an option for this particular project, the supporting role of the available digital tools was essential in the formation of design knowledge, in enabling collaborative thinking, and design development until its very completion.

2. Project’s Background

After winning a local competition authors were commissioned to complete all phases of the design, from the initial design conception to the final design with technical details and site supervision provided. The design task: to redesign and extend the existing Central Green Market (within a total area of 14000 m²) in Negotin - a small town in East Serbia was conditioned to be low-budget given that this is one of the poorest regions of Serbia. The old market was in a poor condition itself, with many of the existing structures in devastated condition, ready to be demolished.
In a given context, with a limited building technology available and insufficiently skilled construction workforce, the preservation of the old building was estimated to be unfeasible. The restrained budget allowed for only a few of the existing structures to be preserved, including the alley of large sycamore trees and the rotunda in the middle of the market place (figure 1), both of which authors planned to incorporate into a new design, as the key identity features of the place.

3. From Modular to Parametric

From the very beginning and throughout the whole design-span of the project the digital tools were employed to drive the process. An array of software applications were used for design exploration and inquiry (Rhino, Grasshopper), for creating 2D and 3D representations (Rhino, Sketchup, CAD, Adobe applications), for design detailing (CAD, Rhino and others) and for the interactive communication with the engineers and other participants in design chain.

Based on the market stand space requirement analysis and the analysis of circulation of people and goods, a mathematical pattern of 11m’ x 11m’ was defined to be applied at the main market area and the above canopies. Through the further steps of the design exploration the set primary modular unit was modified and adapted to the more specific requirements of the project (figure 3).
4. Parametric Aid to Design Exploration

The pattern found its application in the functional organisation of the green market, and even more directly in the design of the market canopies. This was especially important given the specific microclimate of the Negotin region characterised with high temperature fluctuations during the year, but also with the highest number of bright days (88 day in average) and the longest sunshine duration in the country (Smailagic et al 2013). Thus, the canopy structure had to be designed so that it provides both sufficient light and shading during the hot summers, while being able to protect the market space and its users from the elements - rain and snow during the winter months. The existing canopy, a simple double pitched roof, was covering the whole market space and provided insufficient insolation (figure 3).

![Figure 3](image)

Figure 3. A simple algorithmic schema for the canopy geometry manipulation in Grasshopper.

Authors used Rhino for quick 3d sketches and formal tests, and complementary parametric application (i.e. Grasshopper) for creating a number of possible canopy’s geometric behaviours that could vary in fragmentation and roof inclination. The roof dynamics had to comply with the requirements for the protection against the elements, to appropriate the direction of the rain water away from the market stand areas, in a way that all market stands are well sun lit (figure 4). For this purpose authors have created a simple algorithm for geometric manipulation to take place within a parametric modelling space (i.e. Grasshopper for Rhino). This simple schema assisted the process significantly in terms of generating a large number of iterations and variant solutions to be discussed and evaluated.

5. Parametric Designerly Experience

Now, if we are to identify the approaches that characterise the exploratory stage of the design process of the Central Green Market in Negotin, we would need first to note that authors have operated (almost) exclusively in a digital realm, exploring the potentiality of variant geometric behaviours parametrically. However, before starting off with parametric exploration, based on their previous experiences with parametric modelling, authors recognise the necessity to create an algorithm with a high degree of explicitness. The necessity to do so has been advocated by many long before. Knuth, for example states that algorithm must be based on precisely defined steps and that following actions must explicitly be specified for each case (Knuth 1997). In other words, designer’s intention and deliberation play a central
role in parametric modelling.

Therefore, a designer needs to have a predefined notion of what is being explored and to which (parametric) extent - i.e. when shall the parametric exploration rest for the human designers’ cognitive perceptual capacity to intervene and complement it. The limited complexity of the algorithm used for the canopy geometry exploration and its manipulation in Grasshopper (figure 4) should also be seen in that light. Moreover, it has been evidenced that an excessive number of parameters in the schema can easily lead to the non-manageable design solution spaces. In this scenario, a number of design variants would grow exponentially and pose a challenge to both human designer’s cognition, and just the same to the computational system (Bittermann 2011). Many point that an excessive complexity of the schema could easily hinder the process and encumber the process of evaluation of each design variant due to the restrictions in time and in other resources (Kilian 2006; Turrin et al. 2011).

Research shows that designers who have managed to overcome complex design situations with success use an approach often referred to as a designerly way (Cross 2001; Buxton 2007; Moggridge 2007). In the case of the Central Green Market project, the explicitness of the algorithm and the limited complexity of its schema made it possible for designers to discuss, evaluate and compare a number of variant solutions at a relatively early stage of design exploration, and thus to establish a cognitive methodological designerly approach to design, and grasp its systemic nature timely. The relevance of understanding the systemic nature of design has been brought to light by Stolterman who sees it as an iterative process of inquiry that moves between the whole and its parts: “...a rational designer works on many alternative designs in parallel in an iterative way, while going back and forth between the whole and the details. This way of doing design is not a choice. It is at the core of what it means to act in a rational, disciplined, designerly way” (Stolterman 2008).

Thus, the use of parametric tools at this stage has provided designers with a perspective that is of value for design thinking in at least two respects. Firstly, it bound them to clearly identify distinct issues in the given context and define the evaluation criteria prior to the parametric exploration. The design problem is not given - it is framed within the first stages of the design exploration and inquiry, within the framing and naming stages (Schön 1983). Secondly, through attentive articulation of all geometric elements with consideration of their correlated, interdependent conditions, the use of parametric tools also allowed for a more systemic approach to design to happen.

One could argue that similar values may have been achieved by the means of an analogue approach. But authors had reasons to believe that many of the challenges that emerge at this stage, that one could identify as wicked problems (Rittel and Webber 1973), would be impossible to address in such a systemic way. One of the reasons is that the analogue approach could only offer a limited number of iterated formal outcomes and try-outs to study, discuss and evaluate. This lack of bases for design exploration and inquiry to happen could only result in its incompleteness. Other reasons have to do with the efficiency of the process, as the attempts to explore the design potentials through iterations in analogue terms would entail a
human designer to start the process all over again.

The low-cost conditions of the context made an impact on the choice of software - much of them were licence free or open source (Sketchup, Grasshopper etc). However, designers relied on their competencies to appropriate the tools they had for developing the techniques they found necessary for operating this specific project. Aided by the selection of digital tools authors have explored a full range of resources available in the given design situation, including their knowledge and embodied skills in order to develop a project specific design strategy, or situating strategy as termed fittingly by Gedenryd. The role of digital tools was to assist the authors to go beyond the intramental (i.e., in the mind) design activities undertaken for accomplishment of the intended design idea (Gedenryd 1998).

Even though the digital tools available for the Central Green market project were rather basic in this design stage they have clearly supported the designers in: understanding the present situation (1), exploring potential futures (2), expressing designers’ vision of the potential future concepts (3) and evaluating which course to take in the design (4). In another scenario, without the parametric tool at hand, a limited number of design variants would inevitably constrain designers’ perceptual-cognitive capacity, imposing on the designers rather basic design concepts that have a little chance to develop into well informed and mature design proposal.

6. Digitally Design Communicates

As pointed by Akin, design consists of a series of representations to designer’s mind, and to the minds of designer’s collaborators, clients and others because, as he explains: “the mind has its own internal representations in order to communicate through external representations.” (Akin 1982). Likewise, at the following stages of design’s technical resolution and detailing it was important that external representation conveys the design idea and information that addresses various scales, levels, and scopes of technical resolution.

It was essential to employ tools and techniques that allow an efficient transfer of all relevant design data to, at this point, an extended list of collaborators (mechanical, electrical, plumbing, fire protection, and structural engineers, consultants for waterproofing, roofing, glazing, material suppliers, clients, etc.) that called for explicitness and clarity in how the design is communicated.

The designers worked with detailed 3D models as a method for communicating the tectonic idea most explicitly to the engineers (and all others in the design chain) to calculate, optimise or propose an alternative, and send information back to designers (figure 5).

Figure 5. Detailed 3D models made in Rhino; tectonic resolution by architects in 3D on a level of a structural details – rainwater gutters incorporated in structural system (middle), complex joint of 8 beams supported by 1 column (right).
This also allowed for a high level of precision to be achieved that has particularly proven to be the invaluable in the final, construction stage (figure 8; figure 9). Moreover, it allowed for a few very specific design/structure/construction issues to be resolved efficiently, to name just the two: 1. detailing of the structural joint with 8 steel beams leaning on 1 column at the same height (figure 5; figure 6), 2. detailing of the canopy segments that were to be designed with sycamore trees growing through (figure 8).

Should be said that the method of construction - prefabrication was deliberately chosen, as authors trusted it would support the tectonic logic of the design most explicitly and would leave little room for miscalculations. Given that all steel structural elements were prefabricated, then transported from another part of the country to the building site to be erected and bolted there the tolerance for potential deviations in the production and construction was minimal, as any error in the data transfer to the production line would result in a series of mismatch on the site and hinder the realisation of the whole project.
To conclude, this particular designerly experience of using 3D digital models for architecture/construction collaborative thinking, design resolution and detailing speaks obviously in a support of the BIM software application, and could be seen as a naïve version of it.

Even though BIM was not an option, the making of a highly precise 3D digital models proved to be important in the formation of design knowledge and its sharing, and especially invaluable asset for the construction, as it has directly informed the production and the erection of all steel elements without any welding that resulted in a deviation of a mere 2-4 mm per 11000 mm span (figure 9; figure 10).

It enabled faster production of structural elements, shorter completion time and finally the reduction of the overall costs. Moreover, it helped to keep the authors/architects fundamentally involved in the all stages of the design process, and to be in control of it.

7. Conclusion: Analogue Mind - a Creative Drive

Who designs? This question posed by Terzidis when referring to the parametric design method as a possible alternative to a human designer (Terzidis 2003) has found many opponents, perhaps for the obvious reasons. Scheurer for instance formulates his argument against this idea of potential dehumanisation of the design process in four points: computers as we know them are deterministic, not creative (1), tools don’t find solutions, solutions produce tools (2), simulations are never as real as the real thing (3), computers will never be fast enough (4) (Scheurer 2013). His argumentation places a designer in a central position of the process, because as he explains further: “when we move on from designing buildings to designing algorithms that design buildings, we are just changing the level of abstraction, but not the level of responsibility” (Scheurer 2013). The fear of neglecting human
cognitive abilities in the design processes has been expressed before. McCullough
for instance advocates for taking more pride in human abilities and calls for mak-
ing of: “an inevitable technological change in a more human-centric direction.”
(McCullough 1996).

The authors/designers of the Central Green market and the project itself, ben-
efited from the support of the digital tools in the execution of the design in all of
its stages. Parametric modelling facilitated the addressing of the questions of
design in relation to geometric articulation and in that respect contributed to the
expansion of authors’ cognitive and perceptual abilities. On the other hand, it also
confronted the authors with a number of challenges, such as the necessity to ex-
ternalise all relevant conceptual parameters and formulate them algorithmically
in an explicit manner. By having a clear situating strategy, i.e. by defining the
scope of parametric inquiry that authors have closely related to the geometric per-
formance of the canopy structure, and by having a clear design intention, authors
have managed to meet this challenge.

In making the conclusion of what are to be the contributions of this particular
designerly experience, authors recall Schön’s views of design as an iterative pro-
cess of reflection-action activities that he saw as essential for the formation and
the development of new knowledge (Schön 1983), but also his precedent Dewey’s
view of an interactive and experiential learning that he referred to as a project-
based learning (Knoll 1997). Likewise, the Central Green Market should be seen
as an opportunity for a project-based learning, as it has been perceived and expe-
renced by its authors throughout the process of its design and execution.

Finally, the concluding lesson that this paper wishes to transmit is that digital
tools, even when quite limited and conditioned with a low-cost working environ-
ment, fundamentally support designers’ involvement in the process, from helping
designers’ cognitive abilities expand, to sustaining designers’ control over the pro-
cess until its very final stages. In this particular designerly experience, due to the
limited digital tools at hand, designers were set straight in the centre of the process
that was for that reason precisely evermore integral and connected.

Figure 11. The Central Green market completed and in use.

References
Akin, O. 1982, Representation and architecture, in O. Akin and E.F. Weinel (eds.), Representa-
tion and architecture, Information Dynamics, Inc, Maryland, 1-26.
Bittermann, M.: 2009, Intelligent Design Objects (IDO): a cognitive approach for performance-
Buxton, B.: 2007, Sketching user experience – Getting the design right and the right design, Morgan Kaufman, San Francisco.


