Tornado Pavilion

Simplexity, almost nothing, but human expanded abilities

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In the context of the fourth industrial revolution, not all regions have the same access to technology for project development. These technological limitations do not necessarily result in worst projects and, on the contrary, can stimulate creativity and human intervention to overcome these shortcomings. We report here the design of a small pavilion with scarce budget and an ambitious goal to qualify a space through tactical urbanism. We develop the project in a multidisciplinary partnership between academy and industry, designing, manufacturing and assembling Tornado Pavilion, a complex structure using combined HIGH-LOW technologies, combining visual programming with analog manufacture and assembly. The design strategy uses SIMPLEXITY with ruled surfaces strategy to achieve a complex geometry. Due to the lack of automated mechanical cutting or assembly, we used human expanded abilities for the construction; instead of a swarm of robots, we had a motivated and synchronized swarm of students. The pavilion became a reference for local population that adopted it. This process thus shows that less or almost nothing (Sola-Morales 1995), need not to be boring (Venturi 1966) but less can be much more (Kolarevic 2017).

Keywords: *Simplexity, CAD-CAM, Ruled Surfaces, expanded abilities, pavilion*

Tactical Urbanism approach

This project is the result of a commission for an urban structure under the concept of tactical urbanism using new generative design and manufacture methodologies. The intervention took place in the Technological Park of the Federal University of Rio de Janeiro (UFRJ), a modernist site that lacks small-/medium scale structures to bringing personality and life outside the corporate buildings in the park. Located on the shores of Guanabara Bay and away from University City access, outdoor space is empty for daily use, as their users rather stay inside the buildings. Thus, the outside environment of the Park is not appealing for the users that do not appropriate these wide public that lack a sense of bellowing.

To develop this project raised different challenges: the macro coordination of institutions and industries, the need from the professors to propose a new discipline, defining the teaching methodology and to achieve the construction with few resources.

This article reports the process of design, conception, manufacture and assemblage of the Tornado temporary pavilion. We developed the structure in a multidisciplinary activity between undergraduate and graduate students in the areas of architecture, design and engineering under a partnership between the Laboratory of Models and Digital Fabrication (LAMO) and the Laboratory of Temporary Interventions and Tactical Urbanism (LabIT), the Postgraduation Program in Urbanism (PROURB), the UFRJ Technological Park and the Faculty of Architecture of the University of Lisbon. The project development happen under an optional course (PROURB) during the university first semester, the manufacturing occurred in September included in a workshop and the UFRJ Technological Park supported the material acquisition.

In short, the discipline, intended to implement a multidisciplinary collaboration method, combining expository and practical classes with contents involving tactical urbanism, temporary interventions, parametric design and digital manufacture. The students organized in mix undergraduate and postgraduate students from different careers to merge different visions and specialties in the same team. We requested a flexible project, economically feasible according to the supplied materials.

This work led us to rethink on the theoretical basis of how to “take milk from stone”, or how to use SIMPLEXITY to materialize a complex geometry.

The Tornado Pavilion - was selected between 4 proposals, from 5 groups of students and built in September 2017; To accomplish the pavilion we had 67 grasshopper versions, 5 mockup models, 1 digital file, 600 wooden slabs (Dimensions of 4 cm x 8 cm with 3 m length), 660 circular spacers, 1440 type A screws, 1360 type B screws and 40 infinite-screws, 8 days of manufacture, 2 days of assembly.

The group of the selected proposal conceived a temporary pavilion to re-signify the vacant space providing shade and seating spaces, occupying the abundant free space. According to specific characteristics of the space, they positioned the structure obliquely, as close to the Park entrance as possible, connecting the entrance with a bus stop, crossing a future public square and creating an iconic reference for the users.

The pavilion opening was in 21th September 2017, in the context of the opening of an outdoor Art Space Gallery (Galeria Curto Circuito) that announced and gave wide visibility to the project, both for the academic community and for UFRJ Technological Park users. The pavilion was immediately appropriate and the structure spread quickly on the social media, attracting people from different academic units who had never visited the place, as shown in the following records.

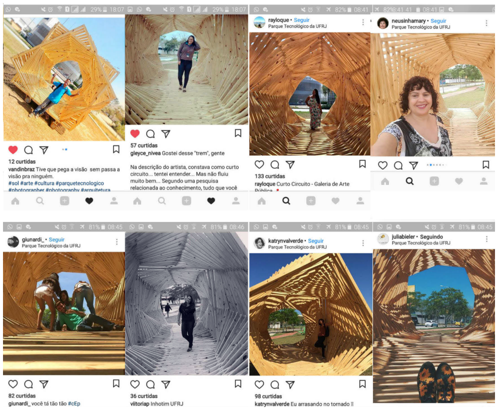


Figure 1
Tornado on the social networks promoting local empowerment

The concept of tactical urbanism refers to an approach to build and activate neighbourhoods using short-term, low-cost interventions that allow the immediate recovery, redesign, or programming of public space for future transformations (Lydon and Garcia, 2015). Applied in the field of urbanism, the term is recent (decade of 2010), however, its origin is in the writings of urbanist and French philosopher Michael de Certeau (1998). Certeau establishes the difference between strategies and tactics, calling strategy the calculation of power relations from the power point of view, and “tactics” the gradual reaction that takes advantage of “occasions” and the loopholes to act.

It is a small-scale approach related with bottom-up and Do-It-Yourself processes, allowing the student or professional to work “close to the ground”, reinforcing their social responsibility and encouraging cooperation with other professionals and society (Sansão-Fontes, 2018). The actions that respond to this approach operate tactically in a partial and agile way, serving to test an idea and its support by the community, in a process of trial and error. Acting in steps, prevents large investments that do not have the ultimate guarantee of success.

The particular feature of some tactical interventions is their temporary dimension. Named as “temporary interventions” (Sansão Fontes, 2013), these actions value transitory as a strategic quality to explore the place possibilities, seeing the city as a laboratory for testing ideas in real time. In addition, we can consider temporary interventions as breaks in everyday life, intentional moments to break the routine.

We based the intervention in the Technological Park in these premises, in a strategy coherent with the profile sought by this institution, precisely open to innovation and the articulation between different disciplinary fields and between university and companies. The Park emerges as an arena of mobilization of several technical innovations, with high infrastructure and technology, being the place to stimulate both young entrepreneurs and large companies, who can benefit from the supply of skilled labour.

LESS FOR MORE

According to Montaner (1996) Less is More is uncertain, but Mies' most used slogan was Beinahe Nichts or ”Almost Nothing”. Montaner in his book on minimalism points out that the ”less” is inseparable from the ”more”, an ambiguous and contradictory dialectic, ”Less is more denotes a unity, neither of the two terms can be separated from the other, as they cannot be the day of the night, the light of darkness, the life of death. ”

Kolarevic (2016), with a solid theoretical foundation, explores this ambiguity and makes it a wordplay, mixing “simplicity” and “complexity” to define some other categories of performance::

Table 1
Kolarevic (2016)

SIMPLEXITY AND COMPLICITY		
simplexity	arising from complexity = complicity	Complex form part of simple rule
complicity	Simplicity arising from complexity = complicity	Simple form of "complicated" fabrications

Complicity

Kolarevic (2016) points to a mutualism, that is, to hybrid interventions that necessarily become interdependent. This posture makes him say that it is reductive the thought that postmodern sciences point to complexity and the modern sciences to simplicity. In a sense, Venturi (1966) anticipated this situation in his book Complexity and Contradiction in Architecture, when he pointed out the need for a third way, or “several” third ways as opposed to a situation of binary opposition.

”Architects can no longer afford to be intimidated by the puritan moral language of orthodox Modern architecture. I like elements which are hybrid rather than ”pure,” compromising rather than ”clean,” distorted rather than ”straightforward,” ambiguous rather than ”articulated,” perverse as well as impersonal, boring as well as ”interesting,” conventional rather than ”designed,” accommodating rather than excluding, redundant rather than simple, vestigial as well as innovating, inconsistent and equivocal rather than direct and clear. I am for messy vitality over obvious unity. I include the non sequitur and proclaim the duality.

I am for richness of meaning rather than clarity of meaning; for the implicit function as well as the explicit function. I prefer “both-and” to “either-or,” black and white, and sometimes grey, to black or white. A valid architecture evokes many levels of meaning and combinations of focus: its space and its elements become readable and workable in several ways at once.

However, an architecture of complexity and contradiction has a special obligation toward the whole: its truth must be in its totality or its implications of totality. It must embody the difficult unity of inclusion rather than the easy unity of exclusion. More is not less." (Venturi, 1977)

This contradiction is evident when the minimalist concept of almost nothing sometimes implies an enormous and complex projective effort. We can refer here as an example to the dematerialization of the windows of the living room of the Tugendhat house of Mies Van der Rohe in 1930, if we think of the design features, too sophisticated for the time, that were made to attain the results. Mies elaborates here a hidden and very complex mechanism by which the window of the whole room of the house descends to the subsoil and thus dematerializes in this "almost nothing" desired. The window is magically reduced to nonexistence, so we find a hidden mechanistic complexity used to support the conceptual simplicity of "almost nothing".

Solá-Morales (1995) in his article "Mies Van der Rohe y el minimalismo" proposes that the work neither evokes nor appeals to anything other than itself; is self-referential, and at most only makes explicit its materiality and its evidence. Without seeking any meaning it refers, and ends in itself.

This in part coincides with Montaner's (1996) classification with the idea of Pure Present, which again evokes self-referential, the lack of meanings (without allusions) and the anti-historical condition, thus seeking the notion of eternity.

The quest for almost nothing here is fundamentally of aesthetic order, and to make it, uses complex design mechanisms. Kolarevic defines this resource as COMPLICITY, in which the simple form is the result of complex fabrications, however, here complexity and simplicity cease to be antagonistic and begin to work in harmony in a hybrid consensus, whereby aesthetic simplicity depends on the complex design.

MINIMALISM		
1 Minimal Picturesque	Contextual Chromatisms	Atmosphere of Place
2 Geometric Rigor	Geometric shapes and patterns - Formal economy	Maximum formal tension with minimum means
3 The ethics of repetition	Repetition of the identical tending to infinity	Serial systems that eliminate hierarchy
4 Technical accuracy and materiality	Conception as pure technique and mechanical precision	Aesthetics that emanates exclusively from materiality
5 Unity and simplicity	Existence is limited to the essential	Austerity and compositional rigor. With indissoluble and indivisible elements
6 Scale Distortion	Strange, non-relational, self-referential scale	Predominance by size and perfect repetitive treatment of the skin
7 Predominance of structural form	Structure as aesthetic-constructive apparatus	that conveys a sense of eternity
8 Pure present	Self-referential, without allusions, anti-historical	Narrative and phenomenological experiences

Table 2
Montaner (1996)

Simplexity

In the construction of the Tornado the idea of almost nothing or less is more - reinforced by the approach to tactical urbanism that is based on resource saving - enter both in design and manufacture, and are adjusted throughout the process. In this sense, we oriented the design development towards ruled surfaces, to face material and manufacture limitations; we requested wooden joists with screws connections.

The Tornado fits within the precept defined by Kolarevic of SIMPLEXITY, by which it presents a complex form that arises from the exploration of topological formative models (Oxman 2006), a twisted cube, (Fig.2), however, the result arises from the use of simplified design and manufacturing rules. The project begins from a line (that becomes a slab) of 3 m in length that performs simple serial operations of movement and rotation to define the form.

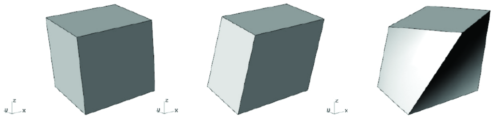


Figure 2
Topologic formative model in Carmo (2018)

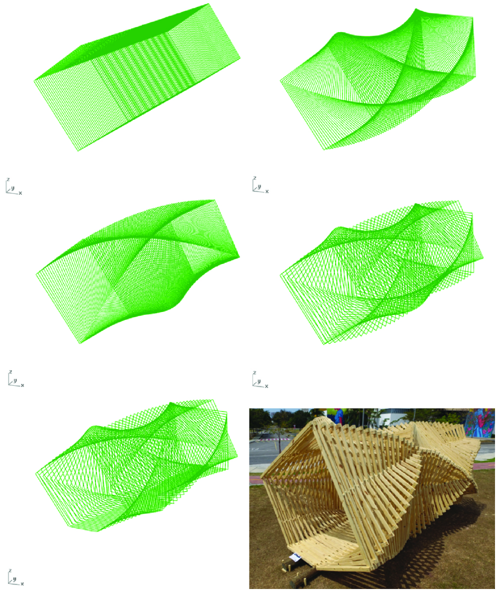


Figure 3
Capture of the kinetic development: 1 Move in series, 2 rotation CW, 3 rotation CCW, 4 base form, 5 ground section, 6 result

During the design process, we move from the topological formative model to a generative based model of simple grammatical transformation (Fig. 3). This situation occurs during design, from the moment we apply series of commands to a single primitive. (Oxman 2006). In addition, we did the manufacture in the same way as the design, that is, with a superposition of lines that form frames and rotated frames. The only prerogative that we allowed ourselves to break this condition was the execution of the floor, in which the design starts from a horizontal section in the XY plane to allow the transit and permanence of people.

In this case, unlike Mies, we pursue the idea of Simplexity, as: from simple parametric rules, we elaborate a complex form.

In addition, in the Tornado is the conceptualization of Solá-Morales (1995) by which the work is self-referential, or it evokes itself and makes explicit its own materiality. However, within the Montaner classification we find ourselves in a situation of the ethics of repetition where there is a repetition of the identical tending to the infinite, using a serial system that eliminates the hierarchy.

The search for almost nothing in this case is NOT of aesthetic order, because it uses simplified design mechanisms. Kolarevic defines this feature as SIMPLEXITY, whereby the complex form is the result of simple design rules. Again, complexity and simplicity cease to be antagonistic and begin to work in harmony in a hybrid consensus already double-handed, whereby the aesthetic complexity, within the precepts of less is more depends on a simplified design.

RULED SURFACE PAVILION

During manufacture, we find a simplification of means, when we use the same slab, and the same logic of fittings, inside and between the frames. In principle each frame would be made by 4 boards of 3 m in length positioned intercalated, and will drew each slab to pass 4 screws at each end. However, by dividing the square to allow a floor (XY plane), a new fitting logic originated and the frame had 5 sides. This new logic of assemble with 5 sides was neither generic nor universal, since in certain moments the assembly logic had to undergo modifications.

We solved this situation by always adopting the frame with 6 sides, an even number (2 of them overlapping, which facilitated the floor execution and fastening), in this way the logic of fittings became universal and we can apply it ad infinitum.

We made five types of fastening throughout the pavilion, three of them to connect the frames together and two to fit the boards into each frame. We establish the connection between frames through single and double spacers, positioned due to the interlayer of the battens; from the point of intersection of slats of different frames; and the locking of the floor, made by infinite screws. We determined the connection inside the frames by the passage of four screws at each end of the battens, which could be lowered (type A screws) or not (type B screws) depending on the existence of conflict with the previous frame.

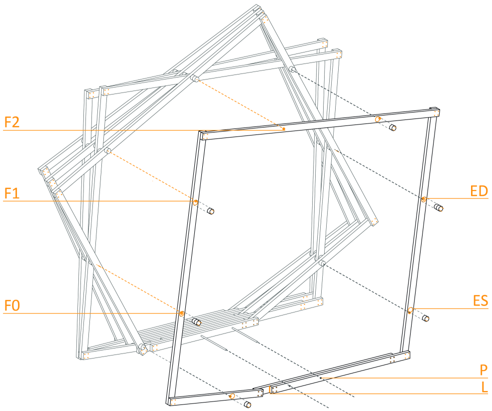


Figure 4
Diagram of connections and fastenings

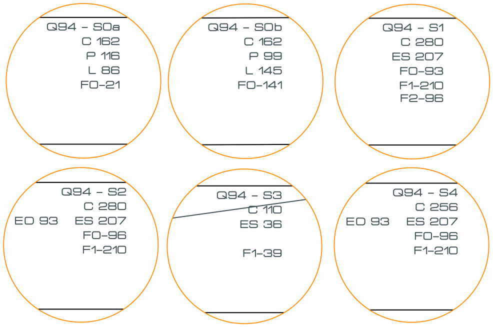


Figure 5
Frame #94 mounting instructions

We thought about the manufacture in a productive logic. As we do not have the Hundeger K2 Robot machine, which would allow the digital manufacture of the slabs, not even a CNC, so we looked for an economy of means. We organized the manufacture and assembly in 9 steps: 1) Marking on the laser machine; 2) Slab marking by hand; 3) Slab cutting; 4) Slab drilling with jigs; 5) Spacers placement; 6) Frames organization; 7) Frames transport; 8) Frames assembly; 9) Frames placement; 10) Pavilion assemblage (Fig. 6).

1 - Marking in the laser machine: due to the intercalated rotation of the frames and their section (with the xy plane) to form the floor, the connection of the floor with the other slabs made different angles, making it difficult to design a common template. Therefore, we used the laser marking to draw in the floor slabs the projection lines of the upper slabs, adjusting the parts position;

2 - Slab handwriting: we created a vocabulary of assembly with all the fixations and information necessary so that the students could draw and mark each slab. Considering always from right to left we marked the following information: the board number (Q), slab name (S0a and S0b for the floor, S1, S2, S3 and S4 for the others), slab length (C), intersection point of slabs of different frames (F0), single spacers center of the front frame (F1), double spacers center of the front frame (F2), projection of the simple and double spacers (ED), axis of the infinite screw of the floor (P), projection lines of floor (L). We gather all this information in a table distributing it to every students group.

We produced this vocabulary during the assembly of mockup models that made possible to understand the rotation and the behavior of the geometry, to verify the importance of each marking and to simulate the assembly of the pavilion, foreseeing possible difficulties

3 - Slabs cut: using the line marked by the students on the slabs (C) cut in the circular saw;

4 - Slabs drilling with jigs: marking the holes (F0, F1, F2, P, screws type A and screws type B) on the table drill;

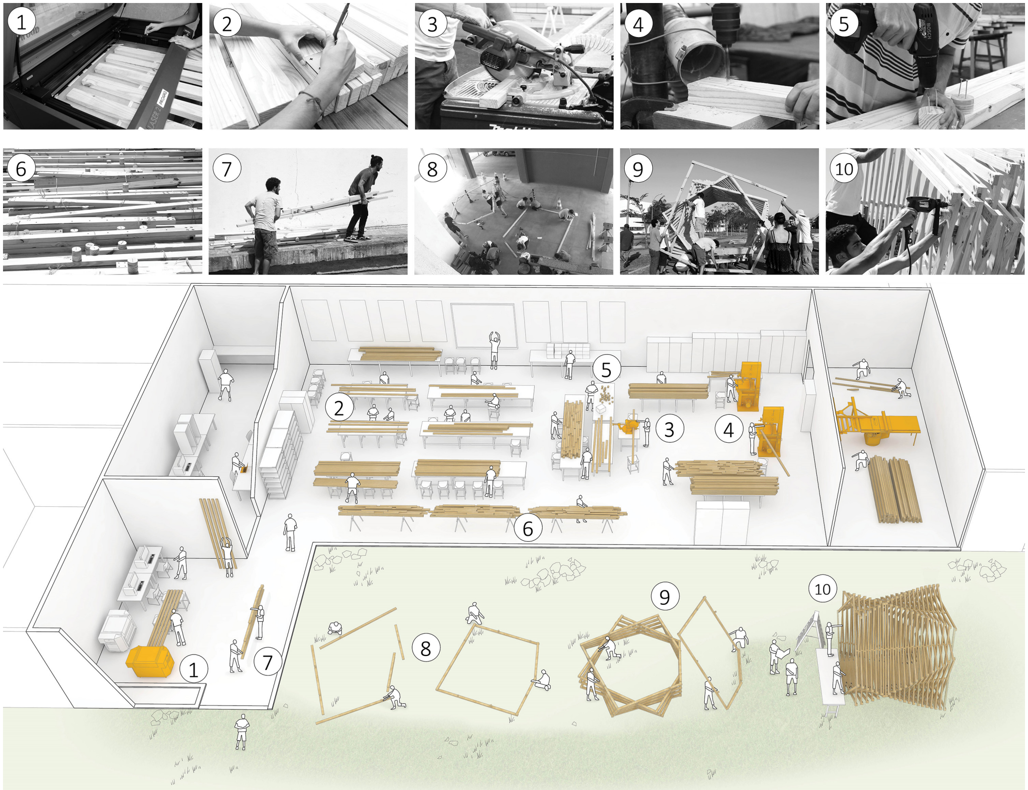
5 - Spacers placement: in the designed projections, we placed the single spacers (ES) and the double spacers (ED);

6 - Frames organization: we grouped the finalized slabs and prepared for transportation;

7 - Transport frames: displacement of all the frames from LAMO to the Technological Park;

8 - Frames Assembly: due to the asymmetry of the pavilion and its manual assembly by different students, it was necessary to produce an assembly notebook. In it, each we drawn each board with all text and marks in the slabs so that the students could follow the map.

Figure 6
Assemblage diagram



9 - Frames Positioning: we use the F0, F1 and F2 holes to adjust the positioning of each frame with the next frames, performing a geometric triangulation.

10 - Pavilion Assembly: final placement and fastening of the frames.

The pavilion remained for 18 months in the open air, installed in the Technological Park of UFRJ, changing the routines of the place. The intervention meant an ephemeral experience whose objective and subsequent result, besides attending to the task requested, generated knowledge. By bringing together "bottom-up" collective design and construction in a do-it-yourself process, the experience puts both the precepts of tactical urbanism and temporary interventions in practice, as well as to learn the design, fabricate and assemble, in 1:1 scale.

Technology and human expanded abilities

Both in the complicity Mies design and in the simplexity of the Tornado Pavilion we identify the concept of human expanded abilities. Mies in search of an aesthetic of almost nothing and the Tornado with the condition of scarcity of resources and technological limitations. The context made us design and produce considering the human expanded abilities that in both cases unfolds creative solutions.

Still in the context of complexity in architecture, post-Venturi, different areas of Design Think-

Figure 7
Tornado inner vortex, photo. Protection, dynamic shade and breeze. Photo Stefan Kasmanhuber

ing and Design Cognition, rethought design complexity starting with the design concept as an Artificial Science (Simon, 1969). This idea gained new support with the reformulation of the generative systems and the computational tools and processes that enable a synthetic evolution of the project, generating new species and families of solutions. In this sense, research goes in the direction of Design as a complex, comprehensive and innovative activity capable of contributing itself to the "science of complexity". Other sciences face also the same challenge:

"Simplexity may be defined by the combination of simplicity and complexity within the context of a dynamic relationship between means and ends. The quest for simplicity constitutes the basis for all future challenges of organic synthesis: diversity, selectivity, green chemistry, and beauty. Due to the infinity of structures, i.e. properties, that has to be discovered, the focus of synthetic research is shifting gradually from target-oriented synthesis to diversity-oriented synthesis." (Compain, 2004).

This description from organic chemistry can summarize the SIMPLEXITY of the Tornado Pavilion approach. That is also focused on the idea of diversity-oriented synthesis, which goes in the direction of "human expanded abilities" that go against the idea, somehow dominant that the advance of technique per si is a convergent and unidirectional advance. On the contrary, we encourage considering various techniques - disagreeing with the dominant image of unidirectional progress, of an artificial intelligence without context - but rather lead considering

Figure 8
Tornado pavilion and the group swarm. Photos Stefan Kasmanhuber

the advances to include the human and cultural context in the technical evolution (Henriques, 2016).

In this sense, the Tornado is a simplexity crafted that results from a bottom-up process of a collective, a group of laboratories, and a swarm of motivated, technology-enhancing students. That is, instead of thinking only of augmented technology - for example, by completing the human vision with augmented reality - we present the counterpoint, which is technology augmented by human bottom-up action. In the context of technological shortage, this alternative is a synonym of creativity and overcoming. In this sense, we emphasize the importance of assigning a meaning to the technology that locates it. In the above context of "economy of necessity", we are the robots of this swarm. Give meaning to technology and its practical application, it is undoubtedly a necessity, given the extensive disruptive advance of the fourth industrial revolution.

TECHNICAL CREDITS

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REFERENCES

Carmo, C 2018, *Design Computacional e Performance Acústica.*, Master's Thesis, Rio de Janeiro Federal University - PROARQ

Carter, P 1999, *Mies van der Rohe at work*, Phaidon

de Certeau, M 1999, *The Practice of Everyday Life*, Berkley: University of California Press,

Dunster, D 1994, *100 casas unifamiliares de la arquitectura del siglo XX*, Gustavo Gili

Fontes, AS 2013, *Intervenções temporárias, marcas permanentes. Apropriações, arte e festa na cidade contemporânea*, Casa da Palavra

Fontes, AS 2018, 'Urbanismo tático para requalificação gradual do espaço público metropolitano: O caso do Park(ing) Day no Rio de Janeiro', *Arquitetura revista*, 14, pp. 91-104

Henriques, GH 2017, 'Incorporating information technology in a network condition', in Celani, G and Kanoun, O (eds) 2017, *Selected extended Papers of the 7th Brazilian-German Conference, Campinas 2016 Brazil*, De Gruyter, Campinas, pp. 169-85

Kolarevic, B 2016 'Simplexity (and Complicity) in Architecture', *Proceedings 34th eCAADe Conference*, pp. 25-31

Lydon,, M and Garcia, A 2015, *Tactical Urbanism: Short-term Action for Long-term Change*, Island Press

Mendonça, D, Passaro, A and Henriques, GC 2018 'WikiHouse: A Generative and parametric tool to customize curved geometries', *Proceedings XXII SIGRaDi IAU-USP*, pp. 714-718

Montaner, JM 1996, *Less is More*, Col.legi d´ Arquitectes de Catalunya y ACTAR

Oxman, R 2006, 'Theory and design in the first digital age', *Design Studies, Elsevier*, 27, pp. 229-265

Rhode, C 2018, *Design Computacional e Fabricação Robótica*, Master's Thesis, Rio de Janeiro Federal University - PROARQ

Simon, H 1969, *The sciences of the artificial*, MIT Press

Terzidis, K 2014, *Algorithmic Architecture*, Routledge

Venturi, R 1996, *Complexity and Contradiction in Architecture*, The Museum of Modern Art, New York