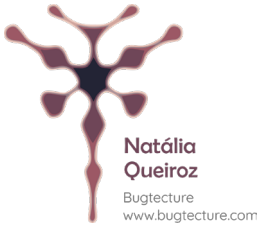
NATALIA QUEIROZ: Nature as a measure of efficiency



Natália Queiroz is a multidisciplinary Architect, researcher, and visual artist. Her interest in nature as inspiration began by having contact for the first time with bioclimatology, even before graduating as an architect and urban planner in 2009. This was also the beginning of her research activities in the area. Bioclimatology is a term created in 1963 by Victor Olgyay and addresses the intersections of four fundamental areas for architecture: architectural design, climatology (climate patterns and characteristics), technology, and biology. Over time, the term became primarily associated with the intersection between architectural design and climatology; but for Natália, biomimicry applied to architecture was the link that Victor Olgyay envisioned when he included biology in the diagram.

In her master's degree in product design from the Federal University of Pernambuco in Brazil, she began studying Biomimicry. Nature serves as a reference for geometry studies, but primarily it serves as a source of systemic and performance inspiration. She believes that design can be an interconnected system that incorporates aspects of performance and optimization, similar to nature. Everything in nature has an optimized reason and function. She is currently a PhD candidate in Architecture and Urbanism at the Federal University of Santa Catarina (UFSC), researcher at the Environmental Comfort Laboratory (Labcon - UFSC), and affiliated researcher at Lawrence Berkeley Laboratory, USA (2020-2022), and part of the research group Performance and Innovation Applied to the Design (DiaProj - UFPB).

Natália has experience in research in environmental comfort, environmental performance computer simulation, energy efficiency, parametric modeling, sustainability, and biomimicry applied to building design. She is currently researching performance-based design processes that consider data integration with parametric modeling, performance requirements, and optimization. She has worked professionally on building retrofits and participated in various research projects, scientific publications, and creative projects. She has received awards in research, architectural design, and industrial design.

Dra. Natália Queiroz

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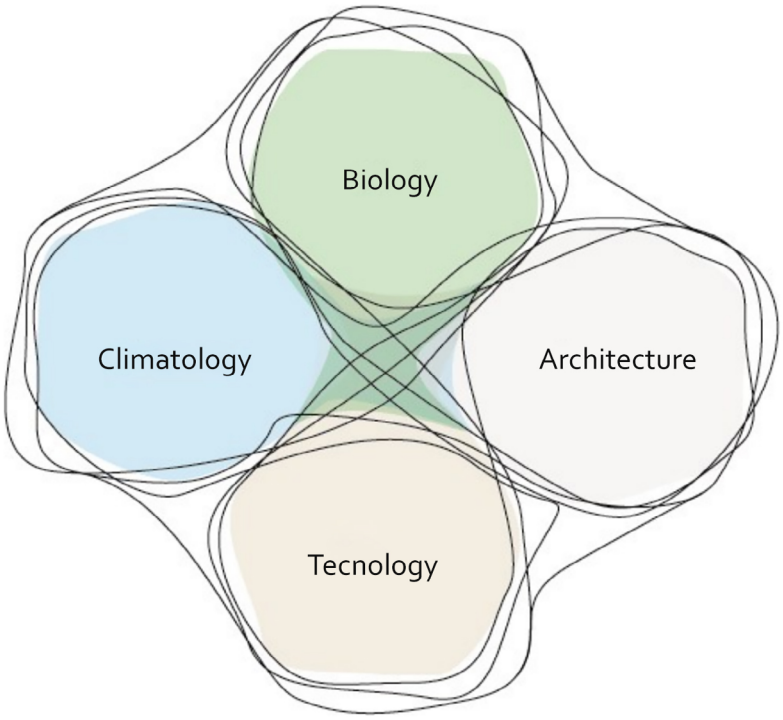

Image 1. Bioclimatogy diagram. Font: Adapted from Victor

Case 01 – Leaf Brick, 2015

Natália Queiroz, MsC.

Ney Dantas, Ph.D.

The disconnection between the built environment and the natural environment creates several imbalances, one of the most well-documented being the heat island effect in urban areas. The energy imbalance caused by impermeable surfaces and the building materials used in architecture increases the temperature in the urban microclimate. The alteration of the water cycle in the built environment is a contributing factor to this energy imbalance. The design concept of the Leaf brick was born from the search for solutions to heat island problems.

The design is inspired in the cooling system of trees and leaves, that involves micro systems, water, and solar radiation balance. It was developed a prototype of a modular shading device system that use the sun's own radiation for evaporative passive cooling, it is biodegradable and consider cycle economy applications. Leaf brick considers natural fibers, bioplastic and a hydrogel, a polymer that absorbs and stores 400 times its

weight in water from the air. The mixture resulted in a flexible compound that use the air natural humidity, and works for the Brazilian coastal climate very well to cool buildings surfaces, also to generate green facades, or to incorporate in urban furniture. The brick system can be fabricated using traditional forming technique and allowed the creation of curved surfaces and complex geometries. The controlled laboratory tests had very promising results: a comparative test with reflective materials, which are recommended for reducing the heat island effect, showed a reduction in heat transmission. This resulted in a decrease of up to 10°C for the Leaf brick. This project ended up winning a traditional prize in Brazil, *Museu da Casa Brasileira* award, in product design in the prototype category (2016).

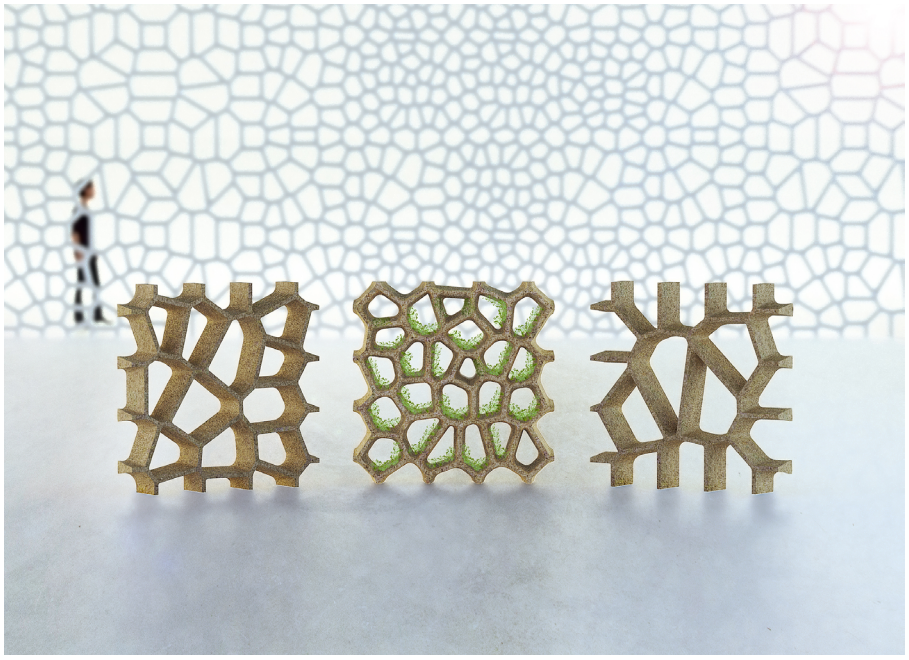

Image 2.
Leaf brick concept

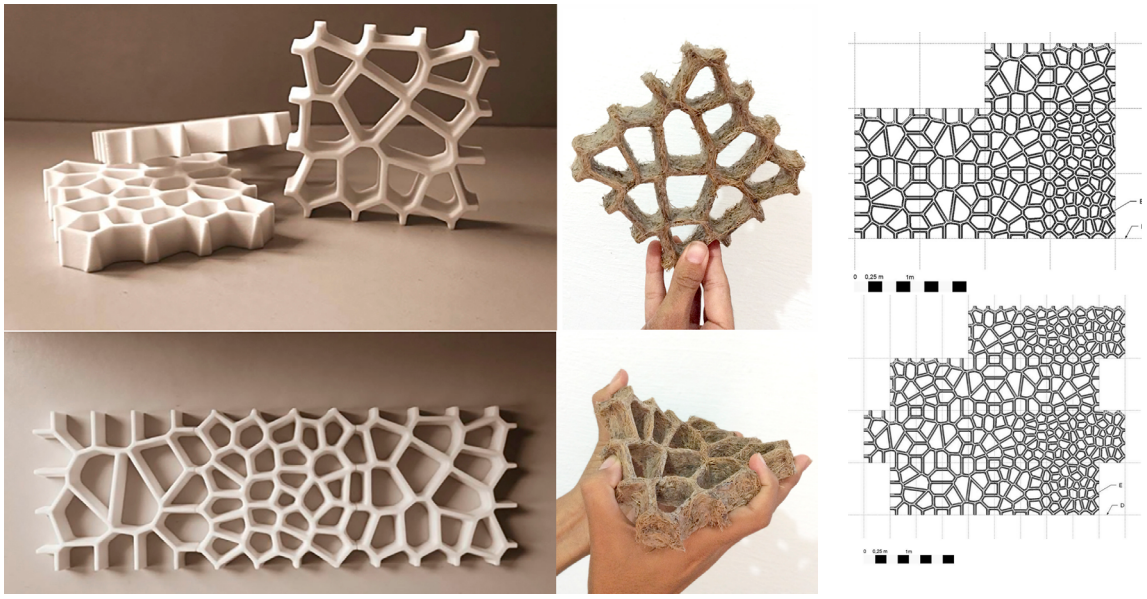

Image 3.
Leaf brick. Scaled prototype and modulation study.

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Image 4.
Application ideas

Case 02 – Building skins based on performance (2022)

Natália Queiroz, MsC.
Fernando Oscar Ruttkay Pereira, Ph.D.

One of the main elements related to the building efficiency is the facade design. It is the skin that filters and promotes the interaction between the interior and exterior of the building. During its conception process, one must understand the environmental patterns, observe the incident climate, and propose solutions that take advantage of the climate benefits and avoids bad situations. Facades are composed of opaque and transparent elements, closed and open elements as well. The openings are the components that promote the strongest connection between the external and internal environments. Due to this characteristic, it is crucial to understand the physical behavior to establish solutions that are not only based on aesthetics but also on performance.

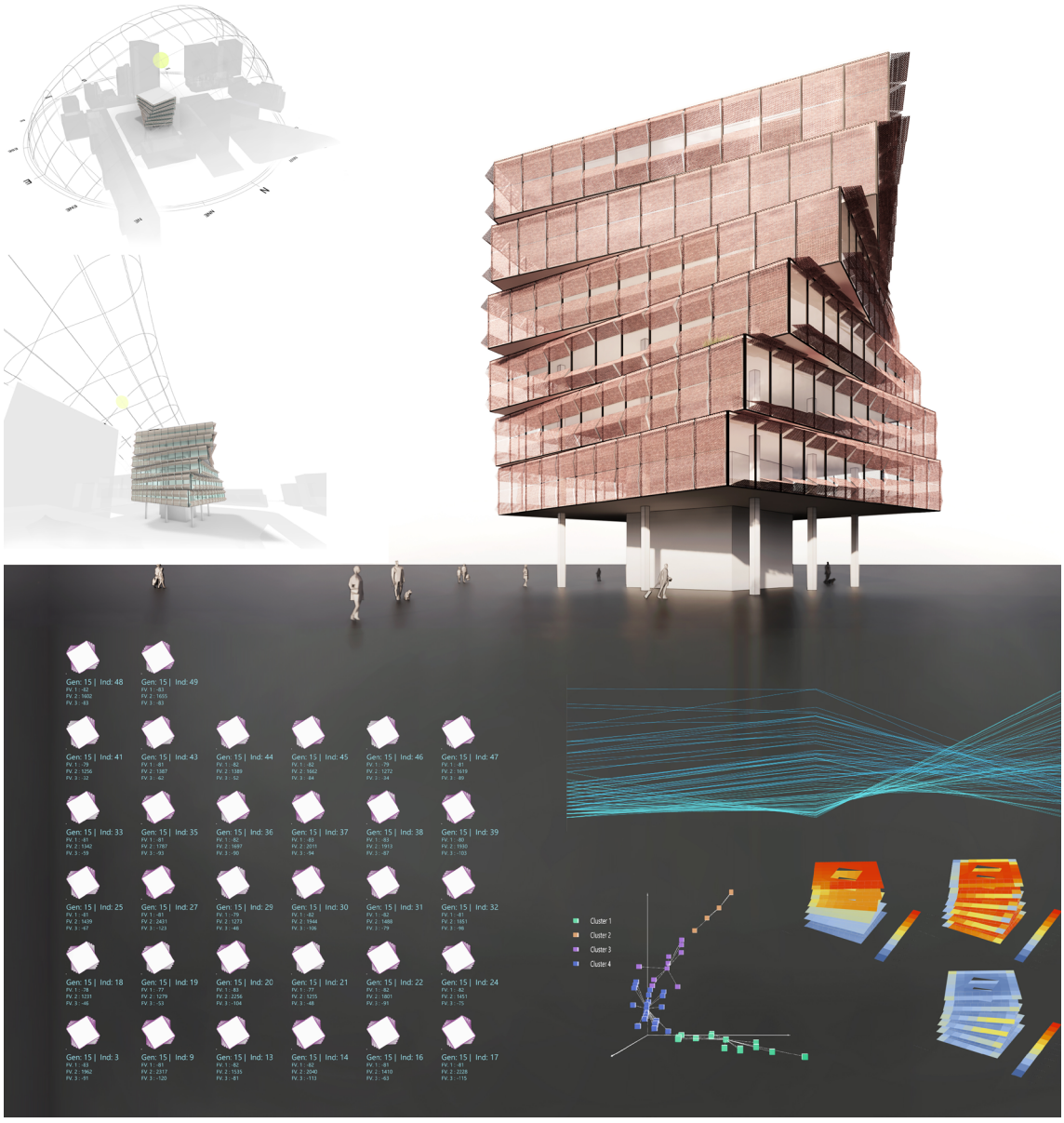
The goal is to explore building skin design and the building envelope in relation to sustainability and performance. This involves studying relevant physical phenomena to gain a deeper understanding of design processes based on performance and optimized skin solutions. The focus is on thermal, daylighting and visual performance, which encompasses all phenomena related to the interaction between the sun and the indoor environment. At the end of 2020, the research proposal was one of 15 selected worldwide in the first World Ph.D. Workshop organized by the sorority of digital graphics societies. It was one of the representatives of SIGraDi (The Iberoamerican Society of Digital Graphics). The research is divided into three main themes:

1. The first theme explores the building skin and window design. It intends to establish a systematic view of the design and physical aspects that involves the building envelope. The objectives are to establish design relationships and to answer how the envelope design impacts on indoor performance, human behavior, comfort and health.

2. The second, concerns the performance-based parametric modeling strategies for solar control devices (shading devices, and translucent materials). It considers strategies for optimization processes and the characterization of flexible patterns, thermal characteristics, optical characteristics, and geometrical aspects relevant to the performance of solar control devices.

3. The third theme involves the methodological structure for multicriteria simulation in support of the architectural design process. This step establishes representative performance criteria and simulation settings applicable to interoperability, fast analytical cycles, optimization process fitness, solution selection, and simulation model validation.

Image 5. Building skin optimization.



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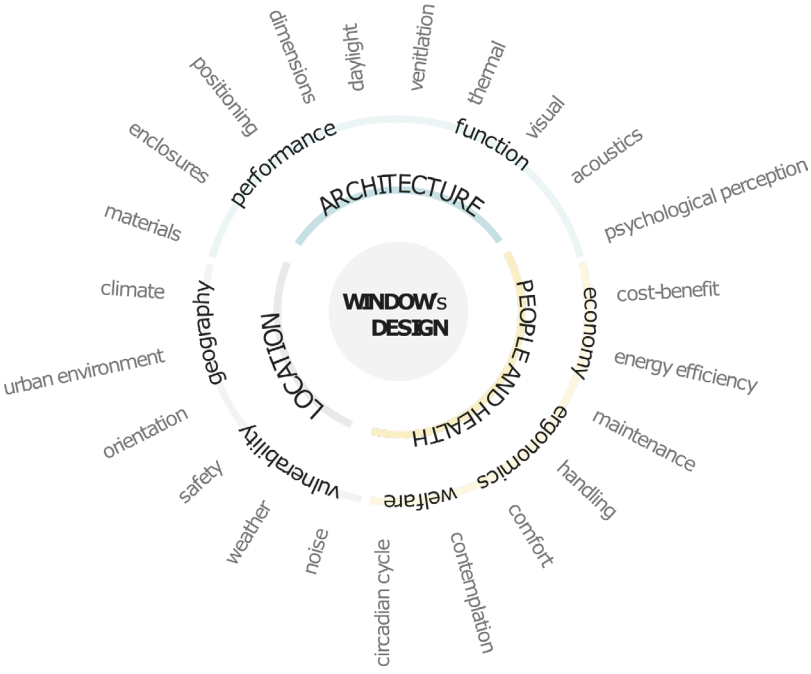


Image 6. Building skin in a systematic point of view. It is fundamental to understand the physical behavior to design an integrated building skin solution.

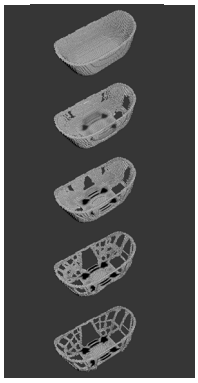
Case 03 – Product Design

Natália Queiroz, MsC.

The optimization processes and the geometry principles studies inspired by nature also generated other cases in product design field. Among them, there is furniture explorations and jewelry designs. The common link in these projects is the parametric/algorithmic, and the mathematical modeling of the geometries, always inspired by nature principles. The selected images highlight part of these explorations. Among them are 3D-printed jewelry inspired by natural geometric principles, such as cellular groupings, symmetry, harmonic patterns, fractals, and the

logarithmic (golden) spiral. In furniture, stands out the digital prototype of a crib inspired by the butterfly wing. The geometry is the result of topological optimization considering the structural efforts on the proposed form.

Image 7. Nature inspired geometry studies applied in Jewelry design.



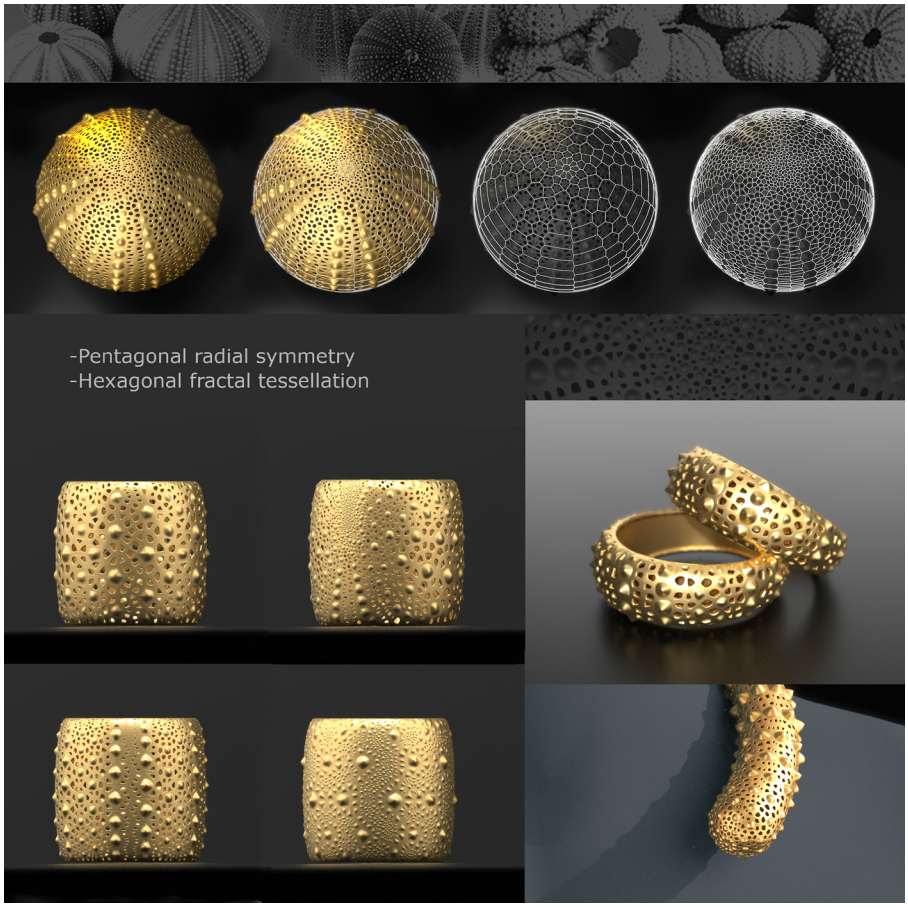


Image 8.
A crib for Helena. Topological optimized crib inspired by a butterfly wing.

Image 9.
Parametric tesselation study inspired by the sea urchin skeleton for jewelry design applications.

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Case 04 – Teaching experience

Natália Queiroz, MsC.

Natalia also works as academic faculty. Professionally, she worked at the Federal University of Paraíba, Federal University of Juiz de Fora, and Pontifical Catholic University of Minas Gerais. She ministered workshops at the Federal University of Santa Catarina, and in events, such as in the three editions of DigitalFutures World. Her workshops have diverse themes and range from parametric modeling principles to performance-based design principles. She has taught disciplines such as Introduction to Plasticity, Environmental Comfort, Building Design, and Energy Efficiency applied to Parametric Modeling. Biomimetics is always the background of theoretical and practical classes. The selected images highlight only a few initiatives. Image 10 shows a model of a kinetic facade that is responsive to the sun in order to avoid glare and human proximity and movement (2018).

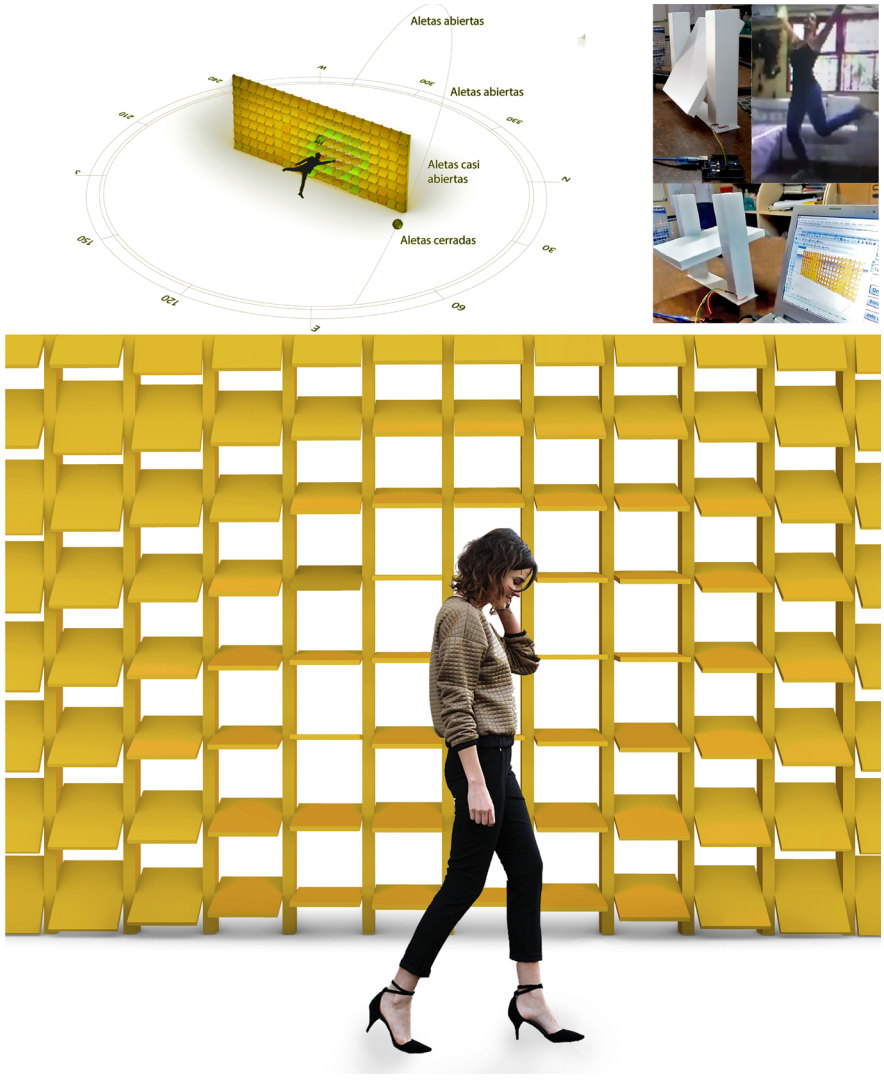

Image 10. Functional digital prototype of a responsive kinetic wall used in workshops. Authorship: Natália Queiroz and Jessica Carvalho.

The digital and physical prototype is used in her workshops and is available for free in her blog (http://www.bugtecture.com). Image 11 shows one of the results of a Lamp Workshop held at Pronto 3D – Florianópolis (2018) for students with no contact with parametric modeling. Image 12 shows a student prototyping a physical model at the Federal University of Paraíba in the class of Introduction to Plasticity (2016).

Image 11. Student work, Uirá Duarte, UFSC. Workshop of Parametric Lamps for students with no experience in parametric modeling at Pronto 3D Florianópolis - Brazil

Image 12. Student in the Introduction to Plasticity workshop, UFPB.