Design in the Digital Age

Technology
Nature
Culture

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SITdA Società Italiana della Tecnologia dell'Architettura
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Il Progetto nell'Era Digitale

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La pubblicazione raccoglie i contributi di studiosi, *PhD* e ricercatori che hanno risposto alla *call for paper* promossa dalla SIT*d*A in vista della conferenza internazionale "Design in the Digital Age. Technology, Nature, Culture", che si terrà a Napoli l'1 e il 2 Luglio 2021.
I saggi raccolti in questo volume costituiscono un insieme di idee, riflessioni, posizioni e proposte che, nel quadro della crisi epistemologica che investe le ragioni, il senso e le strutture stesse del progetto, possono aiutare a comprendere in che modo la svolta digitale sta trasformando profondamente il ruolo della cultura progettuale nel rapporto tra tecnica e natura in una transizione storica caratterizzata da cambiamenti climatici e sociali con enormi ricadute di tipo politico, economico e produttivo.

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The publication collects the contributions of scholars, PhD and researchers who participated in the call for papers promoted by SITdA for the international conference "Design in the Digital Age. Technology, Nature, Culture" to be held in Naples on 1 and 2 July 2021.
The essays in this publication provide a set of ideas, reflections, positions and proposals that, in the context of the epistemological crisis that affects the reasons, the meaning and the very structures of the project, can contribute to understand how the digital shift is deeply transforming the role of design culture in the relationship between technology and nature in a historical transition affected by climate and social changes with enormous political, economic and productive consequences.

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Indice

The ECAlab Experimental Project: Opening to Digital/Traditional Culture

Paola Ascione[1]

Abstract

The new digital technologies for prediction and control of form and performance often enter the design process directly, risking the development of autonomous processes distant from the architectural objectives. Instead, these new instruments could allow us to open to new developments in the design experience. The Environmental Ceramics for Architecture Laboratory (ECAlab), of the Liverpool School of Architecture, combines design, research and training, materiality and immateriality, science and art, tradition and digital technologies, all responding to the urgent need for sustainable development.

Keywords:Architectural components, Environmental ceramics, Digital fabrication, Craftwork, Parametric design

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The risks of solely technological action

In contemporary architecture, the application of new technological solutions is facilitated by the use of computer tools in the design phase, allowing elaboration of shapes, simulation of behaviours and "virtual assessments" of the performance of the real object. The degree of sustainability achieved in the technology of architecture (materials, executive techniques, installations), however, depends on the development of innovations compatible with the environmental context, and the computerisation of the project tends to shift the architect's action to the virtual context, thereby risking conflicts between the "technological action" and "responsible action". In the current era, it is thus the development of new ethics of technologies (Fabris, 2012) that opens the way to equally new developments in architectural design, aimed at achieving a renewed balance of the architecture-technology-environment relationship, and giving new life to the design experience.

The more valid approach, in the technological culture of contemporary design, would be to recognise the priority of the "ecological challenge", without renouncing the "technological challenge", adopting computer technologies as tools but still privileging the environmental issue. In this way, contemporary design can enter more fully in the complex "technological question" (Maldonado, 1994), exploiting the invaluable opportunities of experimentation represented by the design phase. Instead, the first studies on the introduction of computer technologies, from building information modelling (BIM) to 3D printing, often immediately assumed these tools in support of design and production, without thought of the greater issues. More recent lines of research bring together virtual, real, theoretical and practical aspects of design, demonstrating how technological innovation can trigger innovation, from the ways of designing to the final built architecture. This is the case of ECAlab (Environmental Ceramics for Architecture Laboratory) a research centre for the design of high-performance building envelope components: an atypical atelier, initiated by an international group of researchers and companies.

A laboratory of tradition and emerging technologies

The aims of ECAlab, established in 2011 at the Liverpool School of Architecture, are to investigate the potentials of emerging computer technologies in the production of ceramic components, and ultimately the potentials of clay as a material for environmentally sustainable architecture. ECAlab, also sponsored by the Association of Spanish Ceramic Tile Manufacturers, networks with the School of Architecture of Harvard University, Darmstadt University, and with a number of universities in both Spain (Alicante, Barcelona, Castellón, Madrid and Valencia) and the UK (Leeds Beckett, Liverpool Hope, Glyndwr). The combination of directors underlying ECAlab is certainly unique: Rosa Urbano Gutiérrez's interests centre on the exploration of emergent materials and technologies in sustainable design, environmental and energy management, while Amanda Wanner has long focused on aspects of social responsibility through architecture, relying on collaboration with artists and craftsman as central to these aims. In combining these experiences and aims, ECAlab has developed a series of research programmes in innovative components for the structural envelope, examining the role of emerging technologies of digital design and fabrication, but also combining the knowledge and practices of the artisanal traditions. The teaching programme is research led, but brings in different knowledge areas and levels of practical operation: high-profile architects, factory directors, engineers, software specialists, ceramic craftworkers and artists. The holistic approach assumes the design phase as a central place of development and growth of communities, and requires constant updating, in line with the rapid evolution of computer technologies. At the same time, the environmental perspective deepens complex issues in the technological culture of the project, in particular the compatibility and interoperability of different softwares and their potential for results in quality of design and final product. The central aim, of improving daylighting and control of solar radiation and its related functions of comfort, serves as the fulcrum for two other main experimental objectives: investigation of the translucent and insulating properties of ceramic materials and their potential configurations in high-performing systems, and finally the development of a design methodology that balances the triple contributions of advanced technologies, artistic creativity and artisanal know-how. According to the founders, ECAlab «seeks a holistic approach, not only to the subject matter, namely sustainability, ceramics and digital design, but to design that engages the designer (architect), the maker (ceramist), and the analyst (engineer), whereby we contemplate not only the embodied energy, but also the embodied identity» (Gutiérrez and Wanner, 2016). The aim is to reach higher performance levels, but the process involves changes in production, from the design of the component to the architectural solution, in continuous feedback between real space and the digital environment.

Experimental progression

Since its founding in 2011, the Liverpool group has engaged in a sequence of several research programmes. The first, *Illuminating Through Ceramics*, was open to exploring any possibilities of ceramic light-control systems and building-system components. In the following two years, the *Performative Ceramics Screens* programme turned to a tighter focus on the design of a light-diffusing ceiling capable of filtering and uniformly redistributing daylight, by means of texture and multiple reflection in 3-dimensional tiles. Eighteen tile designs were developed using Rhinoceros and Grasshopper software, each in five iterations, for analysis of form/performance relationships. Through parametric design, the researchers developed varying geometries and surfaces, using 2D ray-tracing to assess their performance in reflection and propagation of light. This process leads to the selection of designs with greater commercial potential, for potential submission to prototyping and then measurement on finished products.

The use of digital optimisation technologies in the design process, such as parameterisation and environmental simulation, is not conducted in isolation, but rather with a view to integrating and improving design processes of "traditional" ceramic building components. Examples would be the integration of mainstream fabrication techniques such as extruding or slab forming with technologies of CNC milling and cutting, or 3D printing, leading to practicable manufacturing solutions. The aim was also to search for potential integrations between advanced technologies and techniques originating in centuries of craftsmanship, ensuring high quality production that could still retain the sculptural and artistic properties inherently expressed through "hand skill" (Tab. 1).

The ECAlab team therefore identified four approaches to prototyping ceramic components: from the most traditional *hand caressed*, to *hand tooled*, to the already common *robotically tooled*, and finally to *digitally automated 3D printing*. The aim was, by testing to the two more traditional approaches, to identify possible combinations between artisanal practices and technologically advanced procedures, elaborating the qualities of the manually produced component and refining it with the adoption of new production tools, always in search of tangible, economically viable manufacturing and construction solutions.

Case Study	Digital Modelling	Lighting Performance	Fabrication
Tessellating Hexagonal Curtain	AutoCAD/Sketch-Up	Ecotect	Hand Building
Cruciform Helix Surface	Rhinoceros - Grasshopper	Grasshopper - Geco -Ecotect	CNC Milling, Laser Cutting, Extrusion, Extrusion Forming and Hand Throwing
Sinuous Cone Surface	Rhinoceros - Grasshopper	Grasshopper - DIVA	CNC Milling, 3D Printing, Slip Casting

Tab. 1

Among the key objectives were the optimisation of design and computer processing time prior to manufacturing, and of costs (at that time very high for 3D printers). One quickly emerging observation was that such costs would in part be dependent on the level of interoperability between any software used in support of the design process and that of the environmental performance

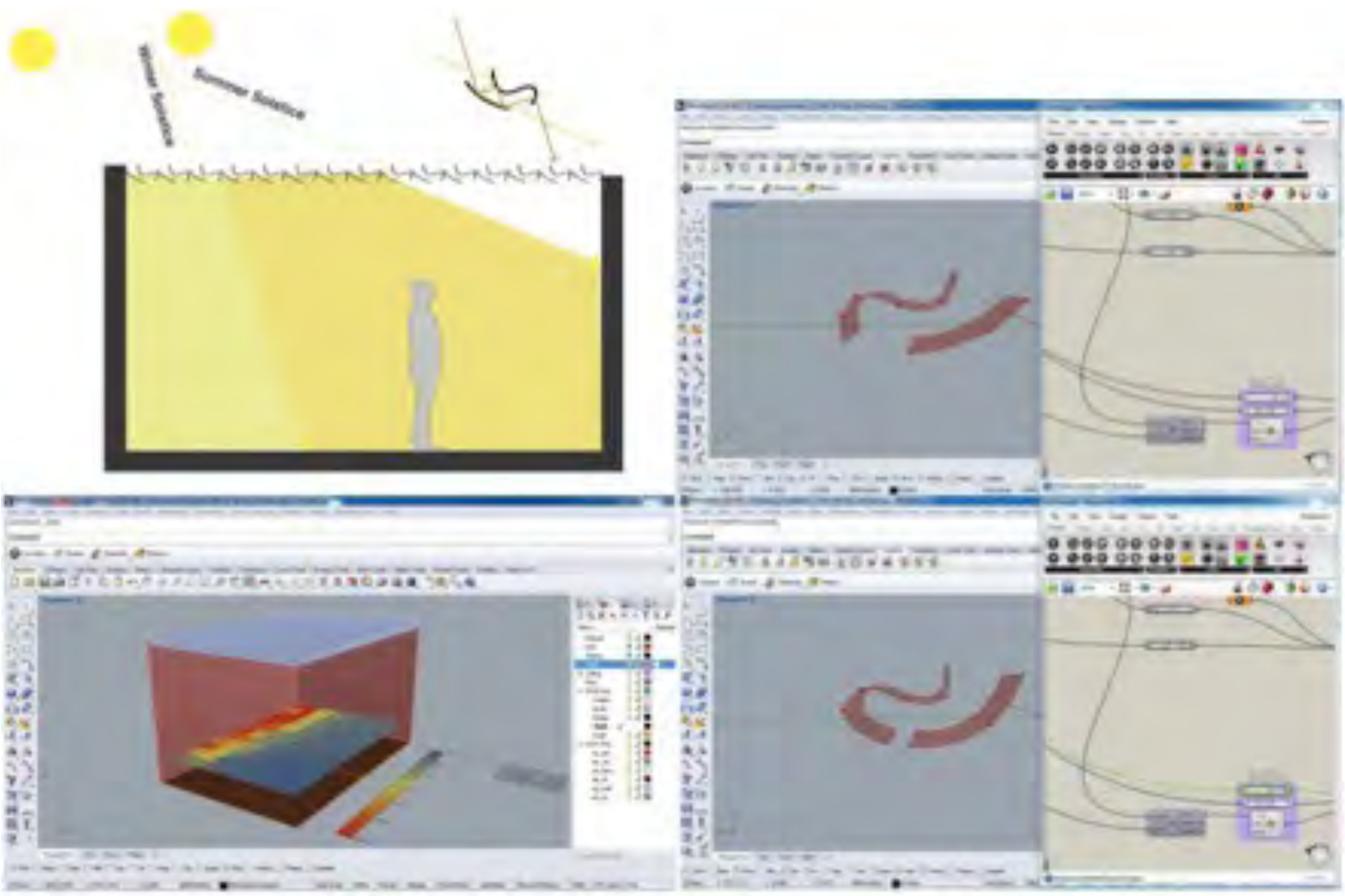

Fig. 1

evaluation (Fig. 1).

The *Tessellating Hexagonal Curtain* case study took an essentially "hand caressed" approach, to the production of 28 planar hexagons which could then be attached to metal bars using revolving fixing, forming a vertical curtain for control of light, by concentrating or distancing the elements in a particular area of glazing. This dynamic system, composed of two-dimensional of simple geometry, did not require parametric modelling, but paradoxically the very absence of parameterization «made feedback from the lighting simulation slower, demanding more time to inform and optimise it» (Guitérrez and Wanner, 2016).

The *Sinuous Cone Surface* project instead took the "hand tooled" approach to the fabrication of translucent white pipe-like elements, capable of capturing, reflecting and directing light to optimise its diffusion (Figg. 2, 3). The profiles were developed using the Grasshopper parametric grid, and their daylighting behaviour could then be assessed using DIVA. The 3D model of the conical element was exported for 3D printing, and this print was in turn used to produce a slip-casting mould, using a series of precise and time-tested artisanal processes and intermediate stages. Although the slip-casting production method "is labour intensive and expensive", it also "allowed an almost perfect translation of the original 3D model", and «still proved more cost effective and time efficient in comparison to 3D printing in clay» (Gutiérrez and Wanner, 2016).

Parametric design allows to define a basic shape that can be virtually replicated in several alternatives, all verifiable by data analysis. Once the solution has been chosen, further variations can be proposed, according to the creativity of ceramic artists, enriching the design with a range of solutions.

Over the years, the developments in software have allowed the ECAlab team increasing control over the convergence of material, shape and environmental performance. The latest project, called *Interface Soundscapes*, ECAlab's latest project (Gutiérrez and Wanner, 2014), extends the performance of the component to the realm of sound, inserting microchips and artificial light within the cavities of multiple ceramic "earshells", assembled as a "sensorial wall". The translucent porcelain elements developed through laboratory experimentation go beyond aims of daylighting, creating a stimulatory, interactive installation that transports the individuals elsewhere, among known and imagined environments (Fig. 4).

The ECAlab research experience thus began with investigating the digital possibilities for innovating the design process, the ceramic product and final structure, but now extends the experimentation to new fields of investigation. The artistic installation of the interactive wall is in reality not far from the original research concept, since the environmental performance of the ceramic component still remains central, but now includes a performative aspect. Environmental performance is updated and "amplified" to a contemporary vision of buildings, having a life of their own, returning emotions and sensations that go beyond those of the sphere of the visual, and far beyond solely "climatic" parameters. Through sound, the "building wall" becomes a place of experiential connection, serving as prototype architectural component embodying all the complexity of the contemporary world, and opening new scenarios that push beyond the goals of uniting craftsmanship, digital fabrication and manufacturing.

Time has passed since the founding of the ECAlab project, yet the problems of environmental performance, and opportunities of interoperability, still confront the worlds of architectural design and industry.

Most of the materials and processes of more recent energy-control technologies themselves represent high embodied energy, with negative impacts on the environment, therefore we must continue to also explore and develop our traditional materials, and draw on the knowledge of craft practices for their proper and successful use.

Where craftsman meets computer

Before we proceed with any further technological experimentation, however, some questions arise as to the ultimate goals of architecture. Indeed, the current environmental imperative requires the development of a new design culture, integrating the tangible and intangible. The theorists, researchers and practitioners in the technology of architecture must critically examine the procedures, systems, processes and materials of building, and set the conditions for the advances, transformations and improvements sought through for innovation. In this way we can help chart the course of change through experimentation and the "invention" of buildings in harmony with natural systems.

The ECAlab experience serves as an important example of innovating our ways of thinking about the design of "sustainable" components. The laboratory platform, in the process of prototyping elements for industry, follows a process relying on both material and human resources to develop new ways of creating and making objects that are sustainable (Gutierrez, 2018). This is perhaps the greatest contribution of ECAlab, serving as a replicable but open-ended model of a research structure, simultaneously operating in higher education,

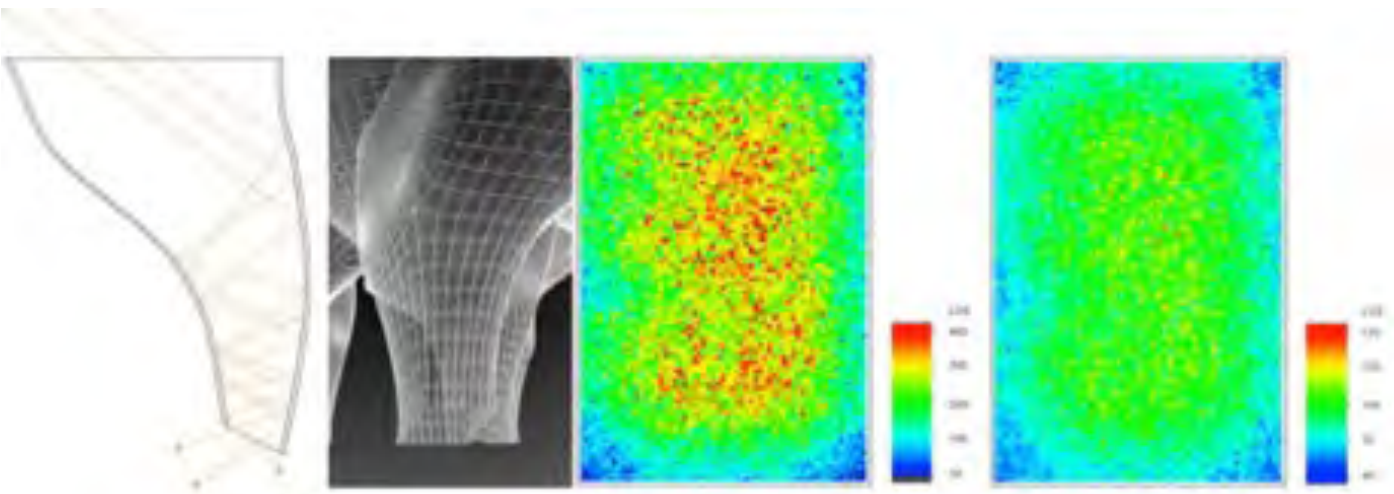

Fig. 2

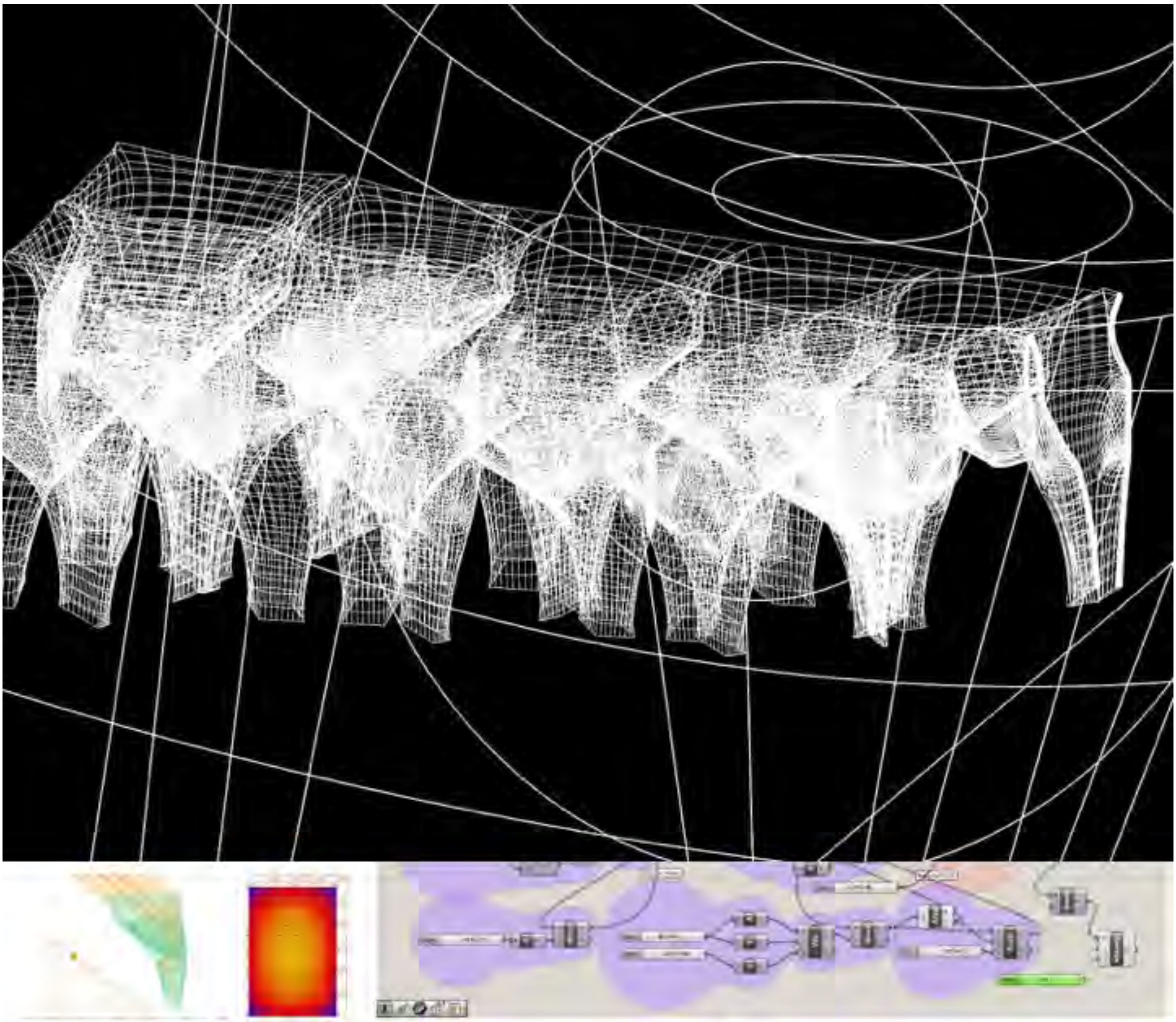

Fig. 3

the coordination of skill and knowledge networks, instilling development processes in small-medium enterprises, and the provision of operable prototypes to industry.

In the ECAlab experience, one of the most interesting observations is that of the range of potential technological solutions identified, demonstrating the fact that successful product innovation depends on the combination of existing creative skills and of a complex mix of technologies, from highly traditional craft processes to advanced material chemistry and digital applications.

ECAlab's latest projects concern a louvre system (Gutiérrez, et al., 2019) and a new collaboration with Assemble/Granby Workshop to develop architectural components using recycled ceramics. The latter is a project within the framework of the Low Carbon Eco Innovatory, funded by the European Regional Development Fund, which has recently been awarded.

By the combination of matter and form through the aesthetics of play (Ortega, 2019) by simulation and data analysis, the architect can verify the intangible, the immaterial: the performance. But only the architecture realized will prove how much the quality of the component will affect the overall quality of the architectural product. In ECAlab the employment of digital technologies in the designing phase takes on an experimental character when consciously related to the "know-how", artisan logics of "doing well" (Sennet, 2008); manual skills give concreteness to the idea and perfect it by the application of technical innovation, which becomes part of the creative act itself. In this sense technology, meant as a process device, through the typical responsible action of 'doing well' can be placed with precision and measure in the experimental phase aiming at architectural innovation.

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Fig. 4

Fig. 5

Fig. 1 - Example of 2 Iterations in a design optimisation process using Grasshopper –Diva. ©ECAlab. Source: Urbano Gutiérrez, R. and Wanner, A (2016),

Fig. 2 - Sinuous Cone Surface project. 3d model with ray-tracing, and lighting performance for extremes of worst-case scenario: Liverpool, sunny sky, 12.00pm, 21st June (left) and 21st December (right). Source: Urbano Gutiérrez, R. and Wanner, A (2016).

Fig. 3 - Sinuous Cones production process: 3-d print model, generation of plaster mould, and slip-casting to obtain the final ceramic pieces. ©ECA-lab. Source: Urbano Gutiérrez, R. and Wanner, A (2016)

Figg. 4, 5 - Interface Soundscapes. The surface is created with 80 of the new ceramic earshells, forming a surface that is 90 cm high by 4.5 m long. 30 are active sonic and luminous chambers. Light attracts the viewers attention to different unknown locations. By listening to the shells, visitors will intimately travel throughout the city. The electronic and sensorised construction allows the user to impregnate the private and domestic space with urban and public qualities. ©ECAlab.

Tab. 1 - Parametric and environmental design and production methods experimented by the Performative Ceramics Screens research: "The three showcased production methods consider existing processes in a new way, and are successful for different reasons, having elements that we can capitalise on or develop further. Understanding the opportunities of these elements is what will give us new iterations in the future". ©ECAlab. Source: Urbano Gutiérrez, R. and Wanner, A (2016)