VIRTUAL SHAPE EXPLORATION PROCESS.

THE INTEGRATION OF ALGORITHMIC AND DIGITAL PROTOTYPING THINKING AS A DRIVING DESIGN METHOD.

Introduction

In this extended abstract, we would like to describe a teaching and research experiment which has been taking place in two Faculties of Architecture in Belgium for the last five years. This experiment focuses on discovering and exploring new design issues based on digital concepts and aims identifying and characterizing the design praxis shifts (mutations) by the digital culture integration. More precisely, this experiment aims at having students discovering and exploring design issues in the first stage of virtual (parametric) model elaboration including fabrication possibilities within its own internal logic.

The object of the teachings is based in the union of a two part practice: shape/space exploration oriented lessons and the fabrication of a physical behaviour based proto-space, using digital methods, tools and devices (Parametric modelling tools and digital fabrication devices)

Using the advanced educational process as a guide line, we will discuss how the parametric design approach consists in a cultural and methodological threshold to get over and what accurate knowledge and specific skills are needed to perform a usable and relevant modelling.

The teaching method we experiment is based on new curriculum skills : at first, digital computation is a matter to be injected inside the core of the 'traditional' architectural design process, elaborating a hybridization of the fields of architectural design and computer science (conception/meta conception). Secondly, the use of parametric design tools mirrors a specific way of thinking and can extend the design possibilities (such as versatility, complexity integration and fabrication) to support architectural design praxis. Both these foundations are extended and articulate another new and decisive aspect to be embraced in the digital design experimentation: the 'design-to-fabrication continuum'. We will explore the extended possibilities offered by prototyping techniques as feedback, the way these possibilities are generated and how they can be integrated into the design process, resulting in new materiality considerations, also need to be reflected on by students.

In this paper, we will first briefly describe the digital mutation **characterizing the design praxis.** We will then focus on the choices we have made to integrate the parametric modeling and digital fabrication as experimentation tools into a coherent academic subject. We aim to initiate a reflexive attitude about digital experimentalion and designing

Technological mutation and educational context

a) Technological mutation

The last fifteen years witnessed a mutation of the architectural production through the improvement of digital design and fabrication tools. After a breaking point between free-form seduction and tectonics (Picon, 2010), it's more and more possible to interlace shape, material and forces in the architectural design. This evolution is mainly due to a methodological threshold, which enables the **integration of computational processes** like parametric **in the core of the architectural design process**.

More precisely, there are significant **differences** between traditional architectural design and the digital mediated design. We can say the digital design in architecture constitutes a unique body of knowledge and architectural concepts.

Designing and modelling freeform surfaces and curves as building elements that are associated with different components and have multiple patterns are possible by the power of algorithms and scripts that are further pushing the limits of the traditional way. **High levels of parametric modelling skill means using the computational power in a design process.** It is obvious that even to think about a **complex geometry, we need appropriate tools, especially software packages**, which are capable of simulating these geometries and controlling their properties.

b) Educational process: integration of parametric modeling in the academic curriculum

Any new **framework for design pedagogy** must be responsive to condition in which digital concepts are integrated as a **unique body of knowledge** consisting of the relationship between digital architectural design and digital design skills.

To meet these design transformations, our teaching integrates a few **elementary theoretical principles**. As a first step, we sketch the historical background in which parametric modeling appeared and was developed. We highlight the concept of parametric (which existed long before the arrival of the computer). It is necessary to remind the students of the origin of the terminology questioning (parameter and parametric) , the history of science (Apollonius , Newton, Pascal, etc.) and its use in art (Dürer, etc.), architecture (Gaudi, Moretti, etc.) and structure (Frei Otto , Sergio Musmeci, etc…). In the practical teaching of the parametric, the crux lies in the transition from paper sketch to the parametric structure.

Secondly, it seemed necessary to draw the students' attention to the epistemological transformation of the architectural design process. Indeed, the defining feature of a parametric model is not the outputs but rather the need to construct and maintain relationships associated with the model. Some researchers develop this approach as the **creation of the process** instead of formal products. Consequently, the result of the computational modelling process is not simply a shape or an object but provides the possibility of **a wide** (or infinite) **space of design solutions**.

The designer no longer draws an object but a system of possible objects, a machine to explore virtualities. Thus, the domain of competence has jumped logically upstream, and objectification of the realities is necessary to allow a logical shaping of the intellectual operations.

This epistemological transformation of the architectural design process is taught as a new cornerstone in the curriculum introduction. The teaching method we experiment is pursued on discovery, experiment and practice of new ways of thinking: the algorithmic thinking oriented way of mediated design provided by the use of the parametric tools.

As a designer, the student also has to be aware that the parametric model is defined by a set of heterogeneous elements put in relation through a set of rules to form a coherent whole. Secondly, the design logic of the model creates complex relation sets as a network of associations. In this design model, the visual representation is not a direct production from hand but appears as the result of a computational process in which the user has to manipulate geometrical concepts through a program (visual or textual).

Then, the output variations can be achieved by the variations of the parameters included in the schematic structure of the model (as a visual algorithmic process). In this way of thinking, we can say that the design method comes out of the linear and vertical design process only controlled by the architect. Every other specialist will steps in the first stages of the architectural project development. This inclusion in the architectural design process constitutes a methodological transformation.

Among the most important notions being taught is that the designer himself decides what parameters to use and what the range amplitude of the variations is the most relevant regarding the outcomes of the studied object.

How we explore different ways of constructing parametric design models and their outcomes, like the passage from sketch to logic model schema, the integration of material and structural constraints, or the capability in shape versatility will be discussed in the next paragraphs.

The 'design-to-fabrication continuum', an algorithmic design process:

The first educational context if proposed by The Faculty of Architecture of the University of Liège that offers two optional courses *(Shape generative processes* and *Digital design in its materialization ways/ advanced practice*) to the Master degree students focusing on the use of digital tools and devices to form-finding and generation.

The second context is an optional course (Architectures and Digital Cultures : Prospects) proposed by The Faculty of Architecture and Urban Planning of the University of Mons in Belgium to the Master degree students. It is a digital design studio that initiate students to integrate digital culture to the design process. The course is divided in two phases. The first phase is a learning and stabilization of the parametric modelling and digital fabrication processes. The second phase is an application and experimentation one where students must propose a design process integrating the digital culture in a prospective approach.

These courses aimed to:

- Learning of parametric and digital mediated design foundations.
- Discover and analyse training of parametric rules based modelling structure as a network of relationship (model as an algorithm, implementation, data management), exploring and training-free form generative processes (associative geometry) and versatility possibilities by introducing fundamental notions as topology and mesh surfaces.
- Define, manage and integrate heterogeneous (geometrical, physical, uses,) parameters in the design process
- Explore, manage and integrate complex shape contexts
- Explore new shape behaviour (kinetic architecture)
- Discover and experiment basics physical behaviour based modelling (minimal surface) by the use of a dynamic relaxation simulation computing. (skin-structure complex)
- Learning and experiment versatility by discrete surfaces modelling and pattern studies with the aim of perception of space variation and fabrication possibilities.
- Real scale prototyping elements for real perception of the model, assembly checking and material fabrication possibilities.
- Feedback to the model by the use of hand-made sketches of details, implementation of new data generated by the assembly issues. Improving the logic solidity of the parametric model regarding the material issues and constraints (self-weight, resistance, plasticity/rigidity, …).
- Both the latter steps are iterated until the fabrication is reliable…

Augmented architects?

Beyond the evolution of the formal and architectural vocabulary that we have mentioned, the evolution of the means of design and architectural technology, is leading to an (r)evolution in the practices of the discipline. Through the teaching we experiment, we can examine how the computational logic could be powerful as a partner in the design process and has profound consequences on the fundamental knowledge of

design. We can also evaluate how the ***instrumented design*** and the algorithmic thinking could be the key concepts of an augmented design process.

We organize the description of experimentation into a coherent academic subject to initiate a reflexive attitude for building a solid process which is able -from the first morphogenesis step of an architectural sketch to transform it's virtual representation into the physical space. We can confirm that this extended way of design is not only relevant but is becoming inherent to the design requirements for production of the architecture

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