TÉCNICO LISBOA

Extended Abstract

THE “INTELLIGENT” MODEL

MODELLING in ARCHITECTURE

PROJECT RESEARCH, DEVELOPMENT and COMUNICATION

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Introduction

This thesis is the closing of a cycle of learning and development, corresponding to the Master in Architecture integrated course, at the Instituto Superior Técnico - University of Lisbon. This research was developed over several months, during the academic year 2016/1017, in Lisbon, and along a period of internship in Basel, Switzerland.
The scope of this research is analysing the role of physical modelling in the context of the process of architectural conception seeking to understand the relevance of the act of doing, while action or thought, within the research, development and communication of the project.

Methodology

Starting from a question of broader investigation concern - the modelling - this study evolved by being decomposed, through a logical process of theoretical and practical analysis and discussion, which will allow for the discussion on the relations of reciprocity between digital and physical realities.
After clarifying the concepts of Model, Physical Model and Digital Model, it is necessary to clearly understand the characteristics that define a model in architecture. Based on a theoretical research, additionally supported on case studies, the investigation proceeds with the analysis of the various functions of modelling and the way in which the same is relevant in the design process.
This clarification and analysis grounds an informed discussion on reciprocity relations between the concepts: *physical reality* and *digital reality*. Through this investigation, analysis and discussion, it is then possible to perceive the relevance of the different means of modelling and what consequences they induce in the perception and intelligibility of the project, which later informs the work of the architect.
By developing a debate about modelling, in its broadest sense, it is possible to rethink the present and future role of the model and of the prototype in the process of architecture design.

Analysis and Discussion

The architecture results from a complex and non-linear creative process, which implies a progressive transformation of the project, supported on various tools such as sketches, drawings, images and models. These instruments are crucial for structuring concepts, logics, organizational schemes, spaces, volumetries and textures, that allow research, development and communication throughout the various phases of the project.
In addition to the two-dimensional depictions, the three-dimensional exploration tools have acquired a great deal of relevance, from the Renaissance to the present, as a means of manipulating, experimenting and communicating the project. Since the end of the twentieth century, in addition to the physically

produced traditional modelling vehicles - the model and the prototype - there is a growing development of computational models specific to architecture.

In the practice of architecture, a clear relevance of tri-dimensionality in the manipulation, experimentation and communication of the project may be noted. However, in architecture the definition concept of the word *model* is very dubious. It is an extremely broad concept and can have an analytical, analogical, qualitative or scientific character. Modelling in Architecture does not fit into any of these classifications, as it is sometimes understood in a rather subjective context.
Currently associated with the concepts of dimension and scale reduction, the word model derives from *modus*, which in Latin means measuring. Thus, following Phillipe Boudon's definition, the model is the set of "indications of various natures"[1] (1992, pp. 90), that allow to operate and transform the project. So what defines model is its function as measurement operator.

However evident this function of measurement may be in physical modelling - the one that shares the physical space in human understanding - this is not equally clear regarding digital modelling – the one that exists in the computational space through the exhibition of data and results on a display or screen.
Considering architectural conception can be taken as something that, "beyond an art (which, moreover, not always achieves to be)" is rather a doing [2](Boudon, 1992, pp. 22), leads to express modelling through a "poietic discourse" through which it is possible to obtain knowledge from the act of doing.

Is this discourse present in the modelling processes that take place throughout the design of the project? Let us then consider what are the defining concepts of *model*, trying to understand to what extent do they allow for a clearer reading of the discourse that follows from three-dimensional thinking.
The defining characteristics of a model may be objective in character, such as scale and proportion, or have subjective character like abstraction, materiality, tangibility or time.

SCALE

Because it is what allows for referential perception and therefore relate the model to the human being, by way of comparison, scale is fundamental for the understanding of modelling. Thus, according to Phillipe Boudon, "the model is the entity that sustains measurement operations: it is an *operand* (...) The operation where it is an operand implies an operator: the scale" (1992, pp.131) [3].

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[1] "J'entendes ici modèle indications de diverses natures"

[2] "Et n'est-elle pas, avant d'être un art (ce qu'elle n'arrive pas toujours à être au demeurant) un faire?"

[3] "Le modèle est ainsi ce sur quoi portent des opérations de mesure: il est un *opérande*. L'opération dont il est opérande comporte un *opérateur*: l'échelle (...). Si l'échelle est l'opérateur de l'opération, le modèle en est l'opérande".

Furthermore, being the performer, the architect is the operator of the model while the scale, as a measure, is also an operator of the model. Thus, "amidst of the diversity of meanings that the term scale may assume, even outside the context of architecture, scale is understood as the "pertinence of the measure "[4] (Boudon, 1992, pp. 171).

An architectural model is usually referenced to the human being. However, digital modelling is not referenced at all. The operator scale is replaced by the zoom function. Although it allows for varying the magnification of the modelled object, this function does not refer to the human being at all.

The advance of technology made possible to develop tools that allow the perception of the object from a user standpoint, making it possible to virtually "travel" through it. However, these tools are still insufficiently developed apart from having other limitations at various levels, such as tangibility and perception of materiality.

Proportion

While proportion concerns "the mathematical relations between the real dimensions of a form or a space, scale refers to the way we perceive the size of a constructive element in relation to the remaining forms"[5] (Ching, 1984, pp. 326).

Proportionality systems "have the power to visually unify the multiplicity of elements that take part in architectural design, making all parts belong to the same family of proportions"[6] (Ching, 1984, pp. 298). Proportioning systems have the ability to relate the external and internal elements of the building. In the case of modelling, they allow a reading of the relation between the various parts of the object, and of the relation of the same, for example with the context.

Thus, in architecture and modelling, scale and proportions rely on the human body to measure, relate and perceive the parts, the whole of the project, and their relations of reciprocity.

Subjectivity

Architectural manifestations such as drawings or models are the guiding thread between the imaginary and the real, having existence in an intermediate space between these two realities (Frampton, 1981).

Imagination is a way of recognizing a reality that is not perceptible through the senses, thus having a dimension that is absent in present reality (Topalovic, 2011; Frascari, 2007).

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[4] "(...) parmi la diversité de sens que le terme d'échelle peut recouvrir en dehors même du champ de l'architecture, j'ai choisi de m'en tenir à une définition de l'échelle entendu comme *pertinence de la mesure*".

[5] "La proporción atiende a las relaciones matemáticas entre las dimensiones reales de la forma o del espacio; la escala se refiere al modo como percibimos el tamaño de un elemento constructivo respecto a las formas restantes".

[6] Tienen el poder de unificar visualmente la multiplicidad de elementos que entran en el diseño arquitectónico, logrando que todas las partes pertenezcan a la misma familia de proporciones".

Consequently, modelling contains a broad degree of freedom, within the constraints imposed by the architect. "To model is the ability to imagine, and thus the manifestation of the ultimate freedom" (Topalovic, 2011, pp. 45). This freedom of manipulation is clearly noticeable through the degree of abstraction, the sensory perception, and the various times of the model. These are the characteristics that give greater freedom to architecture.

Abstraction

In the model Architects may find a freedom of expression that leaves space for the imagination and stimulates creativity (Moon, 2005). As representations of ideas, models are abstractions because they capture the essentials of what one intends to represent and discuss.

Architecture must contain reality and abstraction, functionality and beauty, even though these dimensions are sometimes opposed. For the architect, the model is a vehicle for translation and expression of ideas and logic, and therefore does not have to represent simultaneously all the levels of complexity involved in the project, allowing to isolate the problems and, when necessary, put them in confrontation.

Tangibility

Our hands have a creative and imprecise dimension, through which thought finds its expression in the drawing and in the model (Faria, 2004). In addition, the hands also act mechanically and accurately, as they operate in the conception and design of these representational instruments.

The instruments that support the development of the project thus benefit from a particularly sensorial combination - "(...)that between feeling and seeing" (Frascari, 2007, pp. 4).

The understanding of the model is utterly physical and requires human perception of matter. The continuous process of developing the project stimulates the senses - visual as well as tactile through the hands. Thus, "a model is not solely a representational entity, but is rather primarily a sensible object of visual as well as tactile perception" (Frascari, 2007, pp.35).

Materiality

Materiality is a medium that allows the perception of what surrounds us through four of our senses (Picon, 2010) - smell, sight, hearing, and touch. In modelling this characteristic is crucial for the communication and representation of the project.

The choice of model materiality depends on what it intends to focus on. The criterion for the choice of materials relates to particular features of the project such as the program, the concept, the scale or the development phase. (Schneider, 1999)

Beyond its representational character, materiality also refers to how the human being understands and experiences the world by promoting the connection with it.

Materiality is closely related to our perceptions and sensations (Picon, 2010), whose translation is still very limited in virtual systems.

TIME - LAG

Time factor is decisive in the architectural creative process. Amidst thought and conception there are periods of discovery, analysis and construction of the project. Thus, design in architecture takes place over successive times that allow a constant forthcoming of the time of the final construction (Faria, 2014).
As long as the model is a tool that is part of the project development methodology, the model is considered to be "alive". During this period, the model has the potential to be modified, altered and questioned. (Patteeuw, 2011).
The "acceleration" imposed by digital modelling does not necessarily mean a loss of significance for the methodological process. However, the quality that comes from the project time can be affected by the cumulative repetition of the project, in favour of a systematization of the project processes. Thus, the timelessness of the project can lead to overcoming the permanence of cognitive and sensorial values (Steele, 2001).

It may be of common understanding that models may have multiple dimensions and functions such as sketches, mediators and clarifiers of thought, or elements of representation and communication of the project (Pallasmaa, 2009). Thus, it is possible to clearly identify the inherent functions of a model: communicating, representing, searching and documenting.
In architecture, communication is inherent to modelling - in the first instance the model is a means of communication, from the moment it is produced, until it is changed. Thus, communication can be considered to "(...) to operate as an extension of perception " (Heally, 2008, p.114).
For a model to be representative it is necessary that it takes into account a reality which was studied beforehand. Representation requires a prior study of what one intends to show through other tools such as previous design or study models. In this way, these models provide a reference point for the design process, a moment of pause and analysis of what was developed until a given moment. It is therefore a moment of condensation and synthesis of ideas.
While the representative models contain a clear and relevant intention, the research models are the result of free expression through an internal language of the architect.

Architectural research is in itself a means for the architect communication toward the project - in the way the architect makes real something that only exists as a thought or idea in his imaginary - and from the project to the architect - where, through the model, the architect draws conclusions about a given problem or issue. Models are fundamental to architects because they provide an understanding of their own ideas allowing to develop and define concepts (Smith, 2004).

While anticipating the building or as process documentation leading up to it, the architectural model is recurrently associated with a representative dimension. However, the model as a source of research, is more introspective than representative, in the sense that the concept or study model does not necessarily seek to resemble or document something (Morris, 2012).

Models produced throughout the design process also have a documentary nature in that, when considered together, they offer a library of three-dimensional objects, establishing a collection of precedents to the final object. The archive is a moment of deep reflection within the project process, from which it is possible to perceive the moments and decisive elements led to the final project.

Thus, a model provides communication, representation, research and documentation throughout the design process - from concept, to the basic layout and development, and up to execution and construction.
Through a bibliographically based theoretical grounding and the critical analysis and comparison of several case studies, it is possible to understand how modelling intervenes throughout the design process in architecture.

Modelling is central to the development, understanding and discussion of the project from concept to construction. However, it is not always essential for the development of the final object, and is sometimes unconsciously irrelevant in the methodological process.
Something that is also perceptible through this investigation is that the relationship between physical modelling and digital modelling is not always constant throughout this process. It is therefore necessary to discuss the relations of reciprocity between these two realities, in order to better understand the advantages and disadvantages of one against the other and of the use of these two systems simultaneously.

In the realm of architecture, the understanding of reality and of conception was gradually changed with the appearance and establishment of digital modelling. The understanding of modelling has changed due to the emergence of new forms of perception, transformation and interpretation, which have a direct impact on project methodologies, and architecture itself. Digital tools are clearly established in the teaching and practice of architecture, and have led to occasionally deep changes in the methodological principles that were common practice until a few decades ago. However, it is questionable whether this will be the future of architecture, taking into account the historical relationship of this discipline with sensations and with "physical reality, with stone, with brick and with mortars"[7] (Picon, 2010, pp. 55). It is therefore relevant to analyse and discuss the impact these tools have on architecture, through the discussion of two distinct binomials.

[7] "(...) to physical reality, to stone, brick and mortar".

Digital Modelling VS Physical Modelling

In addition to digital models limiting the imagination, "in computer modeling, forms can be explored in “space”, but they have no substance. The pixels create the illusion of an object, but object does not exist. The screen is flat; out understanding of three dimensions has lost its meanings" (Moon, 2005, pp. 203-204).

In digital modelling the understanding of tangibility is also misrepresented through the use of hyper realistic textures of materials. "The one thing the computer does not have - tangible three-dimensional form - programmers overcompensate for by offering unrelenting pictorial realism" (Morris, 2012, pp. 166).

Thus, while "the model celebrates the aura of the artist's hand and the Ruskian idea of imperfection as the sign of life while the computer simulation revels in the mystique of machinic perfection and in the code of realism" (Morris, 2012, pp. 169).

It is therefore necessary to consider that man and machine are two distinct systems, and therefore follow two dissimilar processes. While man develops a design process, the computer is the machine operator. The relationship between these two systems should not be opposed, since they do not contribute to the project's development, but rather to the association of two systems with potential for self-improvement and inter-perfecting (Negroponte, 2011).

Digital Modelling + Physical Modelling

The variety of means of representation is unquestionably positive for the evolutionary process of the project whenever its use is a conscious choice, with the intent to make research, development and communication more accessible (Moon, 2005).

The challenge for architecture is to understand digital modelling and production technologies in a more informed way, trying to understand their potential beyond the ability to produce unique forms (Kolaveric, 2003).

For the human and technological systems to cohabit and dialogue, the relationship between them must be more fluid and direct. For a dialogue to happen, gestures and expressions are necessary since, for man, a dialogue requires the "involvement of the whole body - hands, eyes, mouth, and facial expressions" (in Negroponte, 2011) - organizing all these components into a harmonious and simple sharing.

Thus, it is at the interface of virtual and physical realities that one can find the intelligence of the combination of different systems.

Intelligent environments are those that give a proactive response to human needs and activities through adaptive systems and interfaces adapted to the human condition as a biological being able to adapt to the technological world (Yiannoudes, 2016).

Therefore, it is necessary to take into account that, in the framework of architecture, because it depends on the context, the limits of the technological system do not allow the flexibility and adaptability needed in the design process.
In fact, what is expected from technology is not the replacement of the architect by a machine, but the creation of a reciprocal relationship between the adaptability of the sensory system as well as the accuracy and multiplicity of the technological system.
With the understanding of the need to maintain physical modelling in the current design process, this thesis allows for the first conclusion that it is important to develop a deeper understanding of the processes of architectural production, according to a criticism point of view that counters the trend towards an insufficiently sustained and sustainable technological development. This knowledge is not intended to neglect digital modelling, but rather to develop reflection on the current impossibility of replacing physical interfaces with digital ones, due to the unintelligibility inherent to the computer.

A second conclusion is based on the conviction that human understanding of physical space, as well as the relevance of tangibility, is essential to create sufficiently interactive dialogue interfaces to respond to the needs of conception within project design.
Consequently, the need for freedom of imagination and of the assignment of scale and tectonics in the design process cannot be restrained by the limits imposed by the computer, which currently need support tools such as the physical model itself.

Considering that the "INTELLIGENT" MODEL is the one from which, through the exercise of the senses, it is possible to generate knowledge of the project and for the project, it may finally be concluded that it can also generate knowledge about the influence of “a doing” in the perception and Intelligibility of the project: the "INTELLIGENT" MODEL is one that seeks to meet the human body in all actions of conception.

For this reason, the knowledge extracted from the act of doing inherent to the "INTELLIGENT" MODEL, can be applied in the development of an "INTELLIGENT" DIGITAL MODEL, that is able to generate knowledge through the combination of the mental functions, inherent to the conception process, with the technical capacity intrinsic to the use of computers.

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