"Operation of parametric modelling" and/or "operation of architectural conception"?

Expressing relationships in parametric modelling

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Abstract. *This research paper presents a specific understanding of the relations between parametric modelling activities and architectural conception activities. Our main question is: Can we make a distinction between cognitive operations of parametric modelling and cognitive operations of architectural conception? To shed light on this question, this paper is leaning on analyses of some uses of the parametric modeler Digital Project. The cases studies are students' projects from two Architecture Studios: the Cross Over Studio of the Universität die Angewandte in Vienna; and the Studio P9 Digital Knowledge of the Ecole Nationale Supérieure d'Architecture de Paris Malaquais in Paris. Our main result is the observation of a distinction between cognitive operations of parametric modelling and cognitive operations of architectural conception. The distinction of these two kinds of operations leads at questioning the relation between them. We have questioned these relations in terms of induction from one to another. But some interesting merging of these two kinds of operations appeared also.*
Keywords. *Architectural design; parametric modelling; expressing relationship; Teaching; Digital Project.*

INTRODUCTION

Parametric modelling is more and more used in Architecture offices (Kolarevic, 2003; Burry, 2010; Woodburry, 2010; Kocaturk, 2011). These uses of parametric tools are supported by a numerous and proactive community (Smart Geometry [1], Smart Solutions Network [2], etc.). All the skills and innovative behaviors developed seem to be really rich for the architectural practices. However, we can interrogate ourselves about the way parametric modelling supports architectural design and could support it better.

To understand how parametric tools could support architectural design, we make the hypothesis that questioning relations between parametric modelling activities and architectural design activities may be relevant. Knowledge products by such

interrogations could improve the teaching of parametric modelling to architects. This paper aims at exploring the uses of parametric modelling in architecture on purpose to identify some of the cognitive mechanisms implicated. The main question of this research is: Can we make a distinction between cognitive operations of parametric modelling and cognitive operations of architectural conception?

To shed light on this question, this paper is leaning on analyses of some uses of the parametric modeler "Digital Project" (DP) [3][4]. The cases studies are students' projects from two Architecture Studios: the Cross Over Studio [5] of the Universität die Angewandte in Vienna; and the Studio P9 Digital Knowledge [6] [7] of the Ecole Nationale Supérieure d'Architecture de Paris Malaquais in Paris.

Three parts constitute this paper: 1-the theoretical background of the study; 2- a description of the methodology and some chosen cases; 3- the main results of the research.

BACKGROUND OF THIS STUDY

Parametric modelling

Parametric modelling is a representation first developed for industrial design. This kind of representation aims at building an informed and constrained model (Maculet, 2005). Elements which constitute the model (lines, points, variables, functions, etc.) are associated into graphs thanks to attributes (geometrical, numerical, positional or relational) (Barrios, 2007). When an element is modified, algorithms propagate the constraints in the entire graph to update the model (Woodburry, 2010). This representation allows a very high control of the geometry (Burry, 2011). It requests from the designer an explicit definition of his geometry, on purpose to control it and its potential transformations (Aish, 2005). Parametric modelling requests geometry and computer sciences skills (Woodburry, 2010).

Parametric modelling is the object of a lot of interesting researches. These researches tackle different focuses of the parametric modelling: technical potentialities (Aish, 2005); roles in the design process (Gane, 2007); innovative practices (Burry, 2010; Kolarevic, 2003); and so on. Several approaches interrogate the way that parametric modelling supports architectural design and could support it better (Qian, 2007; Marques, 2007; Woodburry, 2010) among others. But questioning parametric modelling through the cognitive activities of conception and modelling is a rarely used focus.

Questioning parametric modelling uses in/for architectural design

This research paper aims at providing a specific understanding of the relations between parametric modelling activities and architectural conception activities. On this purpose, this research introduces a theoretical distinction between "cognitive operations of parametric modelling" and "cognitive operations of architectural conception".

The "operations of architectural conception" are the cognitive operations made by a designer when he gives measure to a designed object (Boudon, 1994, 2004; Lecourtois, 2011). These operations may be, for example, orienting an access in function of an urban context, dimensioning volumes of a building according to the desired impact on the landscape, etc (Boudon, 2004). The "operations of parametric modelling" are the cognitive operations made by a designer when he constitutes a parametric model. These operations may be: choosing a parameter; determining a geometric method to construct an object; associating some data and a feature; and so on.

Studying all the operations of parametric modelling is not the purpose of this study. This article aims at identifying some of the "parametric modelling operations" which are specifically mattered with "linking up" actions. According to Hugh Whitehead (Woodbury, 2010. p.1) "the first requirement [for parametric modelling] is an attitude of mind that seeks to express and explore relationships". In this paper, we are specifically studying the operations which "express relationships" in parametric modelling. These "linking up" operations can be actions

like: joining together different variables; linking a function with external data; associating constraints with geometries; and so on.

CASES STUDIED

Description of the gathered data and the analyze methodology

The cases studied are students' projects from two Architecture Studios: - the Cross Over Studio [5] of the Universität die Angewandte in Vienna; - and the Studio Digital Knowledge [6] [7] of the Ecole Nationale Supérieure d'Architecture de Paris Malaquais in Paris. These Studios happened during the fall-winter semester 2009-2010. During the studied semester, the teachers of the CrossOver Studio were: Kristy Balliet, Justin Diles (Studio Lynn), Robert Neumayr (Studio Hadid) and Niels Jonkhans (Studio Prix). The teachers of the Digital Knowledge Studio were: Christian Girard (Atelier d'Architecture Christian Girard), Philippe Morel (EZCT) and Pierre Cutellic (Gehry Technologies Europ). All students have completed the same DP training. They have been trained by the same team from Gehry Technologies Europ [3]. Modalities of the training have also been identical: a one-week intensive workshop at the beginning of the semester and some sporadic courses and interventions along the exercise. For both Studios, the pedagogical finality was the architectural design and not the exclusive learning of the software DP.

The gathered data of this study are composed with parametric models, final representations of the projects and half-leaded interviews of some students. These data are analyzed with the help of one of the methods of the "Applied Architecturology", developed by C. Lecourtois [8]. This method "give tools to analyze cases from the same postulate that corpus can be read as composed with "indicial signs" of operations of conception" (Lecourtois, 2011). In this framework, representations of the projects and discourses made by architects are studied as tracks ("indicial sign" in Charles S. Peirce's meaning) of cognitive operations of conception and/or modelling.

We propose here short descriptions of three cases, two from the Cross Over Studio and one from the Digital Knowledge Studio. The study leans on the analyses of all the student's projects. However, we consider these three cases as the most representative of this study and its results.

Cases 1 "Pavilion", Philipp Hornung [Cross Over Studio, Vienna]

This project is made of an organization of volumes and surfaces into a hierarchy (figure 1). The composition distinguishes a main space, independent and close. Through the question of the "linking up" operations, we can observe that the parametric model is constituted of: 1- an organization of proportional dimensions between three volumes; 2- a topological

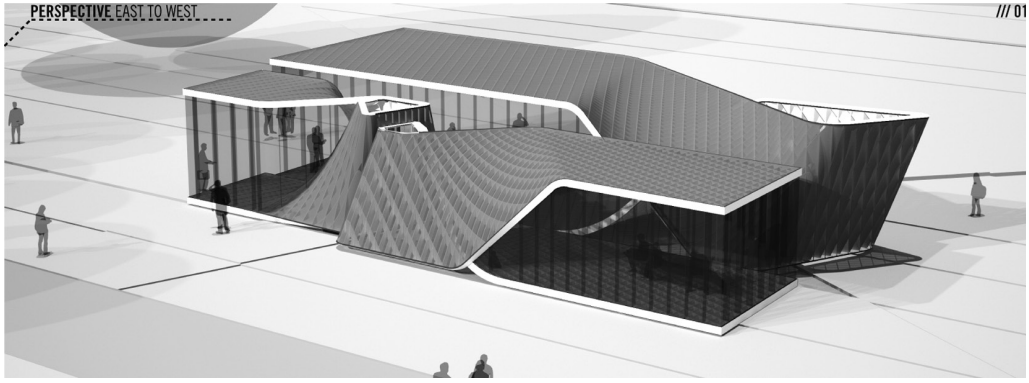

Figure 1: Final representation of the Case 1 (source: Philip Hornung)

construction that links the floor and the roofing into a folding surface for each volume; 3- a hierarchy of the volumes and their dimensions dependently to the human scale and to the functions planned. This parametric model (figure 2) defines a domain of geometric issues, where the designer can explore different alternatives. From these potentialities, the student is designing and refining an instance "pavilion" (figure 1).

The figure 2 is a picture from the studied parametric model. On this picture, we distinguish the three surfaces which are "folded" on purpose to organizing different spaces. The red "box" is the main space of the project. This box is the parameter which helps to build the analogue folded surface, but it is also the parameter which helps to measure the other spaces. Moreover, we can see a kind of basic "human character" which gives a scale to the model; and an urban drawing which indicates some information about the position of the pavilion. Actually in the parametric model, we can simultaneously see two kinds of elements: - elements which constitute the project (the folding surfaces); and - elements which have supported the design (the schematic "box", the human character and the urban drawing).

Here, it seems that some elements of the parametric model, as the character and the urban drawing are only representations which follow "already done" operations of architectural conception. For example, the implantation of the pavilion has been designed according to some elements of the urban context: on purpose to having a desired effect in the public space and some specific openings towards visitors' influx. Yet, in the parametric model, the urban drawing is not used to define this implantation. The urban drawing and the volumes are independent: when the urban layout is modified, the orientation of the model is not actualized. Here, the operation of architectural conception might be autonomous from the operation of parametric modelling.

Besides, there is an architectural design operation which aims at associating the height of the main space with the human scale. The human scale is represented in the parametric model through a human character. As well as before, these two operations are dissociated. The modeled character aims at supporting the visualization of the scale, but the link between height and human scale is not automated. Here, we can question the design: maybe "Le Corbusier" would have automated the link between a "modulor" character and the height of the spaces?

We can see in these two operations (positioning the volumes in the urban context and measuring the volumes dependently to the human scale) that the architectural conception firstly happened for the student. Parametric modelling has followed some operations of architectural conception already chosen.

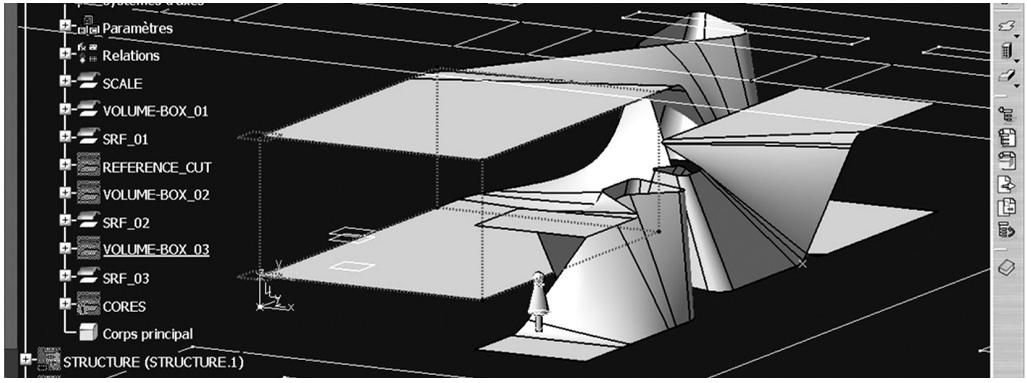

Figure 2: Representation of the DP model of the Case 1 (source: picture proposed by the authors thanks to the model made by Philip Hornung)

Otherwise, in this case some operations of architectural conception seem to be merged with parametric modelling operations. Thus, the operation of architectural conception which aims at associating the dimensions of the three spaces together is also a parametric modelling operation. Similarly, the architectural design operation which matters with the continuity between the floor and the roofing is associated to the parametric modelling operation of drawing the folding surface. In these two examples of operations, there is no induction from one kind of operation to another, but the operations are intricate.

Cases 2 "Les particules en actions", Hugo Houplain and Constance de Batz's [Studio P9 Digital Knowledge, Paris]

This project proposes a built installation, which is a kind of structure (figure 3). From the point of view of the "linking-up" operations, the structure is determined by: 1- a wireframe which constraint the global volume by boundaries and by parameters which determined the number of points and levels (figure 4-2), 2-some geometrical constraints that link vertical and horizontal elements (figure 4-1); and 3- a global reaction to an attracting point (figure 4-3). Then the "structure" had been completed with constructive details in purpose to produce the mock-up (figure 3).

This "structure" is definitely abstract: different applications can be imagined but are not developed by the students. Thus, we can imagine this structure as a building one (with columns and levels), but also as a furniture one; and so on. An instance of the structure had been realized in a mock-up.

Let's observe some of the "linking-up" operations from which the wireframe is produced in the parametric model. The operations of parametric modelling define a network of points by linking up: - a horizontal plan; - four vertical segments; - one parameter which define the number of level; and - two

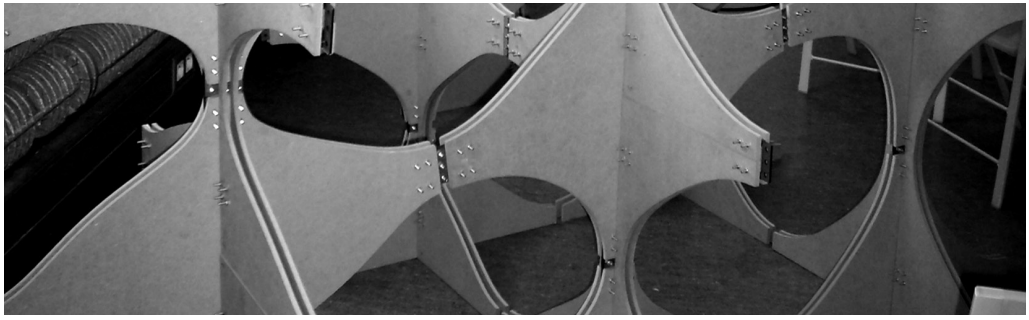

Figure 3: Mock-up of the Case 2 (source: picture made by the authors of the Hugo Houplain and Constance de Batz's project)

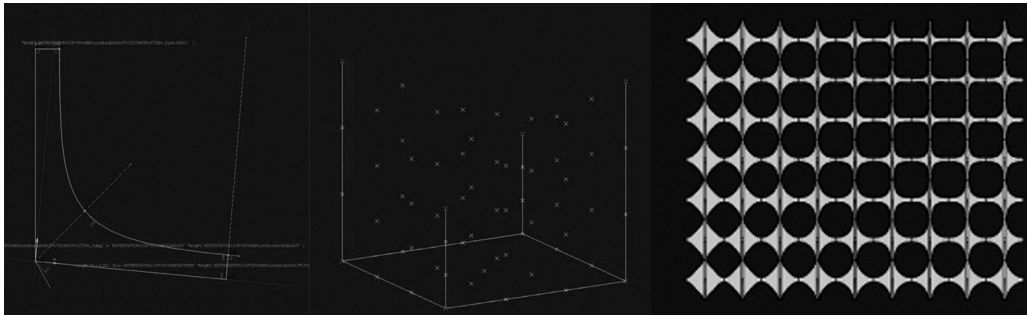

Figure 4: Representations of the DP model, 1- Component which link vertical and horizontal elements; 2- Case of the wireframe; 3- A reaction to an external "attracting" point (source: Hugo Houplain and Constance de Batz)

parameters which define the number of division for each level (u, v) (figure 4-2). These operations are in relation with architectural design operations. Indeed the obligation of a horizontal plan, the alignment of the points and the thickness of the components depend of technical issues. Thus, the regularity of the network of points depends of a geometrical choice.

In this case, operations of parametric modelling seem to be first and almost autonomous. Students seem aiming at building a model the more abstract and reusable as possible. For example, we can imagine many other architectural design operations that could follow this parametric model. We can imagine a reaction of the structure to an attracting point in purpose to modulate an elevation; to have more or less luminosity; etc. Vertical boundaries of the wireframe can be instantiated dependently to an urban context; or to a specific use; etc.

Cases 3 "Radical Production", Adam Orliensky, Daniela Kroehnert [Cross Over Studio, Vienna]

Like in the case 1, this project proposes a Pavilion. This pavilion is constituted by surfaces which organize spaces. On these surfaces, a component is repeated dependently to different orientation and implantation parameters (figure 5).

The surfaces which constitute the pavilion have been designed thanks to a physical model. It seems that the drawing of these surfaces is mostly linked to the urban context: the orientations of the existing buildings and the pedestrian influx in particular are determining variables. The urban

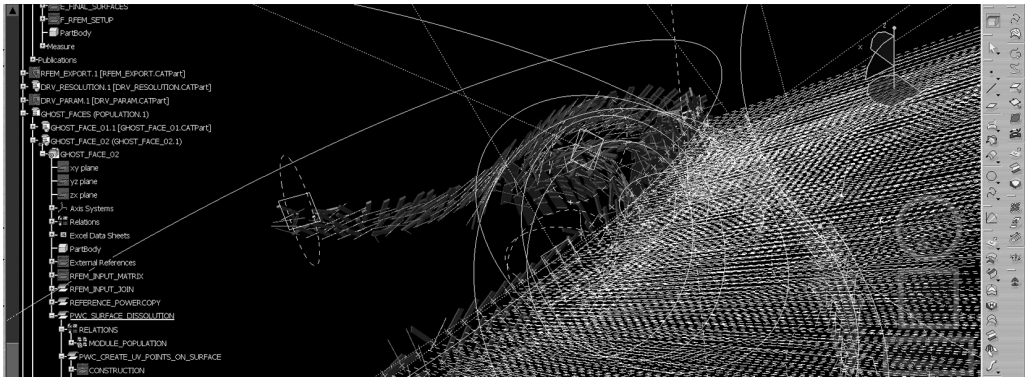

Figure 5: Final representation of the Case 3 (source: Adam Orliensky, Daniela Kroehnert)

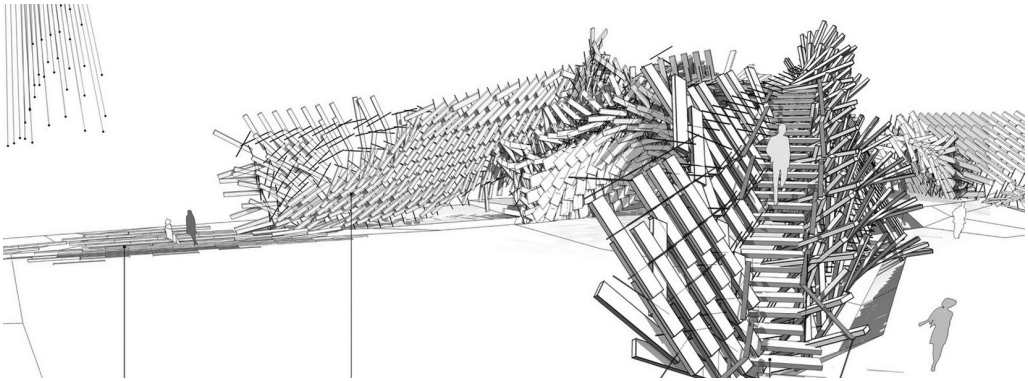

Figure 6: Representations of the DP model, Case 3 (source: Adam Orliensky, Daniela Kroehnert)

context is not represented in the DP model (figure 6). We can imagine that these operations of architectural conception were supported by physical models, sketches and plans.

The idea of the students was to propagate a same simple component on these surfaces. By modifying the orientations of these components, the students wanted to produce a "swarming" effect. Four different types of orientation and implantation parameters have been studied relatively to the class of the surfaces. The implantation parameters and the orientation abilities are not the same if the component is instantiated on a planar surface, or on a cylindrical, undevelopable or conical one. Thus, the mechanical behaviors of the surfaces have been evaluated to adapt the components' positions.

These characteristics of the component are embodied in different "powercopies". A "powercopy" is a kind of copy proposed by CATIA [4] (and so by DP). This copy had a user-defined behavior, and can be instantiated, more than only pasted, in a context which will define it. Defining a powercopy and instantiated it can be analyze as "linking up" operations. From the definitions of behavior "rules", the components are instantiated on the surfaces. Then parameters of orientation are modified by the students on purpose to adapting the components to architectural intentions: to open views on the city; to modulate luminosity; to make a visual effect on an elevation; and so on (figure 5).

The operations of parametric modelling and the operations of architectural conception which treat of the components seem to be intricated and co-determined, with different relevancies: technical, visual, etc.

MAIN RESULTS

Cases exposed here are symptomatic of the other projects proposed by the two Studios during the studied semester. In most projects from the Digital Knowledge Studio, parametric modelling operations come first and are well-defined. These operations seem to lead the operations of architectural conception. On the contrary in the Cross Over's projects, it seems that the architectural design had been considered as first, even if the parametric model wasn't so well controlled at the end of the process. Thus, in the Cross Over Studio almost half of the students decided to give up DP to get back to Rhino or Maya after few months. They adapted their workflow to the specificity of their architectural design activities.

We can clearly observe here the result of a difference in the pedagogical purposes of these two Studios. The aim of the Studio Digital Knowledge was explicitly the fabrication of the students' projects; which needed a well-defined parametric model. And the aim of the Cross Over Studio was to produce a "provocative and highly refined" pavilion [5]; which implied a well-defined architecture.

Designing parametric models and/or designing architecture?

We have focused on the "linking up" operations which are for example: linking a network of point with a wireframe; associating proportions of volumes to each other; etc. To answer the question asked in this paper, we can already say that cognitive operations of parametric modelling can be distinguished from cognitive operations of architectural conception.

We have interrogated the relations between cognitive operations of parametric modelling and operations of architectural conception in terms of induction.

Thus some operations of architectural conception seem to come first: some of the parametric modelling operations follow and represent some already-done architectural design operations. For example in the case 1, volumes are positioned according to urban choices, but in the parametric model the urban drawing is not used to define the volumes. In this case, we can observe the autonomy of the operation of architectural conception.

On the contrary, we observe in the case 2 a lot of inductions from parametric modelling operations to

architectural design operations. For example, there is first the parametric modelling operation which defines a network of points relatively to a wireframe (figure 4) and then an architectural design operation which defines a relevance to this wireframe (here a technical relevance to allow the fabrication of the mock-up) (figure 3).

But we can also observe some cases where relation between cognitive operations of parametric modelling and of architectural conception can not be define in term of induction. In these cases, the relation seems to be a co-determination.

We can observe that in the case 3 where it seems that some operations are codetermined by an architectural design activity as much as a parametric modelling activity. For example components are instantiated on surfaces dependently to their mechanic behavior and to some desired effects (for the view, the luminosity and so on).

But sometimes cognitive operations of parametric modelling and of architectural conception are so merged, that such a complexity should be interrogated. In this case, can we say that the cognitive activity of designing parametric model is also the cognitive activity of designing architecture?

CONCLUSION

In our case study based on student's works, we can introduce a distinction between operations of parametric modelling and operations of architectural conception. The distinction of these two kinds of operations leads at questioning the relations between them. We have interrogated these relations in terms of induction from one to another. We saw the two kind of induction: from operations of architectural conception to operations of parametric modelling (mostly in the case 1); but also from operations of parametric modelling to operations of architectural conception (mostly in the case 2). But there are also some interesting merging of the two kinds of operations (mostly in the case 3, and also in the others cases).

A further research could specifically interrogate cases where cognitive operations of parametric modelling are cognitive operations of architectural conception.

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