Parameters in the Design Process

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“Ce n’est point le navire qui naît de la forge des clous et du sciage des planches. C’est la forge des clous et du sciage des planches qui naissent de la pente vers la mer et croissance du navire” (Saint-Exupéry, 1948).
The paper describes and analyses a course held at Stuttgart University, Germany dealing with the application of parameters in an architectural design process and the transformation of this process into a relational digital model. The course is introduced with special emphasis on its tasks, aims and the implicit didactic concept. It is also investigated if and how a design approach resulting from the identification and determination of parameters can lead to a creation of a unique shape. Finally the impact of the practical exercises for the final design is evaluated.
The course’s structure is enhanced by the “Vorklasse” from Bauhaus and the conviction that using software is taught most effectively by working on an own specific project. At the very beginning the students get the chance to gain experiences with parameters through preliminary practical exercises, like folding and modelling and analysing. Then the use of the software is taught in several compact sessions in parallel to the design process. The impact of the early practical exercises on the subsequent design process is remarkable. Special attention is therefore given to this aspect.
The aim of the lessons is to produce a proposal for the design task. The proposal is then to be presented as a parametric model representing either the global shape or a constructive detail.

Keywords: Design education; digital project; parametrical design.
Introduction

Nowadays people agree that design software should be more than a proper and easy to use pencil. Digital models should overcome to be the simple representation of geometry. The software-developers offer us plenty of products. The software tools are more or less usable, and we can declare that most designers work with digital tools in their every day practice.

With the actual design software like “Autodesk Revit™”, “MicroStation™ Generative Components” or “Digital Project™”, users have the possibility to create digital relational models, using parameters and criteria to define interconnections between objects. The designer describes the relational references between objects and not the final geometrical representation.

Some designers dismiss this design approach. Sketching and building models by hand seems to be the ‘natural’ way to develop architecture. But Raphael, Brunelleschi or Bramante established drawing and perspective representations of future buildings not until the renaissance (Tidafi et al., 2006). Coming from other art disciplines they used the new method of sketching and building models to compensate their lack of knowledge and experience. They explored their own new way to approach the architectural shape.

Kilian showed in his Ph.D. that parameters could be seen as design drivers, not only as hindering restriction (Kilian, 2006). The challenge is to explore, structure and validate the according constraints.

Using the mentioned design software, we have to learn how to use the software, but we also have to investigate the use of the parameters. These points are the motivation to offer a design studio at Stuttgart University exploring the possibilities of parametric design software. Pedagogical goal of the course is the introduction of the design-software “Digital Project™” and to examine the meaning of parameter.

Pedagogical strategy

Introducing parametrical software to students of architecture not only the use of the software but also the meaning and use of parameters itself and their impact to geometry and design has to be concerned. Therefore the course is structured into 3 main parts. On the one hand we will train the students in using the software tool. On the other hand, they have the opportunity to find out what parameters are and how they can drive a design process. This was elaborated in the preface exercises. To bring these two points together they have to understand geometrical basics. This is the third pedagogical column of the course.

For the final presentation the students should work out a design for an event platform.

The course was offered to two following semesters. This gives us the opportunity to compare the results and observations of the different courses.

The first year group had to work with a building site in the city park; the second year group had to deal with the Lake of Konstanz as the building site. The sites are explicit very undefined so that they follow a work with design constraints that are related to the internal logic. Denying a specific description of the function of the asked design, we hoped to support the development of an internal logic of the outer shape. The accentuation was laid to develop a formal principle of shape.

The preliminary exercises were also different in the two years. The impact of these exercises to the final design is surprising and mention later in detail.

The approach to the basics of geometry was differing between the two years.

Regarding the two different courses we try to find out if and why the results are substantial different.

Exploring the tool

For our course we choose the software Digital Project™ from Gehry Technologies. Based on Dassaults CATIA V5, DP (Digital Project) is adapted especially for the needs of architects. This means the relevant features for the automotive industry are removed, and the surface is more convenient to architects use, than the original CATIA V5 surface.
The major point to introduce the software is the fact, that we can represent not only static geometry but also dynamic relations between objects. Design constraints can be formulated as mathematical or logical functions. This allows us to formulate geometrical systems, which are related to adaptable parameters.

During 5 to 7 intensive lessons the students learn the basics of the software. At the end of the lesson section they know how to handle constraints in a simple 3-dimensional model. The can establish formula to drive the geometry. The students could handle the link between objects and their constraints. We used simple example to transport these competencies.

The basics of geometry

As mention before we used two approaches to the basics of geometry. The first was to ask the students to work out a paper about different terms and definitions of geometrical phenomena. The papers were presented to the colleagues. The themes were Nurbs, Translation Surfaces, Nodes and Structures, Iterations and Fractals, Spline Surfaces. The students show a great competency in researching the fundamentals of geometrical understanding. We will see later, that this leads to structural founded results.

The second approach was intended more from the “architectural” site. We asked the students to analyse existing buildings. The aim was to teach the students to observe architecture under defined aspects. The presentations were disappointing form the point of the geometrical cognition. We learned much about history and the architects that build the house but not much about the geometrical background of the constructions or shapes. This leads us to the thesis, that the students at the beginning are not aware, that there is an important and form giving impact of geometry to the final building. Understanding the geometrical structure of a building can help us to understand the architecture itself.

Learning parameters

Influenced by the Bauhaus “Vorklasse“ we decided to acquire the exposure of parameters by using manual exercises. On one hand we admired to start immediately into the course work on the other hand we searched for an instrument to get into the work with parameters. We divided the term “parameter” from the digital world into the manual world. With this medial interchange we hoped to explore the deeper meaning of parameter. Parameters are not only a matter of the digital world. The Euclidian golden ratio e.g. can be seen as a design rule that refers to a certain aesthetic understanding.

In the course we wanted the students to find, formulate and apply design instructions, which can be adapted by transforming the starting point or
The driving parameter. In literature we identify four types of constraints: functional constraints, topological constraints, geometrical constraints, quantitative constraints (Kilian, 2006).

The task was to use a piece of paperboard and to develop a structural object by the serial addition of a certain operations (operation instruction or design instruction). To form the paperboard only cutting and manual treatment was allowed. The use of adhesive was forbidden. On addition the students manifest their design instructions by formulating simple algorithms or logical coherences. With hindsight this externalisation of the design strategy was the crucial step. The students become aware of the implicit decisions they normally make during a design process. The externalisation of design decisions is the major point to come to a parametrical design approach, as Kilian showed (Kilian, 2006).

In the second course the students made a morphological analysis of a chosen movement. This could be a human movement or the movement of an object. They also should work out the parametrical structure of the observed item. The turn to the movement was intended to enforce the role of the parameters.

The students jumped over tables, observed falling maple semen, turned bike wheels with LEDs. Some simulated the interaction of different fluids pour together; others melted plastic bottles in the oven.

The results of the analysis were documented in pictures, films or animations. Like the first group the second group also had to externalise the parametric points and the unchangeable values of their observed object. Knowing from the first group that the transition into a design is the very difficult step in this approach we wanted the students to train this step by building a non-functional but structural sculptural object.

**Transition into design**

The final and crucial step was to transport the gained insight of the preliminary practice into a design with a more or less defined function. Being aware that we stroll on an abstract way and we pursue a very formal design approach, the design task was chosen not to be to close to a functional building than more on structural object in an architectural scale. The students were asked to develop an event platform.
Figure 3
Student jumping over a table

Figure 4
Rotating Wheel with LED.
Falling Maple Leaf
We wanted the students to develop an internal logic of parameters or variables to develop their design. As the genius loci don’t provide an informative basis, the usual parameters like noise, urban lines, traffic flood etc. were not very useful. The students interpreted this step in different ways. We are able to divide these approaches into 3 groups. The application of parametrical structures is also different between these 3 groups. The teams of the first two groups realised a design vision. The parameters came into operation at the detail planning level. So they developed parametric leading details, which can be adapted to the different situations and could be manufactured directly by machines. The teams of the third group used the parameters to create an internal logic that drives the outer shape of the design. We want to discuss 3 examples.

**Visionary design approach**

The students rejected the results of the preliminary exercises and developed a design for the building site. The starting point is a vision for the “building” with its function and appearance. To refer to our demand, they tried afterwards to use parametric strategies to divide the cladding or to describe the manufacturing details with parametric models.

**Figure 5**
Conventional Design with Parameterized Cladding

**Figure 6**
Division Corresponding to Foam Formation
Figure 7
Analysis of the Students Jump

Figure 8
Final Design based on the Students Jump

Figure 9
Pattern for the Following Object
External transition
Referring to the outer shapes, coming from the preliminary exercises, the students tried to imitate the object’s appearance keeping alive the internal logic. This deductive concept leads to a design with has its internal logic. This means the design instructions are valid at any point any time. The design is able to react on changes to the variables in the design instructions as a whole system. The design grammar keeps alive.

Internal transition
In contrast to the deductive concept the inductive concept has its starting point in the awareness of a valid design instruction. The material or the construction principles for example may force these constraints. Based on these constraints the students developed their results. The important point on this approach was, that the final design follows the rules and requirements set by the designer from the beginning. From the designers point of view this approach leads to an experimental design, because there is no vision of the final design at the beginning, but there is an internal logic the design has to fulfill. So perhaps there are several possibilities to solve the design task.

Discussion
The systematical classification of the results shows that we can admit to Kilian (2006), that the transition from an idea into a parametrical design model is the crucial one. The quantitative comparison of results characteristic shows this challenge (figure 11).

It is obvious that this is not a representative study, but in the two different courses we can detect a tendency. Half of the group preferred the visionary design approach, although the assumption was to find abstract design instructions to develop a shape. The group, who followed the external transition, can be declared as the optimization group. They take a found shape and tried to mesh the surface or tried to parameterize the construction details. This group counted about a quarter of the total amount of the group. The third group tried to develop a parameterized design instruction as a starting point of the design. The constraints were developed in advance to follow the special demands of material, geometrical visions or functional addictions.

Comparing the statistics one can see, that the definition and the subsequent externalization of parameterized design instructions cause problems.

On the other hand, we also see that the sort of the preliminary exercise has no influence on the way the students solved the design problem. Concerning

<table>
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<th></th>
<th>group 01</th>
<th></th>
<th>group 02</th>
<th></th>
<th>total</th>
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<tr>
<td>visionary design</td>
<td>4</td>
<td>44%</td>
<td>4</td>
<td>50%</td>
<td>8</td>
<td>47%</td>
</tr>
<tr>
<td>external transition</td>
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<td>33%</td>
<td>2</td>
<td>25%</td>
<td>5</td>
<td>29%</td>
</tr>
<tr>
<td>internal transition</td>
<td>2</td>
<td>22%</td>
<td>2</td>
<td>25%</td>
<td>4</td>
<td>24%</td>
</tr>
<tr>
<td>total</td>
<td>9</td>
<td></td>
<td>8</td>
<td></td>
<td>17</td>
<td></td>
</tr>
</tbody>
</table>

Figure 10
Example for Internal Transition

Figure 11
Classification Table of the results
that these exercises should lead to a deeper understanding of the use of parameters we can admit that both exercises, even they are very different, are equally helpful.

**Conclusion and outlook**

This approach claims not to be architecture. But it was an experiment to investigate the impact of parameters to design. We have to admit that the preliminary work for a deeper understanding of parameter plays an important part.

Perhaps we had disregarded the difficulties to get into the understanding of geometrical dependencies. But we are convinced that we followed the right path to teach a parametrical application. An application like “Digital Project™“ is only useful if we are aware of the parameters power to the design process. The knowledge of geometrical dependencies corresponding to parameters with their impact on architectural form finding and its construction has to be cultivated. As Kilian (2006) or Lömker (2006) showed we should investigate constraints in order to find further possibilities for an extended design process.

We observed the methods and results of the course for a better understanding how we can bring this type of software closer to the students. We see a big interest in this software, but we need new concepts to teach these applications.

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**References**

Gehry Technologies, Digital Project™, 2004, 12541-A, Beatrice Street, Los Angeles, California, USA.


Saint-Exupéry de, A.: La Citadelle, posthum, 1948: Translation: “If you want to build a ship, don’t drum up the men to gather wood, divide the work and give orders. Instead, teach them to yearn for the vast and endless sea.”.

