Urban Furniture

Introducing Parametric Modelling and Digital Fabrication in a Part-time Study

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Abstract. *This paper discusses a design course covering the complete process chain from parametric modelling to digital fabrication. The course was run as a 2-semester elective course at Hochschule für Technik Zürich (HSZ-T), a Swiss University of Applied Sciences that offers as the only school in Switzerland a Bachelor of Architecture as an extra-occupational part-time study (joining ZHAW in 2012). The design objective was to develop pieces of urban furniture with help of parametric modelling and fabricate them with digital tools. Each of the eleven objects was realized in collaboration with a different professional enterprise chosen by the student, which let us experience a wide range of different materials and production technologies.*
Keywords. *Parametric Modelling; Digital Fabrication; Furniture Design; Part-time study.*

INTRODUCTION

Ever since architects and designers discovered the link between digital design and digital fabrication, they have been challenged to apply emerging new technologies to the design of furniture (and 'pavilions', but this is a different story). The complexity of constraints in furniture is rather low compared to buildings while the freedom of interpretation is great – perfect settings for a case study.

Founding in 1994 the C-Labor at HfG Offenbach and in 2000 the NEWCRAFT project (a 'mass customization' network of designers in collaboration with professional carpentries), Jochen Gros was an important driving force in the early years of parametric modelling in furniture design (Gros, 2000; Steffen, 2003). In the first decade of 21st century, numerous researchers at design and architecture faculties experimented with the influence of parametric modelling on furniture design. On the CUMINCAD database, projects are documented as conference papers by Schein (2002), Ebnöther (2004), Kilian (2006), Steinbächer (2007), Vamvakidis (2009) and Sprecher and Kalnitz (2009). It is interesting to follow the developing mindset towards the use of computers in design. While Gros started off in 1995 with a systematic collection of traditional wood joints adapted to CNC milling machines and Kilian (2006) wonders in his 'chair design experiment' about "circular dependencies" in parametric modelling, Sprecher and Kalnitz (2009) state with their C-chair that "architecture is now more then ever putting life at the center of its preoccupation" and that "architectural forms have given place to energetic formations".

COURSE OBJECTIVES

Part-time studying at HSZ-T means that students are employed at least 50% (some even 70–80%). Lessons take place very concentrated on a few days and often do not end before 10 pm. Students of HSZ-T are profiled as experienced hands-on architects, able to realize the design of a building with high-level workmanship.

The recent shift in using the computer from imitating analogue drawing techniques to interrelating form and information with algorithms – namely the shift from 'Computer-Aided-Design (CAD)' to 'Computational Design', described and coined for instance by Menges (2009) – is currently not reflected in the school's agenda, as it is not understood as relevant for the daily workload of an architect.

Within the specific environment of part-time studying, it seemed advisable to create an awareness of how easily accessible digital design and fabrication tools have become in recent years and to which extent the building industry is already penetrated with the respective technologies. We wanted to introduce technologies that we considered as suitable for daily use in the design and construction process – this meant relying on familiar top-down design approaches. The course intended to meet three objectives:

- First, giving insights into 'Parametric' and 'Generative Design' as discussed in magazines and promoted by an architectural avant-garde.
- Second, making students experience the direct relation between digital drawing and digital fabrication ('digital chain').
- Third, and most important, communicating these technologies on a profession-oriented down-to-earth level to make them useful for the student as employee in an average architectural office.

As we could not expect from practicing architects to have experience in programming, we decided to introduce 'Grasshopper', a popular graphical algorithm editor tightly integrated with McNeel's Rhino. The intuitive user interface of Grasshopper (introduced as successor of 'Explicit History' in 2008) makes it possible to build parametric models without programming knowledge – a feature most interesting for visual thinkers like architects and designers.

In a second step, we asked the participants to adopt their acquired knowledge of Grasshopper to a design problem, namely a piece of urban furniture for the school's courtyard. Students were to develop a design idea, drawings, 1:6 model and a cost estimate. As most of the students were in the last year of their Bachelor studies, they were free to choose the topic and material for their urban furniture by themselves.

In a third step in the second semester of the course, the participants developed workshop drawings and realized their design with help of digital fabrication.

A third of the teaching hours were used for each of those steps, applying different educational concepts – 'Grasshopper Introduction' with a traditional teacher-student relation, 'Urban Furniture Design' with individual coaching and 'Digital Fabrication' on the students' own responsibility.

We encouraged the students to choose between two different approaches:

- Fabrication of variants (simple objects that can be adapted with help of parametric modelling to different constraints such as input parameters of individual spaces and users).
- Geometric complexity (complicated objects that become only feasible with help of parametric modelling, such as ornament and free-form).

RESULTS

Nine of eleven participants decided to work on a seating object – it seems that chair design is especially appealing to architects. However, one student designed a barbecue and another student developed a light installation with LED lamps. In contrast to the limited design subjects, their interpretation and materialization was extremely diverse.

Only three of eleven participants investigated 'geometric complexity' with objects consisting of 34 up to 198 varying pieces. The rest of the students went for a 'fabrication of variants'. They stated that their object could be potentially adjusted to different users or uses, while the object itself was built from

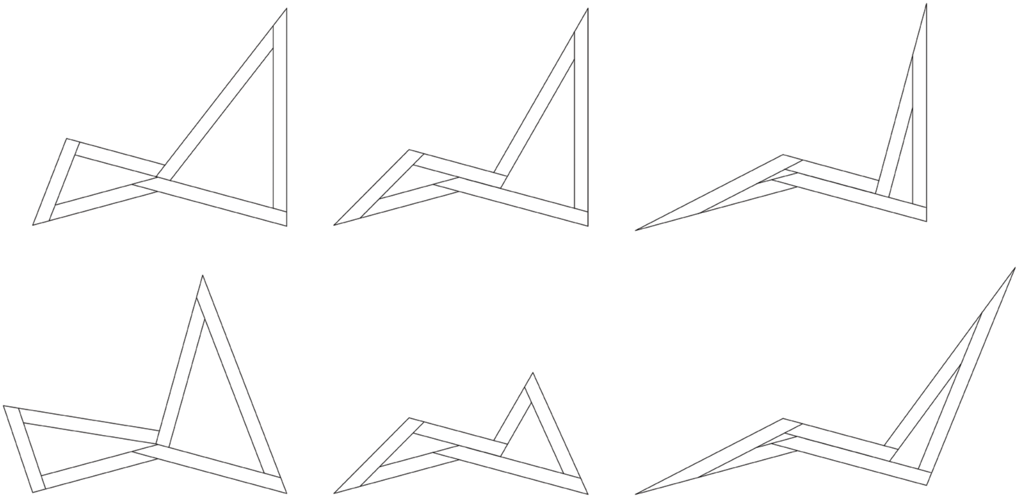
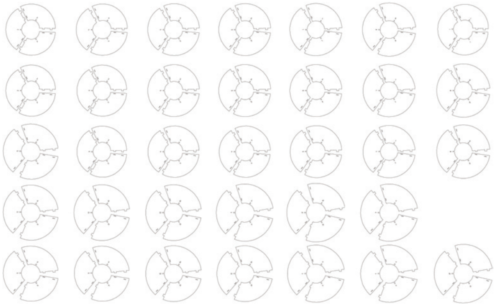


Figure 1
Igor Gasic's 'breakpoint'-chair allows a lot of possible and impossible configurations.

Figure 2
The realized configuration consists of 49 bolted pieces from solid iroko hardwood. Photo: Kyeni Mbiti

Figure 3
34 different lampshades from three sheet metal pieces are the building kit of Dan Cajöri's lamp object 'sinus'.

Figure 4 (right)
The sine-like altering inclination of the lampshades causes an interesting visual effect. Photo: Kyeni Mbiti



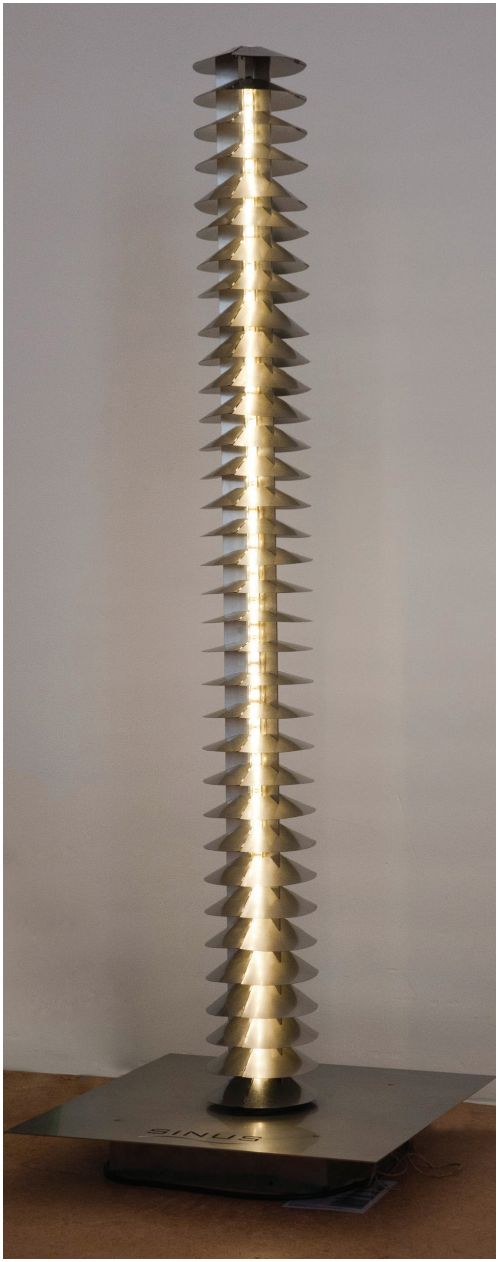
few different or even similar pieces. While the small 'geometric complexity' group had to deal in fact with managing many different pieces in planning and production, parametric modelling remained hypothetical for the 'fabrication of variants' group and could not be realized in the workshop, as our budget allowed only the exemplary construction of just one option.

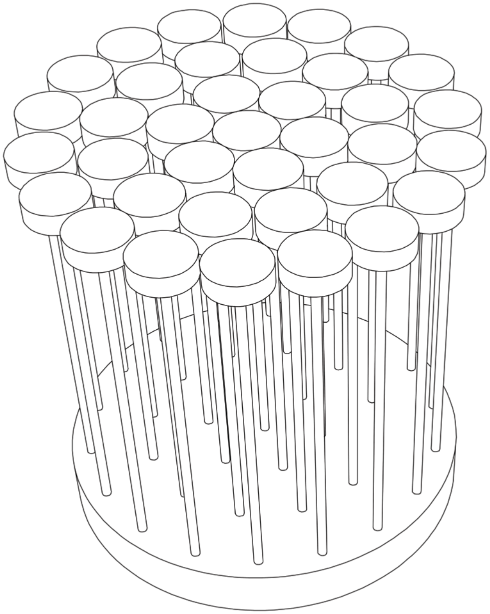
Grasshopper

All of our students seemed to have been fascinated by Grasshopper. They were able to build their own models from the very start – without ever having programmed – and gave us very positive feedback about their first steps. It was especially revealing for them to discover the algorithmic secrets behind some of the largely published free-form buildings and de-mystify them by modelling their geometries through defining a few relations, like for instance Foster's Swiss Re 'Gherkin' Building. Therefore it came as a big surprise for us that only half of the eleven students actually used Grasshopper to generate their urban furniture design.

Digital Fabrication

During the design phase, all students used the digital tools (laser cutter, digital cutter) the RAPLAB at ETH Zurich gave us kindly access to. Students experienced that the geometry on the screen is exactly the same geometry the CNC-tool will follow and that any mistake on the screen will cause the same mistake in the material – drawing a curve suddenly meant taking responsibility. In furniture design, this goes even





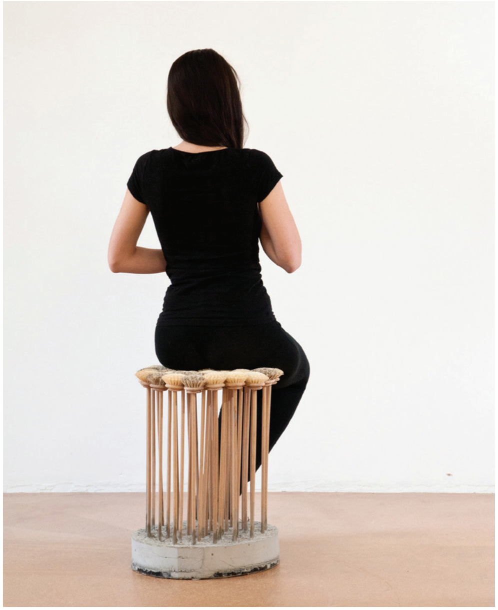


Figure 5 (left)
Brush arrangement and density of Georg Strassburg's brush stool is organized with help of a Grasshopper model.

Figure 6 (right)
Sitting on 37 brushes is far more comfortable than one can imagine.
Photo: Kyeni Mbiti

a step further, as those curve-lines can be judged for their ergonomic or aesthetic qualities.

When it came to the final realization of their object, the special hands-on profile of the HSZ-T students played a major role: Many course participants either had a technical background or close relatives/friends working at medium-sized producers. Most of the objects could be realized at cost price in collaboration with a professional enterprise (ranking from 120 to 900 EUR). This had several effects on the objects:

- The workmanship was beyond the possibilities of an academic workshop.
- As every design was fabricated on a different machine, the range of materials and production technology was very wide.
- All of the objects were stable and – most of them – even ergonomic.

Evaluation

After the course, we asked the participants to give us a personal feedback. None of the participants had experience with parametric design; some had worked previously with database or web programming. In the process of the course, many students declared that they had felt not experienced enough to use the newly acquired parametric tools to solve a difficult design task and therefore relied on proven design concepts and strategies. However, about half of the students do believe that they might use parametric tools in their office. All students consider façade design an appropriate field for parametric planning, "especially where repetition and subdivision are a topic". One student recommended "to invest more time into programming and to determine the digital fabrication strategy in advance."

CONCLUSIONS

The results of our course were well received by fellow students, teaching colleagues, external specialists and curators. However, the projects were rather appreciated for their design and workmanship. In our course set-up, the design task (urban furniture) had been considered adequate for the design tool (Grasshopper). In the progress of our course, the design task became more and more independent from the design tool.

We got the impression that parametric modelling with its inherent algorithmic logic is far less universal as it is considered to be – and this we state after the approach is discussed, developed and applied, in most cases within an academic context, for about ten years. To make our course an introduction to 'Parametric' and 'Generative Design' with the example of urban furniture, the design task should have been specified in a way that parametric modelling is not a nice-to-have, but the only means to solve the task. For us as teachers, the interaction of parametric modelling and real design problems with ergonomic requirements remains a challenging task.

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