Parametrized Systems: Conceiving of Buildings as Assemblies of Varied Parts

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We describe and discuss a design and research project that together with students explores the new possibilities current design tools and manufacturing processes give architects to design systems for building components that transcend the limits of fordist serial mass production in favour of post-fordist individualized mass production, most importantly the supersession of a few equal building components for many similar ones. Contrary to many projects with similar content and intent, ours starts not with the digital tools but with production techniques and materials. Constant physical materialization plays the main role, digital tools assist.

Keywords: *Parametric Systems, Design Build Class, Design Tools, Digital Manufacturing, Digital Materialization*

BACKGROUND

In order to get built at all, buildings have to be subdivided into parts that can be handled by people. Finding systems that simplify the production of these parts has always been an important part of architectural conception. This started millennia ago with using found stones assembled into walls.

Until recently, such systems were bound by the constraints of manufacture or serial mass production to the application of as few equal parts as possible. Today, individualized mass production allows for the production of parts that are all different without increases in cost. The difference of the parts, though, has to follow a logic of similarity: all parts have to be related like members of a family and the relationships described as variants in parameters controlling the shape and structure of the individual instances.

This completely changes the way in which building systems can be conceived and applied in construction, especially with regard to variance: where in serial mass production, introducing variance necessitated complex components that could play many different parts, the components now can be very simple and the variance introduced through their individual differences.

PARAMETRIZATION IN ARCHITECTURAL EDUCATION: MOTIVATION FOR FOCUS ON PHYSICAL MATERIALIZATION OVER DIGITAL TOOLS

Introducing such processes and possibilities into architectural education can be divided into 2 parts: on the one hand introducing a conceptual understanding of parameters and parametrization, and on the other hand familiarizing students with the digital tools necessary for the application of such parametrization.Both parts are necessary. Dealing with the first without the second denies the true power of parametric concepts to unfold properly. Dealing with the second without the first tends to produce rather superficial projects that fail to develop beyond replication of already existing projects.

Although digital design tools and manufacturing technologies are indespensable for realizing the full potential of parametrization, we have found that basing a project on their introduction and exploration tends to lead students to de-couple the projects developed thereby from the conditions of physical realisation. Properties of building materials and ways of joining them to one another tend to get subjugated to the looseness of the digital realm.

In the described design course we therefore start with and focus on physical realization. The students constantly have to produce physical models and take into account their properties, especially with regards to connecting building parts with one another. Digital tools are introduced and explored in parallel, but are very clearly and conciously used to only augment ideas which start in the physical domain.

Through this focus, we aim to produce projects which incorporate materialization instead of confronting it - something that tends to happen in projects which are being driven by digital tools instead of being augmented by them.

As digital tools we employ Rhinoceros and Grasshopper. As their functionality is amply described in widely available literature, we here focus exclusively on the aspects of materialization in the physical realm.

4-STEP DESIGN COURSE STRUCTURE

Our design course is divided into 4 steps which gradually build up an understanding of building parts, parametrization for their variation, questions of connecting the parts, and how assemblies of parts can become spatial physical structures and buildings.

These steps, as said before, explicitly start in the physical. Students have to build models of their proposals. Digital tools are introduced in parallel. This way, students cannot loose sight of questions of materialization, and the digital tools serve as augmentation for non-digital ideas, and not as producers of ideas that do not consider materialization.

The students begin by conceiving building systems that serve no specific functional aim other than an overall spatial structure. Gradually, more functionality and relation to buildings are introduced, and in the final step, the students build a 1:1 scale model of a pavilion-like structure.

Design course step 1: Experimental parametrized building system

The students have to study different materials and production technologies and propose a three-dimensional building system that uses one of each (Figure 1). The focus here is not (yet) on the functionality of the built structure, but on the physical properties of the materials, how they can be connected and how they can be produced using a specific production technology chosen by the students.

Design course step 2: Simple design object built from parametrized building system

The first step is repeated, but this time, the students have to build an actual usable object: a lamp (Figure 2). Lessons learned, possibilities encountered and problems solved from Step 1 are applied.

Our choice of a lamp as objective is based on several factors. Its size: it is small enough to be transported easily. Its number of parts: it is possible to build a lamp with a relatively small number of parts, so as not to overextend the students' capabilities. Its spatial properties as a design object: Already in such a non-architecturally small object, aspects like spatial qualities, transparency and light distribution can be studied.

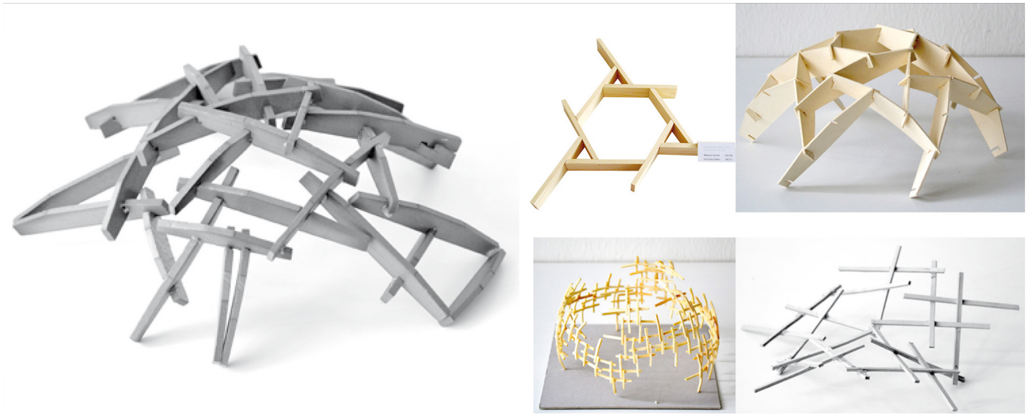

Figure 1
Design Course Step 1: Building systems (Students Henkel and Detko, Aachen School of Architecture)

Figure 2
Design Course Step 2: Lamp design studies (Student Project, Aachen School of Architecture)

Design course step 3: Pavilion architecture designed on the basis of a parametrized building system

Again, the discussions and results from the previous steps are re-considered to design an object with increased scale, complexity and proximity to an architectural building: a simple pavilion, basically merely a roof to provide simple shelter from sun and rain. Although in this step, the projects are built as scale models only (Figure 3), questions of weight and transportability have to be considered. How large can the individual parts be, so that they can still be transported from production facility to building site, lifted from one place to another with standard equipment and handled with tools (Figures 4 and 5) ?

Design course step 4: 1:1 Scale installation built from parametrized building system

In the final step, the students in course chooses one of the projects from step 3 and build (parts of) it as a 1:1 scale prototype (Figures 6 and 7). Questions of transportability and handling become even more important and also become 'real' for students as opposed to 'merely' theoretical as in the previous steps.

Furthermore, the students now have to organize as a group with a common objective. This means that they have to divide labour, that is to identify and assign specific tasks. Typically, they discover new in-

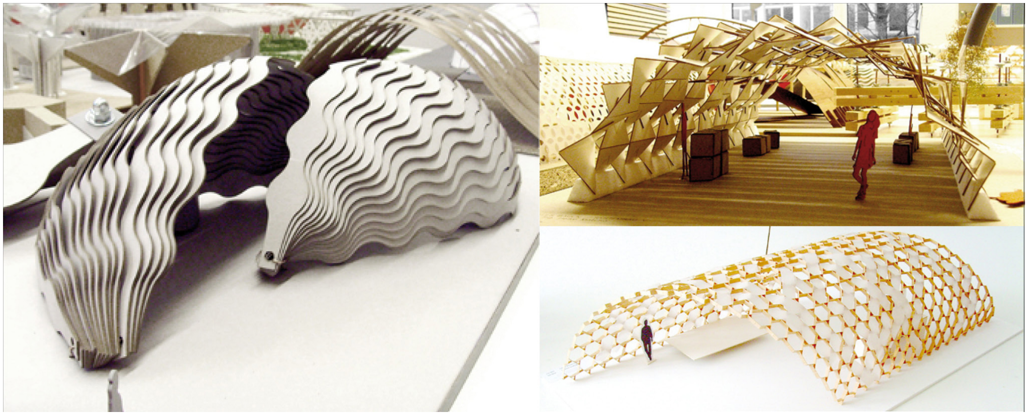

Figure 3
Design Course Step 3: Pavilion designs (Student Project, Aachen School of Architecture)

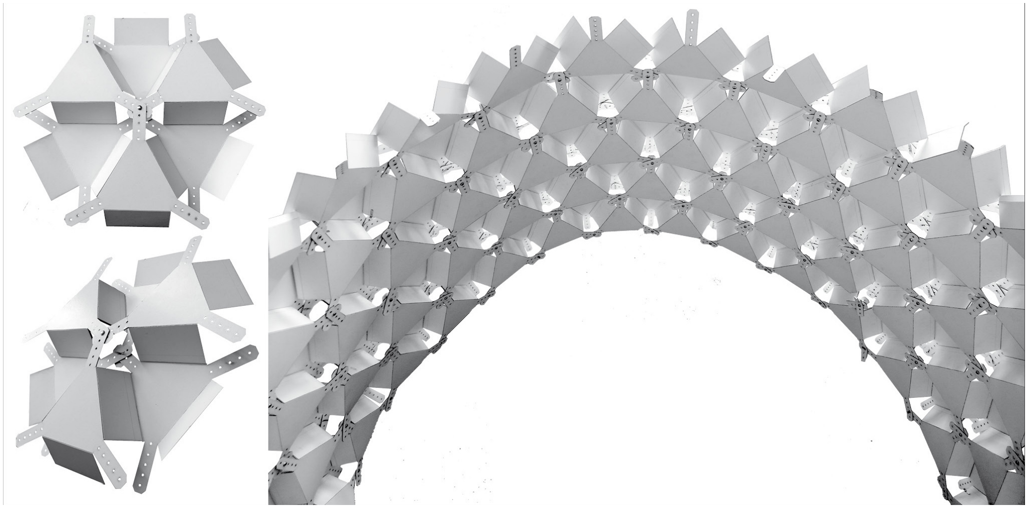

Figure 4
Design Course Step 3: Pavilion designs Component Assembly Studies (Student Project by Esra Bektas, Marc Mevißen, Ümmü Dedeoglu, Selin Sönmez, Aachen School of Architecture)

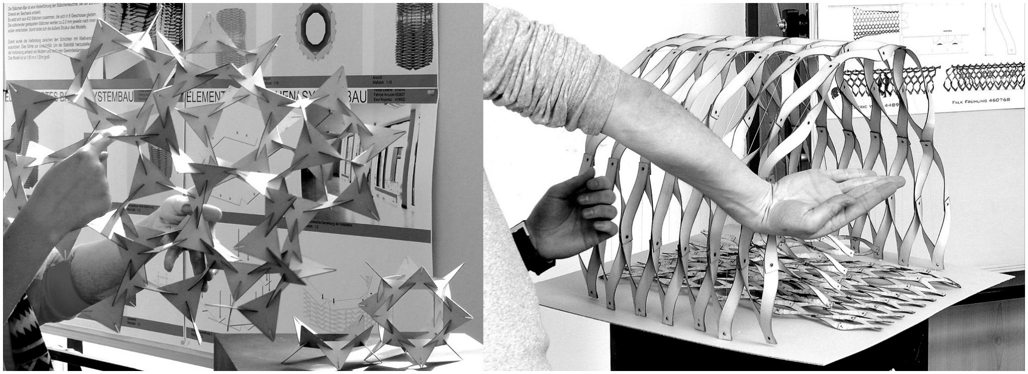

Figure 5
Design Course Step 3: Pavilion designs Component Assembly Studies (Student Projects by Nazli Ceyhan, Alexandra Koch, Nadja Schneider (left) and Frederic Walk, Matthias Wenn, Falk Frühling (right), Aachen School of Architecture)

Figure 6
Design Course Step 4: 1:1 Scale Prototype - Milling and Assembling of Building Components (Student Project by Larissa Niemann, Michael Meuffels, Alena Puchleitner and Lara Waibel, Aachen School of Architecture)

dividual skills, capabilities and talents: students who may not have developed strong designs may be very adept at organizing the group, or finding transportation or sponsoring. Students who may not be very accomplished at using digital tools or building small-scale models may come into their own in the large-scale manipulation of physical parts.

REVIEW AND OUTLOOK

Overall, the students' understanding of buildings and their components is deepened and made more fluid: no longer do they cling to rigid and fixed objects, but rather to relational fields of possibilities that respond to changing design conditions. The incorporation of physical properties of real materials, manufacturing of parts from them and transporting and handling those parts into students' design thinking is much improved through the experiences gained in the project.

In the future, we aim to extend the duration of the project from 1 to 2 or more semesters in order to increase the degree of experimentation with parametric possibilities in the digital design space.

Figure 7
Design Course Step 4: 1:1 Scale Prototype - Finished Project in School Exhibition (Student Project by Larissa Niemann, Michael Meuffels, Alena Puchleitner and Lara Waibel, Aachen School of Architecture)

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