AGGREGATES

Digital design for design 1

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Abstract. This paper discusses an educational design methodology for undergraduate studio instruction, which uses a systematic and research based design approach. Based on Lars Spuybroek’s methodology that was originally developed as a one-year graduate and postgraduate studio, a new method for undergraduate teaching has been developed. The paper will discuss Spuybroek’s methodology, as developed for the graduate and postgraduate program, and explain its adaption for undergraduate studio instruction. Spuybroek’s approach is based on a model that starts with research in systems in general that is them tuned to a certain set of architectural questions and developed into parametric buildings in a stepwise procedure by delaying the specifics of site and program.

Keywords. Methodology of CAAD; education in CAAD; generative design; parametric modeling.

1. Introduction

Conventional architectural studios may start with research of site, program or a specific building technology that drives the design process, using digital tools as a means of representation. In recent years we witnessed a larger number of digital studios that have been taught with the emphasis on digital tools. Foregrounding the tool these investigations often focused on the investigation of formal novelties for architecture. Greg Lynn, Zaha Hadid and Patrick Schumacher are leading this method in the studios they taught in Europe as well as in the United States (Terzidis 2004).

The studio that will be discussed in this paper is an attempt to move the focus from the tool to methodology, as a constructive generic framework. The
discussed method is based on Lars Spuybroek’s approach to teaching digital design, which he developed at Columbia University, University of Kassel and the Georgia Institute of Technology. Certainly, similar approaches to digital design can be observed at the Architectural Association in London, the University for Applied Sciences in Vienna, at MIT, at University of Pennsylvania and at other university. Instead of analysing the similarities and differences between the different programs this paper will specifically focus on Lars Spuybroek’s approach to digital design.

2. Research and design

Figure 1. Structure Ventulett Studio, L. Spuybroek.

Lars Spuybroek describes a paradigm shift in architecture in the foreword of R&D in the following way: “Information was text; form was architecture. Today, things have changed. Tools aren’t fixed anymore, type isn’t fixed anymore, demographic maps have been changed completely, products are being replaced by half-products… and everything seems to be fluid and vague. Design requires more and more research, since the transfer into architecture is without prefixed codes, without prefixed forms and procedures. It is no longer enough that we do research before entering a design phase: we now have to research design itself.” In that context he postulates that our methods of teaching and designing must become more rigorous and clear. His teaching method seems to follow that aim.

Lars Spuybroek’s work at the Georgia Institute of Technology is the best documented of the three schools mentioned above due to the fact that the Ventulett program was published each year in the Research and Design series - R&D I and II. His teaching methodology is based on a two semester program with two subsequent design studios, two theory seminars and a symposium that is linked to the topic of the specific year (2007 Uniformity and Variation, 2008 Textile Tectonics, 2009 Seeing and Feeling, 2010 Digital Craft, 2011 Beauty). His program is open to students at the end of the graduate program.
and postgraduate students. The first semester in his program deals with digital design and the second with digital fabrication.

Figure 2. Foam Tower (R&D2). Instructors Lars Spuybroek, Daniel Baerlecken. Students: Geoffrey Braiman and Dave Beil.

The first semester starts with research in pattern systems. The studio Textile Tectonics in 2008 for example, published in R&D 2, focused on the structure of vertical building types. The topics researched in that studio include gothic figures, braiding, foam, radiolaria and minimal path systems based on Frei Otto’s form finding experiments with wool threads (Kolodziejczyk 1992). For each topic students were asked to diagram patterns as systems with varying figures and their configurations. In this first phase these systems were understood by the students through analogue computing – Gaudi and Frei Otto – and through rigorous diagramming and subsequent translation into a digital systems. The diagrams were parametric and were still able to vary within a certain defined range. During this phase students worked in pairs, which helped to foster a dialog-based approach.

In a second phase these pattern systems informed architecture in one or more of 3 interconnected systems: a façade system (structural and/or ornamental), a structural system and/or a volume/massing system. A pattern for instance might have been first used to inform a structural system that further informed the distribution of program elements, the positioning of floor slabs, the composition of the façade, the formation of apertures and possible relationships to a specific site. Students in such an approach are also challenged to develop a wide range of prototypes for building components and elements and their possible relationship. Tectonic systems are developed to potentially respond to different external and internal forces such as site and program without being tailored to a specific context.
In the second semester students are using their systems to respond to parametric forces of a specific site and program. The projects actualise themselves in this process as a consequence.

The second semester focused further on the exploration of tectonic properties through digital fabrication with an aim to produce “large models, all involving computer numeric control, which would eventually add up to a potentially infinite Borgesian “zoo”, a Wunderkammer of variations and studies… (Spuybroek 2009, p. 7).” These models included 2 m high structures as well as mock-ups in full-scale façade structures.

3. Studio methodology for Design 1

In summer 2011 Lars Spuybroek and we were asked to develop a new teaching method with the second year undergraduate studio. This studio is the first design studio in the undergraduate architecture curriculum at Georgia Institute of Technology. After a Common First Year, Design 1 is the first design studio, in which students are asked to develop a larger architectural project. Students are also new to digital modeling, fabrication and scripting.

Different to Lars Spuybroek’s option studio that is usually co-taught with about 15 students we had 60 students, split in 4 groups of 15 students each. In order to maximise the consistency in approach, structure and outcome the studio was structured into four parts with a midterm review positioned halfway in the process. The four parts were titled: 1) Aggregation Techniques: Analysis, 2) Aggregation Techniques: Digital diagramming, 3) Differentiation and Integration: Programming and Siting the Aggregation, 4) New skills: Drawing, modeling and rendering.

Beside the challenge of compressing a studio that Lars Spuybroek usually teaches over a period or two semesters into one semester the main challenge
was to transform an upper level option studio into a beginning design core studio. This change raised three main questions: First: How do we respond to the core curriculum agenda and cover aspects such as program and program site relationships, second: How do we connect the introduction of architectural representation convention of with the studio’s overall agenda and third: How do we integrate the teaching of software with the studio.

These three challenges are not so much an issue in upper level option studios, where it can be assumed that students already have the right software skills, are familiar with architectural representation techniques and have already exercised architectural problems that deal with a certain complexity of program and site. On one hand the challenge was to introduce a large volume of material to the students simultaneously within a very short time frame. On the other hand the parallel introduction of software, representation techniques and complex architectural issues opened the opportunity to redevelop the way digital tools are introduced in the undergraduate curriculum.

In the previous schools curriculum software courses were taught separately from design studios and framed around different applications. In many cases these tools informed renderings of final projects, but not the design process itself. In this studio we focused on building digital skills more integral to an architectural design process. Rather than introducing technical knowledge separate from design, digital skills are introduced to become the instrument for design. Talking about digital skills does therefore not mean the tool itself, but the method that drives design. The techniques and tools of design are linked to the design through method. Similar to this analogy students in our studio were asked to develop methods, digital methods in our case, before introducing an architectural program and a site. Our goal was to walk students through a process were “digital” methods are used to define internal relations within the program and relations between the program and the site.

### 4. Structure

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**Figure 4. Structure undergraduate studio aggregates.**
The studio that was first taught in the Fall semester of 2011. An investigation and unpacking of existing non-architectural systems was used to develop
digital methods, which were used to develop an architectural project at a specific site. Students were asked to diagram and unpack aggregates as rule based
systems, collections of items that are gathered together to form a total quantity. (Middle English aggregat, from Latin aggregatus, past participle of aggregare to add to, from ad- + greg-, grex flock, join together, attach) Climate for example is the aggregation of all local weather formations over longer periods of a season or year – with its local variations.

4.1. AGGREGATION TECHNIQUES: ANALYSIS (WEEK 1–2)

The studio did not investigate a material aggregate as a construction material (Dierichs and Menges 2010), but as a system or architecture embedded within
aggregational systems, that can be used to inform texture, structure, volume, program and any other architectural system. The aggregational parts are understood as varying parts, parametric parts with flexible properties that respond to different vectors or forces within their systemacy. This method followed an evolutionary process, which allowed for differentiation and integration of different systems with increasing complexity: “Complexity increases when the variety and dependency of parts increases. The process of increasing variety is called differentiation and the process of increasing the number or strength of connections is called integration. Biological and cultural evolution produce both differentiation and integration at many scales and levels… (Weinstock 2010, p. 30).” This development of architectural complexity through differentiation and integration was developed in successive order in different layers and scales and not all at the same.

The types of aggregations researched were: cracking and nesting of different floating sea ice types such as drift ice or pancake ice, aggregation of people in a park, patchwork in self-organised African markets, complete and incomplete states of mud cracking, radial and linear types of glass cracking, diffuse-porous and ring-porous hardwoods, log driving, slime mold, igneous rocks, metal alloys, flocking of herds such as sheep, patterns of angelfish, sand formations and crocodile skin. For the first five weeks the students worked in pairs and choose an aggregational structure from the given list of topics. Students learned how to transform images into diagrams in order to explain and gather a fundamental understanding about their aggregational system. The tools used were Photoshop, Illustrator and Rhinoceros. Students were asked to trace the images with typical diagram tools such as lines, dashed and dotted lines, arrows, colors and texts in different sizes in order to learn how to represent their analysis as a set of rules and pseudo-scripts.
4.2. AGGREGATION TECHNIQUES: DIGITAL DIAGRAMMING (WEEK 3–5)

In this phase students transformed the analysed material into more architectural issues using specific architectural software applications such as Rhinoceros. They started by re-working the analytical diagrams into 2D patterns first and later into 3D patterns and morphologies. At the end of this phase the students had a broad range of aggregational structures, forms or patterns with parametric variation. This work was explored through large fields/carpets of configuring parts illustrating the variability of these parts and the rules of configuration. At this point parametric history editors with real time feedback were introduced to explore variability.
4.3. DIFFERENTIATION AND INTEGRATION:
PROGRAMMING AND SITING THE AGGREGATION (WEEK 6–10)

The teams split up in this phase and the students worked individually from this point. They were asked to explore how aggregated systems can respond to the typology of the architectural program and to the site. The program for this particular studio was a cultural center with exhibition areas, a multipurpose area, a small indoor-theater, an outdoor-theater, a cafeteria, administration areas and back of house facilities. The students could suggest additions to the program in order to accommodate for site or program specifics. The site, a larger area in a local park suggested a multitude of local qualities and potentials resulting from topography, vegetation, vistas, accessibility and the existing program within the park. The site was selected intentionally as an anti-urban setting to better respond to the student’s selected aggregation types which all operated on a surface through horizontal extension. The students needed to select a specific site within a larger site area. They were further asked to develop a rationale and narrative for that choice through diagramming techniques.

The design process in this phase comprised the development of the related sub-systems of program, circulation and navigation. Each of these categories is developed in accordance with a specific spatial logic of the aggregation and a sophisticated spatial distribution of the program domains. Boundary conditions between program parts had to be studied to integrate or unify the different domains. A system of navigation and circulation was developed as a mean of orientation through the aggregational structure, which is especially challenging for non-hierarchical structures.

Figure 7. Plan developed from a 3d systemic model.

The students used diagramming techniques closely linked to the diagramming techniques developed in the research phase to adapt the aggregational systems to the requirements of program and site. For example programmatic bubble diagrams, which reflect social relations and hierarchies transform into spatial or tectonic systems, which followed the systemacy as previously developed
in the research phase. Site diagramming involved traffic flows, sight lines, sun and shadow behavior, but also experiential factors such as light or sound which now become part of the aggregational system.

The analytical research that first led to diagrams has now become a potential start of a project, which allows to further-develop ideas for stairs, entries, apertures etc. as part of the systemacy. In this phase the students learn additional modeling techniques in Rhinoceros, extracting digital information from the 3d file for physical model making, 2d drawing with AutoCAD and additional techniques in Grasshopper. A strong emphasis lied on the bi-directional feedback between digital model and physical to question both realms.

4.4. NEW SKILLS: DRAWING, MODELING AND RENDERING (WEEK 11–16)

In the final phase the studio focused on production for the final presentation that included drawings, renderings, diagrams as well as physical and digital 3D models.

5. Discussion

It is, of course, difficult to quantify improvements in architectural design, but it can be observed that the student’s skills in drawing and digital representation show a deeper understanding of space and structure and that the methodology has fostered a conceptual understanding of tools and techniques within a design process.

During the midterm review and the final review external reviewers commented on the methodology of the studio. Most comments were concerned with the scope and complexity of the project. One group of critics was recommending a more research driven agenda without any site or program, whereas the second group criticised the lack of a deeper understanding of the site and program. Both positions have merit, but the lightness of site and program was intentionally selected for the second year students: Students in the second year and first year in architecture after the Common First Year are generally longing to design their first building, but needed the guidance of the research phase to be able to develop a scheme.

From the student’s point of view the studio was a large success. Also one constructive critique in the evaluations of the course was that the methodology came per surprise. We are therefore planning to offer more theoretical background or more lectures that would situate this methodology in a larger context if thought for second time.
Acknowledgements

Figure 2 and 3 show the foam tower by G. Braiman and D. Beil (instructors L. Spuybroek and D. Baerlecken), figure 5 shows diagrams by O. Taylor and A. Wang (coordinators: L. Spuybroek, D. Baerlecken and instructor: J. Stanford), figure 6 and 7 present the work of L. Kvasnicka (coordinators: L. Spuybroek, G.Riether and instructor: A. Vialard).

References