

Towards a Digital Design Episteme

Considering Digital Concepts and Techniques in Architectural Education, Research and Design Methodology

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Abstract. *The paper addresses the issue of integrating digital techniques and methodologies in the conceptual stage of the architectural design process and describes the research and education of digital design procedures and proficiency. Accordingly, research into the correlation between theory and practice in the field of digital architectural design and education is presented. The influence of digital design theory and processes on the complexity and spatial variation of design solutions was studied in a series of consecutive short workshop based sessions in architecture and interior design master classes. The paper describes the aim, technical solution, scope and result of the experimental exercises.*

Keywords: *Digital design; conceptual design; design process; design pedagogy.*

Introduction

Architectural Design Methodology has been the subject of intensive research for more than four decades. In this time span, interactive and digital media have become instrumental in the investigation of design decisions and solutions. Numerous techniques have been introduced in CAAD and related software, allowing different ways for testing, comparing, validating and challenging design solutions through the use of computer visualization, simulation, analysis and evaluation. These newly emerging possibilities have raised important questions regarding design

and as Oxman (2006) argues, there is a need to consider a new understanding of the nature of designing with regard to digital media. Consequently, it has also become imperative to rethink the education of these techniques and processes.

Digital Design

Designing is considered a three-stage process (Jones, 1992). Jones names the three stages divergence, transformation and convergence. In digital design, the divergence of the search space is extensive, with so many techniques that have become available.

Jones clarifies that the methods appropriate for this stage involve both rational and intuitive actions. Rationally, the actions in digitally driven design are limited to the boundaries set by the software tools, while intuitively, the digital paradigm focuses the scope of the design elaboration.

In this study, the approach of rational and intuitive actions with regard to digital techniques and methodologies was based on the preliminary findings that are part of the doctoral study 'Design methodology in the digital architectural practice', which is currently being undertaken at the Antwerp University Association and the TU Delft. The research findings applied in the workshop are threefold:

1. Digital design paradigm. Based on an extensive literature study of both primary and secondary sources on digital design and digital architects, an outline of digital design concepts was made. As Jones (1992) already points out, many of the new methods in design are taken from other disciplines. Likewise, the digital design concepts were considered in the context of contemporary science, philosophy, cultural and social changes and architectural theory, in particular regarding the position digital design takes in reference to critical and non-critical, projective architecture.
2. Digital design examples. A number of designs were selected according to the digital design process that was implemented. The design outcome was studied along with the prevailing design concepts in order to ascertain the main concept and the digital techniques that were applied in the design elaboration.
3. Digital design techniques. To explore the new ways of architectural expression, form finding and communication, several digital design techniques were analyzed and reconstructed. The functionality of the tools the designers used was analyzed to ascertain the principles, techniques and methodology of the digital design processes that were set up. These processes were then recreated using a number of software, which included 3dsMax and Blender 3D.

The findings were applied in the context of a series of workshop based exercises, in order to obtain an insight in the correlation between theory, techniques and intuition in the field of digital architectural design. The digital techniques and the theoretical outline of the digital design paradigm were combined to develop an educational approach in which the creative possibilities and challenges of digital technology are taken into account together with the paradigm shift that is the consequence of the continuous influx of digital concepts, technologies, materials and techniques. The digital design examples were used to familiarize the students with digitally designed architectural geometry.

The workshop experiments

At the Henry van de Velde Institute, digital skills such as image editing and layout [Photoshop and Illustrator], CAAD [Revit] and 3D modeling [Rhino 3D] are taught in mandatory classes in the Bachelors, while concepts and advanced techniques were offered in optional courses for the Masters. Optional courses have shown the advantage of being more flexible and adaptable to keep up to date with the continuously changing technology and possibilities of digital techniques. For the same reason, the workshop model was found to be the best suited.

The series of consecutive short workshop based sessions was set up to study the influence of digital design theory and concepts on the complexity and spatial variation of design solutions. The premise of the sessions was to examine the effect of the paradigm shift on the design outcome of the workshops.

The students were required to investigate different innovative concepts in digital and interactive media and correlate these issues with digital architectural design techniques and creative visualization. This way the Digital Design Master class offered the students the opportunity to explore new fields of design investigation, try out digital design techniques and learn how these techniques could be instrumental in a design. In addition, the classes elaborated on

digital design concepts and the way they are related to the design techniques and methodologies of digital architects.

Apart from the classes offered in digital design procedures and proficiency, students were also able to attend interactive and/or advanced digital visualization classes to assess and study digital architectural visualization.

Aim

The research and its associated pedagogy were aimed at collecting information about the perception and deployment of advanced digital tools and technology, by trying to assess to what degree such tools can be significant in leading to innovative design. Schön (1987) talks about professionals being 'researchers in the practice context'. Action research as a way of working defined by Springer (1999), is very close to the notion of the reflective practice coined by Schön (1983). In this sense, the premise of the exercises was to obtain information on possible changes in the students' concepts, their conceptual designs and design methods by introducing advanced CAAD skills.

Scope

The influence of digitally-mediated design on architecture has been increasing since the beginning of the '90s, mainly due to the growing number of publications showing digitally designed projects. These publications describe and explain designs as the result of digital design processes, but in general the applied software techniques are merely mentioned and more specific descriptions of the design processes are lacking. Kolarevic (2000) lists the new approaches to digitally-mediated architectural design, regarding advanced computational concepts such as topological space, isomorphic surfaces, motion kinematics and dynamics, key shape animation, parametric design and genetic algorithms. In 'Behind the scenes', De Luca and Nardini (2002) elaborated on avant-garde techniques of contemporary design. They explain a number of design processes

in detail and reveal the methods for approaching architectural design using information technologies step by step (Saggio, 2002). The digital design course explores a number of digital design concepts and techniques in a series of assignments, each focusing on a different CAAD based design methodology.

Different software were used, such as the 3D modeling, animation and game engine of Blender 3D. A number of computer related processes and techniques were explored, including networked multi player interaction and visualization, mixed reality representation and dynamic and animated design generation.

Implementation

The approach was implemented in a workshop, which consisted of 4 assignments, each introducing a digital 3D technique to create and explore a number of preliminary and conceptual design variations. The first assignment of the workshops initiated Boolean logic as a technique to design a house. The second assignment elaborated on this idea by using Meta Balls (Blobs) for the design of a museum space. A third assignment introduced students to the techniques of morphing as a way to generate complex variations through time. Time as an inherent part of the design generation process was explored further in the final assignment that touched upon the idea of the digital as an abstract machine for form generation, introducing particle systems as a means to construct abstract volumetric compositions in 3D space.

Boolean logic, with its basic operators AND, OR, and NOT, is the basis of switching theory, used in the design of computer circuitry. Boolean algebra and set theory demonstrate the relationship between groups, showing what is in each set alone, what is jointly contained in both, and what occurs in neither. From this, the 3D-modeling operations of Union, Difference and Intersection were derived, which have become standard tools in architectural CAAD. These tools were chosen to initiate the familiarization of the students with a digital, but altogether not so

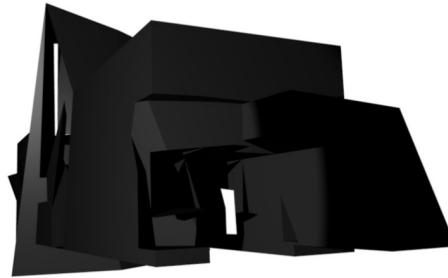
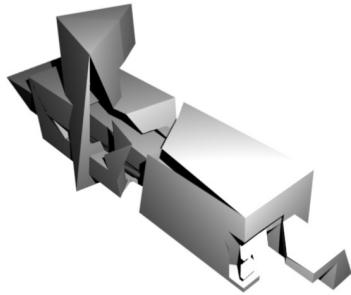


Figure 1
Boolean study by Katrien van Hemelryck

different approach to design as they are accustomed to in the design studio. The possibilities of the Boolean 'toolbox' in CAAD were used to study the effect of recombination and interconnection of spaces and their outcome in an architecture of gaps and traces, collisions and penetrations. Each object in the design of the Boolean house represented a space and/or a function. Different shapes were drawn to create the required spaces, keeping in mind the general size and scale of each one. These objects/spaces were then combined into a spatial composition with Boolean operators, in a series of additive and subtractive transformations. First, a design was made, after which examples were shown of designs using Booleans. Secondly, two more designs were created, showing the effect on the student's design thinking as a result of the additional information that was introduced (Figure 1).

In the second assignment, the concept and technique of the blob was applied in the design of an exhibition space. The circulation in the building was based on a metaphor of continuity, describing the way the spatial composition and navigation through the interconnected spaces in the building could be experienced by the museum's visitors. With the use of Blobs, the Boolean logic of the first exercise was taken one step further, adding continuity as a design concept.

The assignment was carried out in Blender, using its Metaball tool. The parameters that define blobs in Blender are mutual gravity (weight), extent of influence (threshold) and form type (ellipsoid etcetera). At the level of imagination, these modalities of definition lead to a geometry that is distinctly different from solids or surfaces. Lynn emphasizes this difference as a shift to thinking of space as the sheltered enclosures of a flexible handkerchief, instead of drawing points, and connect lines and planes with them. (http://www.time.com/time/innovators/design/profile_lynn.html: 2000). (Figure 2)

Morphing is a special kind of animation that shows how an object changes shape through a number of variations, turning into alternate versions

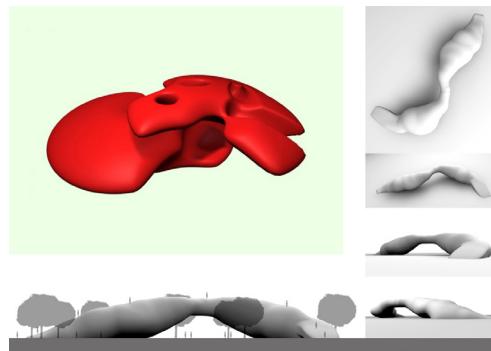


Figure 2
Design of a metaball museum space by David Catala (right and bottom) and Johan Bente (top)

Figure 3
Morphing variations by Julie Delanoy



of the object. Marcos Novak (1997) describes morphing as a new disjunction, opposed to the disjunction of collage that characterized much of the 20th century. According to Novak, collage merely superposes materials from different contexts, whereas morphing operates through them, blending them. He also states that collage emphasized differences by re-contextualizing the familiar, while morphing operations blend the unfamiliar in ways that illuminate unsuspected similarities and becomings.

This concept of morphing was implemented in Blender, by changing, reshaping and deforming 3D geometry in time. The design was based on a 3D solid, which represented a single volume building block, with an office -or apartment building function. A number of variations of the volume were created by applying modifiers to produce different versions of the basic mesh geometry. These versions then became start, end and in-between shapes in a morphing animation, showing the change of vertex positions over time. The transition between the states of the morphing objects was recorded by creating consecutive ShapeKeys on the level of the mesh vertices (edit mode). The Shape Keys were then added to the animation time line by setting Keyframes. This animation technique was based on

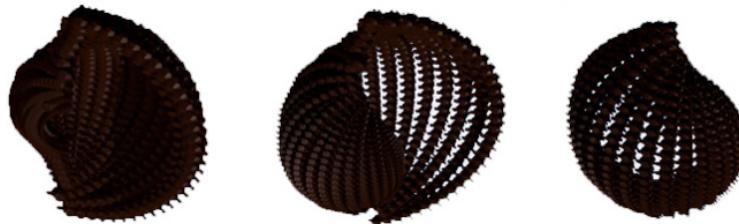
tweening. From the generated series of in-between variations, the students were required to choose two states as design solutions. (Figure 3)

Particle Systems are used to simulate large amounts of small moving objects, creating phenomena of higher order like fire, dust, clouds or smoke. Due to the nature of particle systems, that is, the large amount of objects, the user interaction is limited to controlling global parameters, like direction of particle movement, applied forces, obstacle definition, randomness, particle life etc. Influencing the system becomes almost intuitive.

The particle system in Blender is fast, flexible and powerful. Every Mesh object can serve as an emitter for particles. With the DupliVert option, objects replace the particles in the system. These dupliverbed objects can be any type of Blender object, for example Mesh-objects, Curves, Metaballs, even lamps.

For this particular assignment, the students were asked to create a conceptual volumetric study of a design using Blender's particle system and a mesh as particle object. Different meshes and particle system parameters were studied, as well as the effects of Force Fields, Deflectors and lattice deformation modifiers on the particle flow. (Figure 4)

Figure 4
Particle systems by Julie Delanoy



Result

The outcome of the workshops showed that the acquisition of CAAD skills should be accompanied by sufficient methodological and conceptual understanding and support, for new design solutions to emerge. In most part, the lack of innovation was a consequence of integrating digital technology in design studio work without addressing theoretical and cultural concerns pertaining to digital media and methodologies. The reason for this is can be found in the more abstract nature of the project topics compared to regular architecture assignments. The main effect has been a widening of the students way of thinking and designing.

Conclusion

Over the years, the consecutive workshops showed that the students overall computer and CAAD skills were gradually increasing, but not their conceptual thinking or ability to apply these skills in an innovative way. During the workshop classes, the emphasis of the student's efforts was seen to shift from an interest in learning advanced CAAD techniques to the application of the techniques in an innovative design process. As digital design education is shifting more and more from mere software training to methodology-driven and technology-driven design exploration, the interplay between skill and concept is being recognized as a part of CAAD education that needs to be addressed.

Along with acquiring CAAD skills, students need to learn about the methodological and theoretical framework of computer based design to be able to discern how and when these techniques can be instrumental in the conception of their designs. It is necessary to look upon digital design theory and practice as mutually inclusive. Digital design is not merely a question of techné, but also one of episteme.

Acknowledgments

The author would like to thank the students for their enthusiastic participation and keen interest in the workshops.

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