William Huff's Parquet Deformations:
Two Viennese Experiments

Werner Van Hoeydonck

Institute of Art and Design, Three-Dimensional Design and Model Building,
Department of Architecture, Technical University of Vienna, Austria.
werner@vanhoeydonck.com

Abstract

This paper aims to bring a new nexus of activities around architect and educator William Huff's work, presented here as an experimental design assignment in architectural education. After his retirement, professor Huff donated a collection of his students' work to the HfG Archive in Ulm, Germany, which inspired us, at the Institute of Art and Design in Vienna to give a semester assignment focusing on parquet deformations (PD). The open search for strategies to transfer the idea of planar PDs into 3D led to fascinating results. We discovered a field of formal research that broadened the students' horizons concerning 2 and 3-dimensional relationships enthusing them considerably by making them aware of the unlimited possibilities of spatial transformation. This is a brief report of a fruitful project in basic design education for architects and designers.

Parquet Deformations in 3D and Cellular Space Sequences

William Huff, in experimenting with his students on parquets consisting of one geometrical shape only, discovered a way to subtly transform one geometrical shape into another, and stipulated rules to be fulfilled: the parquet had to consist of one geometrical shape only (no overlaps or gaps). Permitted lattices were square, rhombic (60-120° rhombus) or regularly hexagonal. Parquet deformation designs, produced for over three decades in a curriculum of basic design studies, are rooted in two analytical disciplines: monohedral tiling in geometry and, deformation in biological morphology (after D'Arcy Thompson). Apart from the collection of handmade PDs, the HfG Archive also hosts a large series of skillfully made wooden 3D models, all made under Huff's guidance. It was especially the "trisections of the cube" (Figure 1, right), and William Huff's comment that they were an attempt to bring the idea of PDs into 3D, which inspired us to assign this project in WS 2017-2018.
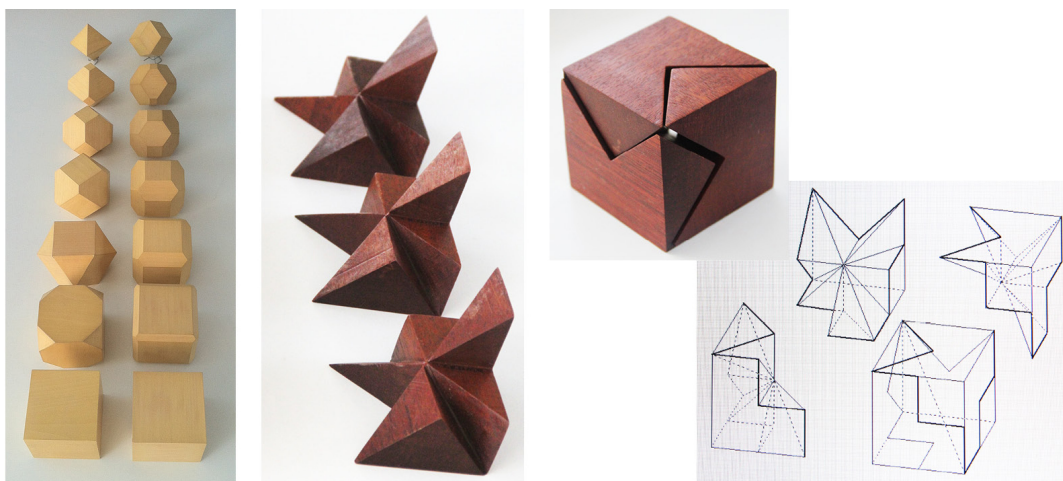

Figure 1: *left: Vertex truncations and edge truncations of the cube, Basic Design Studio William Huff.
Right: Trisection of the cube, wooden model and axonometric drawing,
Kathy Saffire, University of Buffalo, Fall 1987. © HfG Archive Ulm.*

Research and lectures on William Huff's students' works, tiling theory, space-fillers, topology, symmetry operations, M. C. Escher, abstract art and optical art etc., were organized. Literature [1-8] and visual materials were made available to all lecturers and students. The first task was to design 3 regular parquets in 2D followed by the PD exercise in 2D (Figure 2). To increase student awareness of subtle, continuous deformations and how one geometrical shape can be transformed into another, drawing by hand was preferred and encouraged. This facilitated a more sensorimotor experience thus leaving the students with more comprehensive and long-lasting impressions.
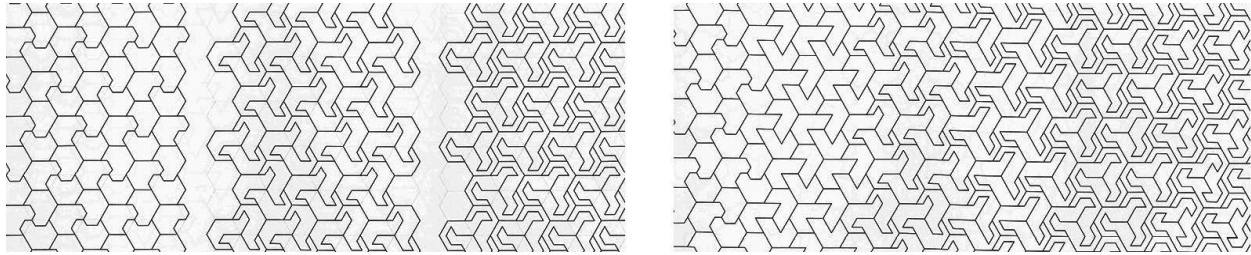

Figure 2: *left: three parquets. Right: parquet deformation,*
Tobias Dirsch, 2017, Design Studio Anita Aigner, © Technical University, Vienna.

William Huff's legacy is so important because it forces students to explore parametrical design without the aid of computers. In the last century, mathematicians contributed immensely to 2D and 3D topology. Although many architects today do use (mostly computer-generated) patterns in their designs, basic concepts of topology are still underrepresented in architectural education today. We therefore strongly recommend assigning design tasks like these in order to better merge mathematics and design, a bond that has been neglected long enough.

Our students spent eight weeks working on the 3D assignment – before submitting their 3D models. The challenge was both to develop a powerful design concept and to deform space-filling polyhedra containing subtle deformations. The proposed lattices were those of the cube, the rhombic dodecahedron, the truncated octahedron, the gyrobifastigium and the hexagonal prism, although other space-fillers were allowed. Through trial and error, the students used metal, wood, cotton swabs, paper, and casting techniques to create their models. All 450 submissions were comprised of a single A3 sheet containing a general overview of the process as well as an A3-ringed sketchpad depicting the process in length.

William Huff pointed out that a PD necessitates a more "spatiotemporal" and gradual perception rather than an immediate comprehension. Because this was our initial experiment on this subject, our primary goal was to give students complete freedom to develop spatiotemporal concepts in 3D. Robert Williams' 10 *"Methodologies"* e.g. vertex motion, truncation or dissection were of great help in subtly transforming the space-fillers [8]. Figure 4 below depicts some of the results; for details about the designers see [9]. Great benefits to this assignment were reaped by the students: not only the new insight gained concerning space-filling structures and how to subtly transform them, but above all, as an invaluable and enduring design experience for future architects and designers.

In WS 2018-2019, the above-mentioned work led us to "zelluläre Raumfolgen" or "cellular space sequences". In this second experiment – again starting with a 2D-tiling before proceeding to 3D - the goal was to develop an abstract interior space within a space-filler that had a logical geometrical relationship to the space-filling polyhedron itself. This so-called "avocado" model – again with freedom given in building techniques and materials - consisted of a space-filling polyhedron and its dual. In a next step, they had to develop a new "protocell" that, when combined in a grid, the agreggation of many cells evolved in an appealing scenographic sequence thereby creating different openings and spatial hierarchies. Above all, a captivating sculptural composition without functional constraints that could be experienced from all directions spatiotemporally was the goal. The viewer's eye had to be encouraged to dive and dwell into its interiors, as if one could fly through these spaces. The relationship between masses

and empty space provoked new spatial experiences and made the students explore, transform and connect newly-designed protocells of polyhedra in a variety of ways. See figure 5 below for some WS 2018-2019 assignment submissions.
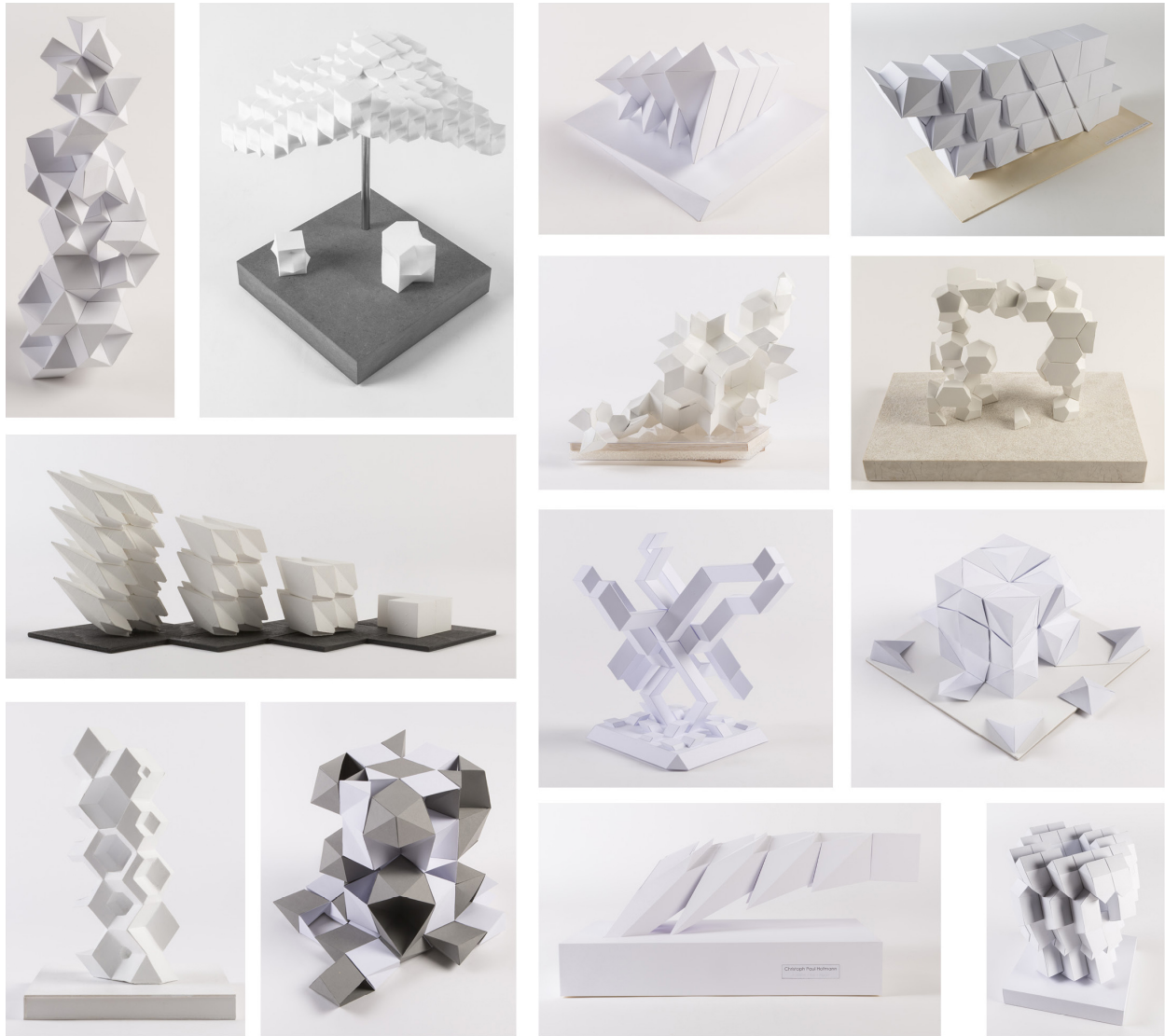

Figure 4: *"Parquet Deformation in 3D" assignments (WS 2017-2018).*
All pictures by Augustin Fischer © Institute of Art and Design, TU Vienna.

In this second experiment, we tried to encourage the students to refrain from (without forbidding it) the use of CAD in order to enable a more lasting hands-on experience. Nevertheless, the use of CAD was practically unavoidable the more complex the models became. Those students using 3D printing – which was neither encouraged nor forbidden - underestimated the process and reported that they missed the hands-on haptic design process. In my group, one student avoided 3D software, and then discovered a new convex space-filler. Towards the end of the assignment I noticed that when he started to work in Autocad, he had a much deeper understanding of space. On the other hand, there were students who failed in building acceptable presentation models - they started too early with CAD – and therefore lacked gaining sufficient hands-on experience. Student feedback indicated they were very content with the learning effect generated and the positive impact of the fusion of mathematics and personal creativity. For

further details about designers and additional submissions see [10].

Figure 5: *"Cellular Space Sequences" (WS 2018-2019). All pictures © Werner Van Hoeydonck.*

A profound reflection on possible methodologies and concepts, as well as analyses of the best submissions in both experiments is going to be published by our institute in the near future.

Acknowledgements

References

[1]   http://www.tess-elation.co.uk/parquet-deformations

[2]   Grünbaum, G. C. Shephard. *"Tilings and Patterns,"* Dover Editions, 2nd Edition, 2016.

[3]   H. Heesch and O. Kienzle. "Flächenschluß, System der Formen lückenlos aneinanderschließender Flachteile." Springer Verlag, 1963, Berlin.

[4]   D. Hofstadter. "*Parquet Deformations: A Subtle, Intricate Art Form,"* chap. in Metamagical Themas: Questing for the Essence of Mind and Pattern, NY, Basic Books Inc., 1985, pp. 191-212.

[5]   W. S. Huff. *"Parquet Deformations, Best Problems from Basic Design,"* State University of New York, Buffalo, 1979.

[6]   G. Inchbald. *"Five Space-filling Polyhedra,"* The Mathematical Gazette 80, 1996, pp. 466-475.

[7]   C. S. Kaplan. *"Curve Evolution Schemes,"* Bridges, Mathematical Connections in Art, Music and Science, 2010, pp. 95-102.

[8]   R. Williams. "The Geometrical Foundation of Natural Structure, A Source Book of Design," Dover Publications, New York, 1972.

[9]   http://kunst2.tuwien.ac.at/index.php?idcatside=813

[10] http://kunst2.tuwien.ac.at/index.php?idcatside=1062