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THE LEGACY OF THE HOCHSCHULE FÜR GESTALTUNG OF ULM FOR COMPUTATIONAL DESIGN RESEARCH IN ARCHITECTURE

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Abstract. Nowadays the use of computational design processes in architecture is a common practice which is currently recovering a set of theories connected to computer science that were developed in the 60s and 70s. Such pioneering explorations were marked by an interest in employing scientific principles and methodologies many developed in Research Centres located in the US and the UK. Looking into this period, this paper investigates the relevance of the German design school of the Hochschule für Gestaltung (HfG) Ulm to the birth of computation in architecture. Even thought there were no computers in the school. It is argued that the innovative pedagogies and some distinct professors have launched clear foundations that can be understood as being at the basis of further computational approaches in architecture. By describing and relating the singular work by Tomas Maldonado (educational project), Max Bense (information aesthetics) and Horst Rittel (scientific methods), this paper describes the emergence of analogical ways of computational design thinking. This analysis ultimately wishes to contribute for inscribing the HfG Ulm at the cultural and technological mapping of computation in architecture.

Keywords. HfG – Hochschule für Gestaltung Ulm; design methods; scientific methodology; information aesthetics; computational design, architecture.

1. Introduction

Albert Einstein was born on March 14, 1879 in Ulm and decades later the city would remember this by associate the motto *Ulmenses sun mathematici* (people of Ulm are mathematical) to his famous countryman. Is it just a coincidence that one of the most fundamental schools of the XXth Century, The Hochschule für Gestaltung was founded in Ulm. During its existence (1953–1968) it had three directors, the Swiss architect Max Bill (who had been on of Hannes Meyer´s students at the Bauhaus), the Argentianina painter Tomas Maldonado and the German philosopher Max Bense.

By the mid 60s, the computer was only accessible to a few mathematicians and scientists, however it became object of a much wider theorization and influence. The mathematical logic inherent to the computer supported the emergence of new scientific areas including, Information Theory, Operation Research, which caused a great impact in the domain of the Social Sciences and the Arts. Some research centers pursuing investigation upon the advances of computing technology when applied to architecture and planning started by then their work. In the UK the Land Use and Built Form Studies Center (LUBFS) at the University of Cambridge and the Design Methods Movement at the Royal College of Art in London were the most prominent. In the USA, the Architecture Machine Group at MIT and the Design Research Center (DRC) at Carnegie Mellon University begin as well to address the use of computational methods in the design process (Rocha, 2004).

However earlier this motivation was also predominant at the Hochschule für Gestaltung Ulm (HfG Ulm), in Germany. Despite its short existence, it was considered one of the most important schools in the twentieth century. The HfG had no access to computer systems and was nevertheless of extreme importance in the history of the beginning of the computer era in architecture due to the work carried out by some of its faculty members. Their research led the foundations for a new theoretical approach in architecture and design: One that uses computer science not as a tool for geometric design but as a tool for computer design. On this realm Kenneth Frampton used to mentioned that computational thinking initially characterized by an analytic approach to methods design research, or data processing that characterizes HfG of Ulm and made it famous, opened the way in mid 60`s to heuristic proceedings related to the power of new computational methods.

This particular pedagogy, constituted a legacy of computational thought, which would characterize some of the vanguard architecture in the 60s and 70s. In short, this paper highlights the contribution of the HfG Ulm, to the introduction of computation in the architecture, a history yet not much studied and known nowadays.

2. The HfG Ulm – Educational Project

The Hochschule für Gestaltung Ulm in Germany (Figure 1), founded in 1953, operated until 1968, lasted the transition from industrial society to post-industrial society. Despite its short existence during the Post-World War II period, the HfG Ulm project also rethought the role of social sciences based on a strong belief in reason. Belonging to an era of Nazi resistance, the founder promoted the idea that, in a democratic society, "good design" should be accessible to all. In one of the few critical texts regarding the contribution of the HFG, Kenneth Frampton (1974) says: "*There is little doubt that HfG has been the most significant school of design to come into existence since the end of WWII, not so much for what it achieved in terms of actual production, nor for the large number of designers it effectively educated, but finally for the extraordinary high level of critical consciousness that it managed to sustain in its daily work (...) The questions that the Hochschule began to ask a decade ago are now being asked, consciously or unconsciously, by every design and architecture school, and the crisis of identity that befell the Hochschule has now become a universal malaise*."

Teaching at the HfG of Ulm, based on standardization and mass production, investigates a scientific approach integrating systemic and objective methods of collecting and processing data in order to inform of the design solution.

It would synthesize science and design in a new scientific humanism that recognized the pluralism of methods and methodological perspectives needed by the

Figure 1. Hochschule für Gestaltung (HfG) Ulm / Ulm School of Design (1953-1968). Architect: Max Bill. Date: 1955. Source: Sammlung René Spitz.

designer in addressing the new problems of industrial culture. What did emerge however were the beginnings of an operational view of design science – what Maldonado sometimes called a "scientific operationalism"- drawing on particular methods from many disciplines, gathered in an eclectic array. Nowhere was this question more focused among designers of "Utter devastation" yet with "unlimited curiosity" about all of the new disciplines of science and new ideas in the philosophy of science and mathematics (Buchanan, 2009, p. 427). As Maldonado states, "The mainspring of all of our curiosity, our reading, and our theoretical work was our determination to find a solid methodological basis for the work of design" (Maldonado, 1991, p. 222). In this way scientific knowledge and new methods could be applied in the search of design problems solution within an industrialized environment.

3. *Computational* Approach

This paper identifies three most visible conditions that gained relevance at the HfG of Ulm: Theory, the Education Project (Tomas Maldonado); Philosophy, the Information Aesthetics (Max Bense); and Methodology, the Scientific Methodology (Horst Rittel).

3.1. THEORY, THE EDUCATION PROJECT

The ideology that emphasized the artistic dimension, a legacy of the Bauhaus carried out by Max Bill – the first director of HfG – was opposed by a multidisciplinary scientific approach, supported by the next director Tomás Maldonado. In this second phase, different subjects such as economics, sociology or mathematics, operational research, statistics, set theory, linear programming techniques, cybernetics or subjects dealing with the history of science and the theory of machines, built a dynamic that determined the emergence of this new School project. Maldonado also introduced semiotics in the curriculum, and he says: "*Our interest, especially mine, was realizing what was happening in the world of information and communication. The first thing that caught our attention and struck me over the years was cybernetics. Today no one longer speaks about cybernetics. There is a talk about communication, but no longer about cybernetics. At the time it was cybernetics of Norbert Wiener, and cybernetics, began to occupy ourselves, from global cyber which was a system of disciplines, according to the conception of Norbert Wiener, in which he had the information and especially the theory of information and of Claude Shannon.*"[1]

The analytical approach with which the Ulm school became identified with gave way in the mid 60s to heuristic procedures related to the increasingly seductive power of the computer. It is important however to highlight some background that nurtured the philosophic epistemology of the Ulm school. By one hand it was grounded in the legacy of Positivism, very much embodied in the work of the Austrian philosopher Rudolf Carnap (1891–1970) who studied physics at the University of Berlin, 1917–18, where Albert Einstein was a newly appointed professor. On the other hand was rooted in the need of new industrial needs and the early philosophy of Charles Pierce regarding Semiotics.

In 1956 Max Bense had already "paved the way" for the introduction in classes of Semiotics and of publications about the theory of signs, largely in the service of aesthetic information and focusing on Charles Pierce's categories of **aesthetics and ethics**. Semiotics was Maldonado's effort to put his "scientific operationalism" at the front of design, partly in opposition to the view of Max Bill, of the designer as a kind of aesthetic coordinator of cultural artefacts, and the school of Ulm was the first school of design to recognize this (Krippendorff, 2006, p. 305).

With his contribution to Semiotics in 1961, Maldonado published the definitions of 94 terms "Terminology Semiotics" (Maldonado, 1959). These definitions were intended to be a series of analytical tools, enhancing the semiotic discourse for design. Subsequently Maldonado's students added rhetorical concepts and applied them widely to the visual phenomenon, materializing the idealized Educational Project for the HfG, Ulm. Maldonado recalls in an interview specifically conducted for this investigation: "*My contribution was important due the formative disciplines such as cybernetics, information theory. The computer was emerging, but there was no computer at that time. We did not know the computer right now. (…) In the first year, students were linked to fundamental course in elementary school, where I think the important question and contribution was how to fix and change the fundamental course at the Bauhaus to one that assimilated these new concerns (…) In the elementary course something very interesting happened. All exercises that were made had a very special character. But apparently they had some things still related with the Bauhaus, but they included one more thing. That was the idea of how through the behaviour of elements could one create an image. The model was a grid of little dots with different diameters to produce an image. This very elementary idea allowed us to manually simulate what you would be able to do later with computers. The students were asked to make such images with incredible detail, which was an immense difficulty. Here one can see clearly the intuition of what would become a computer use, but in our case it was a manual production... that was crazy.*"[1]

3.2. THE THEORY OF INFORMATION

One of the leading figures that stood out the most in the domain of information theory and aesthetics was Max Bense, among others like Abraham Moles, a

German scholar, Physicist and Philosopher, who made Claude Shannon's theory of information popular in Germany. Claiming that the aesthetic of information must be conceived as an exact and experimental science, Bense broke up radically with the still dominant aesthetics in Germany, which had its roots in the Romanticism.

Max Bense took this issue further, regarding "information" not as an obstacle to reach beauty but, on the contrary, as a motto for a particular aesthetics, which defended the general calculability of all objects. Bense had a remarkable role in the Hochschule für Gestaltung Ulm, by inspiring the integration of scientific methods into the design process. It was also Bense who popularized Shannon's information and communication theory, and bound it together with questions of aesthetics. Bense presented a version of the mathematical theory of communication (Shannon and Weaver, 1949), called information theory, in classes between 1954–58. His Informationsästhetik (Information Aesthetics), written in 1956, used models of communication techniques to dissolve aesthetic categories into aesthetic processes. Backed by the general hypothesis of calculability of all objects, Bense`s concept was based on the formalization of aesthetic processes. Every artistic expression and each piece of art was seen as a system of signs, and a message. In the point of view of Bense, the production and reception of art according to traditional criteria of proportion, harmony and symmetry, becomes obsolete. Bense's work, thus, focused on stochastic analysis and synthesis of structures in discourse and the arts, and how they arise.

Above and beyond this analysis, he conceptualized every creative and perceptive act as the realization of a communicative act between a sender (a masterpiece) and a receiver (the observer of the art). Thus, Bense played an important role as a pioneer of the use of information theory. Research on the development of the information aesthetic also shows how a theory that underlies the aesthetic values primarily based on rational and quantifiable criteria can quickly push up against the methodological limits. Despite these limitations, the information aesthetics of Bense points three changes that still affect discussions of art and architectural production today: (1) displacement of the function of the author's art and architecture and the concept of art and architecture, such as, (2) the concept of subject and object, and (3) the role of the reception of art and architecture (Rocker, 2010, p. xxii).

A new situation arose when the first steps were taken to institutionalize the information aesthetics. Bense, who was the responsible for the department of information and theory, developed the pedagogy concerned with implementing quantitative analysis and objective methods in design. The focus became increasingly strong in design methodologies influenced by information theory, cybernetics, operations research and mathematics.

3.3. THE SCIENTIFIC METHODOLOGY

At the HfG the curriculum was academically demanding, included several disciplines related to design, including physiology of perception, ergonomics, social psychology, sociology, economics, political science, cultural anthropology, semiotics, information and theory of communication, but also traditional themes of physical and cultural history of art. They were all made relevant to design, and the intellectual framework intended to assure their integration was the philosophy of science, originally taught by Bense.

The first assignment of Horst Rittel was a lecture on information and communication theory, which everyone at that time thought to be the key to the future. Klaus Krippendorff who graduated from HfG in 1967, recalls: "*The philosophy of science became increasingly relevant to design. It turned into a systematic exploration of the heuristics that designers were using*" (Krippendorf, 2006, p. 311). Horst Rittel's mathematical training gave him access to models, theories, and conceptual frameworks that ordinary designers had barely heard of. He introduced methods of operations research, mathematical decision theory, game theory, systems analysis, and planning techniques, and thus enriched the repertoire of design supporting methods. Figure 2 illustrates Rittel's teaching Notebook where notions of logic are explained. Under the influence of Rittel, the conception shifted to a designer who would be able to handle heuristic planning and design methods, and work as equals in product or strategy development teams (Figure 2).

According to Krippendorff, Rittel greatly contributed to implement a more scientific curriculum at the school, by relating science and design, and by putting into practice the ideology of Tomas Maldonado, and the theory of Max Bense. With a background in mathematics, physics, and sociology, Rittel introduces students and colleagues to a somewhat different perspective through teaching in methodology, theory of science, and operations research. Rittel was not a taxonomist who categorized the world or a positivist, but a pragmatist in the tradition of Pierce. Full of forceful ideas, Rittel teaching methods were thought to prepare students to design a more complex world, opening possibilities for empirical investigation (Krippendorf, 2006, p. 312). Indeed, he explains that the genesis of his own approach to design methodology came when he tried, around 1960, to apply the new methods of design in the area of planning and found that they did yield satisfactory results. This led him to reconsider the foundations of design methodology (Buchanan, 2009, p. 428).

Rittel's work emphasized the early phase of planning and preparation for design work, based on operations research, systems thinking, and the use of information's to support decision – making when dealing with complex problems. However this also involved significant emphasis on human participation in the social process of decision making within organizations. It was this latter aspect of

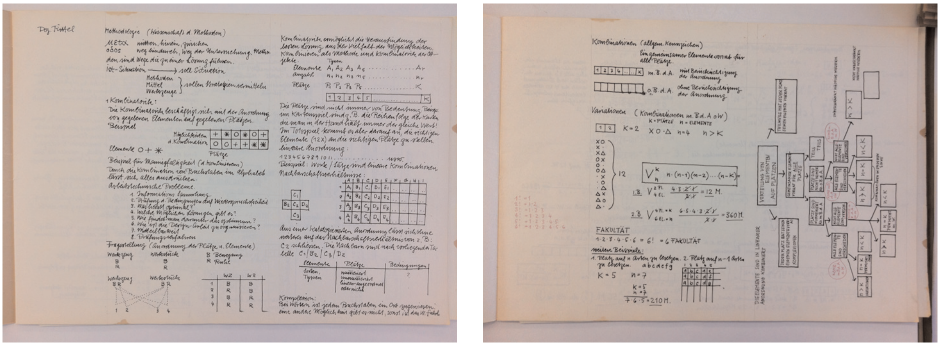

Figure 2. *Discipline "Methodology" 1959, Professor Horst Rittel. Source: Archive HfG Ulm, personal photography, March 2012.*

design, the human perspective and social process, which gradually emerged to distinguish his approach to design and design methodology from the others.

4. Computing without Computers

In "Looking Back at Ulm," Tomás Maldonado also stated that Ulm had a pioneering vision on the design process, but they lacked a machine – the computer. He says, "But in the midst of our limitless faith in method (…) there lay some powerful intuitions that the evolution of information technology, specially since 1963, has to a large extent confirmed" (Maldonado, 1991).[2]

Even before there were computers in HfG, a kind of "computing without computers" occurred, and this aspect was incorporated into the work of three protagonists analyzed above (Figure 3). The few who had access to computer systems at universities and companies in the 1960s shared their knowledge in literature and lectures, invited by Tomas Maldonado. So through these exhibitions and interferences, computer technology has also found its way in the HfG. However the implicit impact of new computer technology exerted by the diffusion of their general concepts rather than your hardware is not yet fully recognized.

"Computing without computers" as much as "computing with computers" led to an increased use of models and simulations in architecture. This development was, at first, a transfer from the sciences and other engineering disciplines into architecture. It was architecture's predisposition towards model making, which explains why at places like the Hochschule für Gestaltung in Ulm, information theoretical and cybernetic models were, despite their abstractness, so well received. Computing without computers allowed for the conceptualization of the computer, while computing with computers transposed the traditional modes of

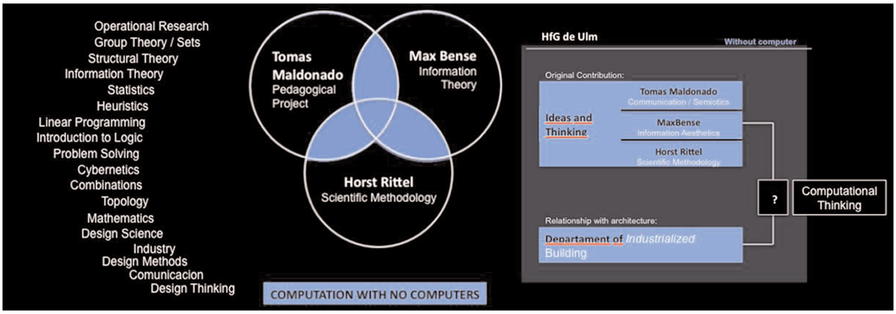

Figure 3. Synthetic scheme that relates "computing without computers" with disciplines, areas and teachers analyzed in this paper (image by the author).

operation and thinking into a new medium. It was computing without computers, analyzed in this paper through the School of Ulm, that had led to a radical shift in the understanding of subject and object that had led to a radical rethinking of the production of form (Rocker, 2010, p. xxvii).

5. Conclusion

The teaching of HfG Ulm promoted a different approach to the design process. Instead of focusing on the design and development of specific and finite forms, students sought to exploit the definition of geometric design rules to control the generation of form(s). Thus, by reflecting a scientific methodology, the design practice starts to embrace the concept of systems, where sets of interdependent information are structured to control the generation of design solutions. The exercises about geometric patterns are some clear examples where this system-based approach is evident. In them, one can see how students think about a set of variation rules for a given geometric module and, from then, conceive geometric patterns where the module is no more a fixed and repetitive entity but, instead, is an element that varies geometrically in each instance. Although these constructions are hand drawn, they already reflect a mode of computational design thinking, similar to the parametric design approaches of contemporary architecture. Expanding the manual possibilities, the computer can extend the idea of design systems to a greater level of flexibility and complexity. On the one hand, by digitally programming the rule-based design system, the designer can generate, view, evaluate and change his ideas in real time and thus refine the quality the solutions. On the other hand, the calculation power of the computer allows handling more complex design algorithms, which would be very difficult to be conceived and implemented only by mental and manual design processes.

To conclude, the HfG of Ulm pioneered in the mid 60s heuristic procedures related to the power of the new computational era. It's a scientific approach based on methods of design research on information processing, powered by aesthetic values. Not an interest in the superficial appearance of the object, but a belief in an underlying object structure which mathematics or logic tries to capture. This pedagogy clearly emerged from Ulm, constituted a legacy of computational thinking that evolved till today. Its cultural and technological context requires the pursuing of a historical reading that would enhance the interpretation of architecture own contemporary history.

Endnotes

1. Extract from an interview with Tomas Maldonado conducted by the author for her PhD research on the Hochschule für Gestaltung Ulm (Milan, 9 October 2012).
2. Maldonado also says "kind of symbiosis of calculation and graphic representation Could be created within the process of problem solving is basic to the widespread present-day use of computer graphic techniques" (Lindinger, 1991).

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References

Bense, M.: 1972, *Introducción a la estética teórico-informacional : fundamentación y aplicación a la teoría del texto*, Alberto Corazon, Madrid.
Buchanan, R.: 2009, Thinking about Design: An Historical Perspective, *in* A. Meijers (ed.), *Philosophy of Technology and Engineering Sciences*, Elsevier, New York, 409–454.
Frampton, K.: 1974, Apropos Ulm: Curriculum and Critical Theory, *Oppositions*, **3**, 17–36.
Krampen, M. and Hormann G.: 2003, *The Ulm School of Design: Beginnings of a Project of Unyielding Modernity*, Ernst & Sohn, Berlin.
Krippendorff, K.: 2006, *The Semantic Turn: A New Foundation for Design*, Taylor & Francis, London.
Lindinger, H.: 1991, *Ulm design: the morality of objects*, The MIT, Cambridge, MA.
Maldonado, T.: 1958, Communication and Semiotics, *Ulm*, **5**.
Maldonado, T.: 1959, Glossário de Semiótica, *in* T. Crosby (ed.), *Uppercase 5 HFG Ulm*, Whitefriars, London.
Protzen, J.-P. and Harris, D.: 2010, *The Universe of Design: Horst Rittel's Theories of Design and Planning*, Routledge, New York.
Rocha, J. A.: 2004, Architecture Theory 1960–1980: Emergence of a Computational Perspective, PhD Dissertation, MIT, Cambridge, MA.
Rocker, I.: 2010, Emerging Structures: Information Aesthetics and Architecture of the Digital Medium, PhD Dissertation, Princeton University, Princeton, NJ.
Spitz, R.: 2002, *HfG Ulm and the view behind the foreground: the political history of the Ulm School of Design*, 1953–1968, Axel Menges, Stuttgart.