TOWARDS AN EVOLUTIONARY CONCEPTION OF CONSTRAINT BASED DESIGN

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ABSTRACT:

This paper basically reviews and reconceptualizes the idea of constraints in design and "constraint based design" from the viewpoint of *Universal Selection Theory*. It reports the application of the reviewed and reconceptualized ideas as a layer to the education of freshman architecture students as a means of their testing within an educational framework. The departure point of the approach is based on the assumption that constraint based design approach conventionally views design as "constraint satisfaction" and constraints are in a sense are often conceptualized as active agents (or sometimes pointers) of design. The paper argues that hidden behind this typical understanding and conceptualization, lies a positivism and a danger of determinism. As in "form follows function," "form or solution follows constraints" is no different: both have the same set of problematics. It also puts forward that yet from another point of view, the approach has an implicit but strong evolutionary argument hidden within, and if such content could be foregrounded by embedding it within a rigorous evolutionary framework, this can lead us to a new (read: a less determinism-prone and less positivistic) understanding of constraint based design. In this modified conception, constraints are accepted as passive filters, namely conditions, which do not imply (or point to, or force towards) a certain solution but working as more of a set of conditions (cultural, physical, aesthetic, functional, programmatic, or whatsoever), that "select" or "eliminate" the unsuccessful proposals while letting the others live. The motivation behind all these is not to provide another explanation of design through a new conceptualization of "constraint based design": it was to develop a pedagogical approach out of this conception to be used as a "layer" for our existing architectural design pedagogy. Hence, the paper presents our experience in freshman class architecture where students showed that the approach has its specific benefits and could be used as a layer for teaching architectural design and concludes by presenting and discussing the approach's relevance within the context of architectural education.

1. INTRODUCTION

Theories often influence other domains, which they were not originally formulated for. Theory of evolution[1] is one of such; presenting a powerful set of ideas, it was adapted to fields such as physics, economics, and computer science, but more important, to the domain of culture. Design was not free of such an influence, if one browses through research reports, there are considerable amounts of reports which sought to apply ideas from the theory of evolution to the field of design, or research those make use of theory of evolution as a conceptual framework. This paper could be embedded within this research framework: In this paper, we try to utilize some of the ideas from the theory of evolution to develop a new approach to (or reconceptualize) a specific concept in design: constraints and constraint based design. The motivation behind all these is not to provide another explanation of design through a new conceptualization of "constraint based design": It was pragmatic and operational. We aimed to develop a pedagogical approach out of it to be used as a "layer" for our existing architectural design pedagogy, which is based on a less determinism-prone and less positivistic conception of constraints.

[1] Theory of evolution here specifically refers to its Darwinian conception and to a degree its present day extensions and advances. For a more detailed information see the corresponding chapter.

2. THE FRAMEWORK AND THE PROBLEM

2. 1. WHAT ARE CONSTRAINTS IN DESIGN AND WHAT IS CONSTRAINT BASED DESIGN?

"Constraint based design" is almost a tautology, actually, there is no design without constraints, or more specifically design is not possible in such a vacuum free of constraints. What we mean is an approach, which puts particular emphasis on constraints in the design process i.e. a method/strategy/approach/methodology that make a special use of constraints in the design process or in its approach to design.

In Webster's Dictionary (1993), the definition of the word "constraint" is given as "the act or action of using force or threat of force to prevent or condition an action," "the quality or state of being checked, restricted, or compelled to avoid or perform some action," "a constraining agency: a constricting, regulating, or restricting force," "a restriction or limitation that contains a motion or other process," and also "compulsion by circumstances: the force of necessity."

According to these definitions, "constraint" on the one hand is conceived as something active (a force) which directly controls one's decisions and behavior, on the other, something like a passive filter which passively regulates, (or rules out) a misconduct, or mismatch without imposing (or demanding) an active control over design process.

Within the context of the design studies[2], generally, the tendency is to take the term in its first conception. Conventionally, design is viewed as "constraint satisfaction" (Archer, 1969) (Archer, 1970) (Coyne, Rosenman, Radford, Balachandran, & Gero, 1989) and constraints are in a sense are often conceptualized as active agents (or sometimes pointers) of design.[3] Representing a recent and popular research framework, so-called "Shape Grammars"[4] within the more general framework of "design computation" and "computer aided design" could be interpreted as a well-known and well-conceptualized epitome of such an understanding.

2. 2. THE PROBLEM

Hidden behind this typical understanding and conceptualization of constraints, there lies a positivism and a danger of determinism. As in "form follows function," "form or solution follows constraints" is no different: both have the same set of problematics. The problem is a "design equation" where constraints become active determinants of the solution or form, regardless if these constraints are in the form of formulas, recipes, or in a more recent version: algorithms. This might not be a problem for an experienced designer, or in an advanced stage where you explore different aspects of design equation (i.e. as in design computation) but within the context of architectural education, this reads a deadlock: student sitting in front of all that requirements, program elements, and constraints waiting to see miracles happen. There is a hiatus to be bridged but for the inexperienced student, it is almost impossible to comprehend how, and for the tutor it is hard to make it clear to the students.[5]

As one might easily guess this is due to the nature of the design equation and the design problems. Design and design problems, whether ill-defined or wicked,[6] simply tend to repel such a conception of constraints.[7]

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[2] The term "design studies" here connotes an academic discipline that addresses the complicated activity of design, which has been developing since the 1960s. For a detailed information see, (Clark & Brody, 2009)

[3] As the leverage of developing computational/digital design paradigm, the idea of constraint satisfaction in design is one of the hard cores of the agenda presented as opposed to the "conventional" form-focused design (Özkaya & Akın, 2006). In constraint satisfaction, designer effectively searches through a solution space until a design, which does not violate any of the defined constraints, is found. (Blanford, 1990).

[4] For a detailed information see, (Stiny & Gips, Shape Grammars and the generative Specification of Painting and Sculpture, 1972), (Stiny, Introduction to Shape and Shape Grammars, 1980), (Mitchell, 1990), (Knight, 1999), (Stiny, Shape: Talking about Seeing and Doing, 2006).

[5] In the field of design studies, hiatus that has been detected between the design and constraints are tending to be taken as a problem that could be eliminated by the degree of experience. "The experienced designer restructures the problem numerous times by modifying the initial constraint set, thus defining the right problem as he is determining the right solution to it, almost simultaneously. This skill is shown to be lacking in the inexperienced designer" (Akın, 1990).

[6] For further information for the concepts: "well-defined," "ill-defined" and "wicked" see, (Rittel & Webber, 1973)

3. TOWARDS A NEW UNDERSTANDING OF CONSTRAINTS

Yet from another point of view, by definition, use of constraints in design have an implicit but strong evolutionary argument hidden within, and we propose that if such content could be foregrounded by embedding it within a rigorous evolutionary framework, this can lead us to a new (read: a less determinism-prone and less positivistic) understanding of design based on constraints. Following this assumption, in this research we try to utilize the theory of evolution, particularly so-called *universal selection theory* to foreground the aforementioned evolutionary argument.

In such context, questions of "what is *Universal Selection Theory?"* and "in what sense it is in a position to say something about our problem situation?" have to be clarified. *Universal Selection Theory* is an umbrella term which refers to a series of applications that basically apply (and sought to apply) the essentials of Darwin's evolutionary theory to other fields. In this sense, these approaches could be seen as an extension of the theory and they provide reinterpretations of the theory itself.

At this point reminding the essentials of Darwin's evolutionary theory would be necessary. In Darwin's conception, blind-variation-and-selective-retention is the essential process behind the evolution of species. The process has three essential components (Campbell, 1960) (Campbell, 1974):

1. "a mechanism for introducing variation"

2. a "consistent" intentional "selection process" which on the one hand eliminates the unsatisfactory variations, on the other hand keeps the satisfactory ones.

3. "a mechanism" for preserving the successful-so-far variations, and a "mechanism" for transferring them to next generation of variations

Campbell (1960) also shows us that typically, this process could be adapted to (re)conceptualize the human creativity and the creative process. If one also examines the design literature there are various attempts to apply this process (or its components) to the field of design.[8]

Typically, *universal selection theory* basically puts the emphasis on the "selection" phase.

If this process is accepted as the backbone of a creative process (i.e. the design process) then how (and where) do constraints fit within this equation? Typically, a deterministic model would propose that constraints would well fit within the first (creation or variation) stage, where constraints play an active role in the formation process. On the other hand, we would propose that, such an attempt is against the grain of the theory of evolution itself. In its rigorous adaptations, (one remembers the Evolutionary Epistemology[9]) elements such as constraints are taken as passive set of filters, which strongly determine the process and the output, but in a non-deterministic way. Here, actually selection (or if you prefer criticism) is put forward as the most essential component of the process and the proposal does not care where the trials were oriented from. Such a conception permits even a free play, expressionism, or whatever process you prefer to put in the place of creative (or formation) stage.

In this modified conception, constraints do not imply (or point to, or force towards) a certain solution but they work as more of a set of conditions (cultural, physical, aesthetic, functional, programmatic, or whatsoever), that "select" or "eliminate" the unsuccessful proposals while letting the others live. As one might guess, this understanding relocates the constraints within the design equation.

4. APPLICATION OF THE THEORY TO ARCHITECTURAL EDUCATION

Nowadays, as educators of design, on the one hand we have to deal with the conventional problems of teaching design: surfacing the creativity lying within students, permitting free expression while respecting what was already existing, encouraging the new while learning from the past, dealing with precedents and design knowledge, teaching how to design,

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[7] This does not mean design process does not contain "such processes" lying within.

[8] For a detailed information on that see, (Collins, 1965), (Focillon, 1992), (Hillier, 1996), (Zarzar, 2003), (Langrish, 2004), (Steadman, 2007).

[9] Particularly see the works of Stephen Toulmin, Donald Campbell, and Karl Popper. It is no surprise that the discourses of these scholars (particularly Popper) radically influenced our understanding of design at the middle of the last century. It was all about the power of the theory of evolution lying behind the discourses of these scholars.

teaching how to criticize and let go, and teaching how to learn from good moves, but to that degree from mistakes. On the other hand, 21st century design pedagogy has to deal with relatively new issues belonging to our age. We live in so-called "information age," and from the pedagogical point of view, this reads: students are continuously bombarded and filled with images and their attached popular slogans and myths, so easily and quickly distributed without control and often taken as granted without a selective filter (And what do with that copy-paste?). Actually, the term "information," here must be taken as a "misnomer," what students really filled with is a set of shortcuts directly establishing a link between the phenomena and its popular image, yet from the pedagogical point of view, could be best described as a "pollution."

This does not mean our well-established modern pedagogies such as *Bauhaus*[10] or *Texas Rangers*[11] should be immediately thrown away or their relatively new revolutionary rivals such as rule-based or algorithmic design (or potentially digital design) should be taken as granted. We cannot throw away such valuable content: neither free creativity, without examples and free expression nor precedent based design and all that design knowledge residing in works of design. Perhaps at the moment what we need is layers to be embedded within these major paradigms, layers specifically addressing the new issues we were confronted.

This being said, the motivation behind this research was not to provide another explanation of design through a new conceptualization of "constraint based design" or provide a new major paradigm of design: It was pragmatic and operational. We aimed to develop a pedagogical approach out of it to be used as a "layer" for our existing architectural design pedagogy for teaching certain aspects of design.

Applied as a layer, we tested our approach in various occasions in our school.[12] What follows is our report about this experience.

5. CONCLUSION

Our experience in freshman students in the department of architecture showed that the approach has its specific benefits and could be used as a layer for teaching architectural design. We can evaluate the experience under four major categories.

5. 1. ADAPTABILITY TO MAJOR PARADIGMS OF DESIGN

First of all, we must admit that what was proposed could only be a layer not a major paradigm of design and pedagogy of design. With this respect it is highly compatible with different educational paradigms (or sometimes strategies) from *Bauhaus* to *Texas Rangers*, and their present-day rivals rule-based or algorithmic design (or potentially digital design)[13] without falling into some type of determinism. This is due to constraints pushed towards the later stages of the design which in turn enables all: intuition; free expression; precedent adaptation; algorithmic emergence, or whatever we prefer, rational or irrational, to utilize in the design of things. It does not basically deal with how things come into being but how do they reside or die in our stead; how do they filtered out, criticized to be eliminated or reconsidered.

[10] Bauhaus is the name of a school of design from the early 1900s, reigned about 30 years. The school has been known with its enormous influence over our existing design pedagogies. It is well known with its emphasis on the importance of surfacing of one's creativity, without the intervention of the external factors, such as history and tradition.

[11] Texas Rangers is the name of a group of architects who taught at the University of Texas School of Architecture in Austin, Texas about 1950s. Still less known, as compared with the Bauhaus, the curriculum and pedagogical approach developed by the group is known with its particular emphasis on the study of precedents, or previous architectural works as sources of architectural knowledge, ideas, and almost all that existed in architectural equation, in/for the education of an architect.

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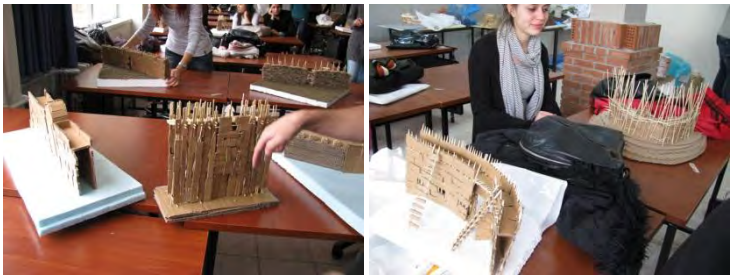
[13] We are not certain about if rule-based or algorithmic design or digital design propose something so comprehensive to be evaluated as "major" paradigms of design teaching. But still they represent a mainstream approach to design and stacking quite a research recently, possibly pointing a direction towards we'll be advancing our design pedagogy. Otherwise we are still left with what was formulated at the beginning and the midst of the last century.

(Figures1,2,3,4,5,6) In our case, in the freshman studio one of our assignments is to create something familiar, something that they believed to know very well and something that begins with form, such as the wall or the lighthouse. To achieve novel results, the process is constrained in a special way (say forbidding to use glue for the model). Or in another case, to create something unfamiliar, something that they believed even none existed and something that begins with constraints such as to design a "variable ground-adaptive shelter." Here variable ground constantly forces/demands transformation in the shelter (filters out an unsuccessful adaptation) while shelter tries to adapt itself to the changing conditions provided by the ground. Students try to design both, in this sense develop an understanding between these couples.

5. 2. UNDERSTANDING KEY NOTIONS WITHIN THE EQUATION OF DESIGN

We observed that the approach could be used for making students to develop their own understanding about the relation between couples such as form and function, form and construction/structure, form and cultural aspects, form and preference, form and tradition, so on so far: practically almost everything which exists within the equation of design, and architecture relates to.



(Figures 7,8). In the studio, after the first tour of making the assigned problem, every new constraint (such as the physical context, historical context, or functional necessities) that we embedded into the design process caused students to make a reviewed critical make over. Sometimes, we added a new set of constraints in the middle of the process: a new material, a new element, a new requirement, a slope, etc. The essence of the learning process thus can be described as: making – seeing/criticizing/adding new constraints - remaking.

5. 3. TEACHING HOW TO DESIGN

Actually, neither constraint based design nor its new evolutionary conception could cope with design emergence or genesis. With this respect as it was implied previously the model could only work as a layer which helps us to illustrate and question certain aspects within the process of design. As such, operationally, it requires more comprehensive upper controlling layer (or paradigm of) design. If we prefer we can encourage free expression, if we prefer we

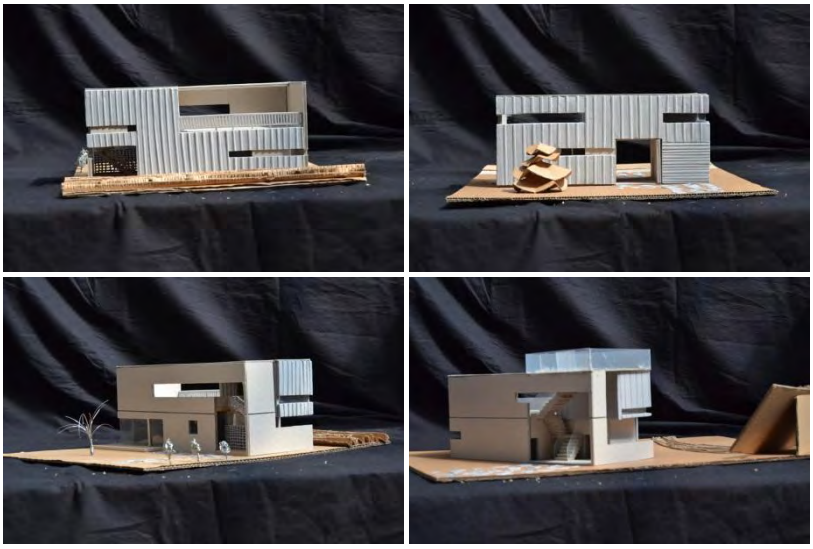
can emphasize algorithmic design. It is not a problem at all since all is (passively) controlled by the constraints, whether this constrains are oriented from physical, cultural or otherwise.

This is not due to the lack of the model itself but basically related with the reference model: *universal selection theory* itself actually lacks to explain emergence or genesis: It is hidden in the name: it is about "selection" not "creation."

(Figures 9,10,11,12,13,14). Sometimes constraints are given in the form of a fixed starting point (say, foundations of an existing building). This is similar to the variable ground/adaptive shelter problem but this time ground is not designed be given. The play is in the upper structure (the shelter), and on the way constantly new constraints are introduced (this is North, then let's see how you deal with the problem of East and West sun) to see how students respond and the structures are adapted. Moreover they learn different type of conditions and how to relate all these with their design.

5. 4. ADAPTIBILITY TO THE PROCESS OF DESIGN

By nature, the approach perfectly matches the process of design. It is about making and matching (a-la-Gombrich) (Gombrich, 1960) naturally evolution itself is essentially about trial and error. Of course, there is a difference from blind trial and error (both in stages of trials and error elimination) since a lot of knowledge and wisdom is involved and most important, we are not operating in the world of nature but also in the world of culture. Unfortunately *universal selection theory* does not primarily deal with (or address) how and from where that "making" comes from.



(Figures 15,16,17,18). Some of the assignments focus on transformation of a well-known precedent. This is as close as it gets to the evolutionary process itself. As shown from the pictures, from the upper row to the lower, students first made the model of an existing architectural design and then remade its variations by analyzing the significant physical characteristics of the designed objects such as: geometry, order, tectonic qualities…etc., and finally they used such analyses as constraints for their own studies, or sometimes new constraints are introduced, demanding a transformation/change in the initial model or some aspect of it. Being novel is very hard to achieve on this, but still it has an important place in the learning process.

We continue our explorations on this line. Constraint based design is a powerful approach to design with pedagogical implications with its evolutionary conception it is even more powerful approach to the education of an architect.

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