TITLE

Generative Pedagogy: Lost in Transition

Topic: Architecture Pedagogy

Author:
Sara Pezeshk
USA, Florida International University, Department of Architecture
www.sarapezeshk.com

Abstract

This paper along with poster introduces an alternative approach for the challenges encountered in algorithm-based pedagogy and digital methodology within the architecture courses that deal with the processes of Generative design, materialization and fabrication. The method requires the students to comprehend the principle of morphogenesis through biomimicry and form-finding approaches in order to find the solution for demonstrating functionality, optimization and sustainability. Digital architecture as an accurate pattern is the result of the execution of prefab codes in artistic activity. In other words, digital architecture could be considered as an instrument rather than a specific subject or topic. In addition, the outcomes of interpreting digital coding into physical fabrication will be lost in transition and create imprecision, which is the natural characteristics of the creative space within the contextual subject matter of this methodology. On the other hand, the prerequisite dynamic of the creativity is the spontaneity within the realm of artistic creativity.

email/address

Key words: Generative Design, Performance-Oriented, Architecture Pedagogy and Digital Methodology

Main References:

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Generative Pedagogy: Lost in Transition

Prof. Sara Pezeshk
Department of Architecture, Florida International University, Miami, Florida
www.sarapezeshk.com
e-mail: sara.pezeshk@icloud.com

Abstract

This paper introduces an alternative approach for the challenges encountered in algorithm-based pedagogy and digital methodology within the architecture courses that deal with the processes of Generative design, materialization and fabrication. The method requires the students to comprehend the principle of morphogenesis through biomimicry and form-finding approaches in order to find the solution for demonstrating functionality, optimization and sustainability. Digital architecture as an accurate pattern is the result of the execution of prefab codes in artistic activity. In other words, digital architecture could be considered as an instrument rather than a specific subject or topic. In addition, the outcomes of interpreting digital coding into physical fabrication will be lost in transition and create imprecision, which is the natural characteristics of the creative space within the contextual subject matter of this methodology. On the other hand, the prerequisite dynamic of the creativity is the spontaneity within the realm of artistic creativity.

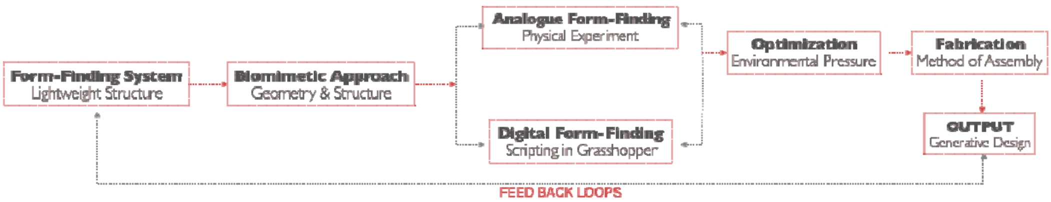

Figure 1. Design Process.

1. Introduction

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Studio design is a flexible studio that demands a high level of independent researches. Furthermore, such a design demands for a high-level digital integration to support the development of a design solution. The design of a pavilion given to the students is a rather a simple program; therefore, they can mainly focus on generative design processes. “Generative Design is a morphogenetic process using algorithms structured as non-linear systems for endless unique and unrepeatable results performed by an idea-code, as in Nature" (Soddu 1992). In this paper, selected projects exhibit a set of case studies that represent the transition from an analogue to digital medium, and from the digital simulation to production and fabrication. The strategies of instruction are an evolutionary process inspired by natural elements. In this paradigm, the form is generated step by step through a defined algorithm which contains a series of mathematical rules: not the actual geometry but the logic behind the geometries. At the same time, the techniques for designing fabrication aspects are driven by natural forms and behaviours which are also adaptive to the local environment. The complexity generated through these processes gives a range of possibilities and solutions by easily changing variables to get new output and results. In addition, this method of thinking allows students to gain a better understanding of how to incorporate the bottom-up design with top-down rules established by them. However, the fluctuation in the sequence of actions between digital feedback and physical matters can cause imprecision and loss of data during the transition.

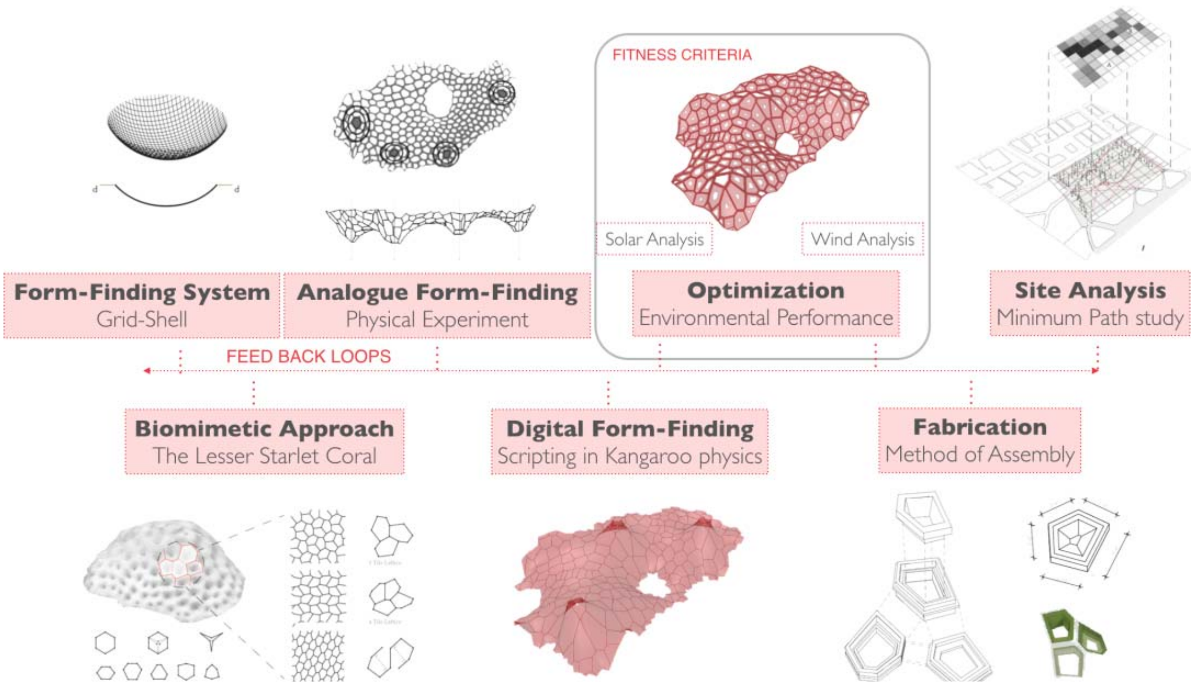

Figure 2. Algorithmic Design Process.

2. Biomimetic Approach

2.1 Nature Driven Project

During past two decades, architects and other designers become more aware and concerned about their environment due to the global ecological challenges; as a result of this awareness, they are trying to learn from the nature itself to find out solutions to deal with these concerns. Architecture, like other fields of design, develops into a more multidisciplinary and research-based career than before. “Moreover, the endeavors guided by a sophisticated knowledge of natural systems have the potential to counteract the increasing fragility and the degradation of natural environment.” (Brownwell and Swackamer 2015). This course encourages students to have a deeper observation of their surrounding and into the Nature by focusing on its principles such as follows:

- Uses a simple rule to create rather complex shapes.
- Is dynamic and adaptive.
- Is very tight to use extra materials but generous with the intricacy of its design.
- Regenerates to adapt new changes and conditions.
- Gives sustainable solution.
- Demonstrates functionality and optimization.

2.2 Decoding Nature

In the initial exercise, each student will be given a specific light weight monolithic structural system, like branching, grid-shell, membrane, net, or pneumatic. According to the given structural system, students selects a natural inspiration. The selected projects in this paper are mainly focusing on the grid-shell structure. The design process begins with intensive scientific research studies which are translated into mathematic codes and structural performance. To discover the laws within the selected inspiration, each student needs to intensively research on science-based resources to understand the main language of nature which translates into mathematic codes. For example, the group who selected Chamber Nautilus as their inspiration, Figure 3, discovered that the growth pattern in this species is following a logarithmic spiral with radii expanding at a constant rate and close ratio. As Ball explains “mathematics enables us grasp the essence of pattern and form. It is the means of description at its most fundamental level, and thereby facilitates our seeing what features need to be reproduced by an explanation or a model.” (Ball 2001). Decoding nature mainly focuses on the geometrical behaviour and patterns or growth process in specific scale, in a way that “scale has to be carefully considered if principles are abstracted from biodynamic system for use in architecture.” (Jeronimis 2004). Although mathematical code gives a precise response, the procedure of decoding nature by students, inevitably can be done unmethodical and randomly. As a result, we observe that students with similar biomimetic research usually have dissimilar outcomes.

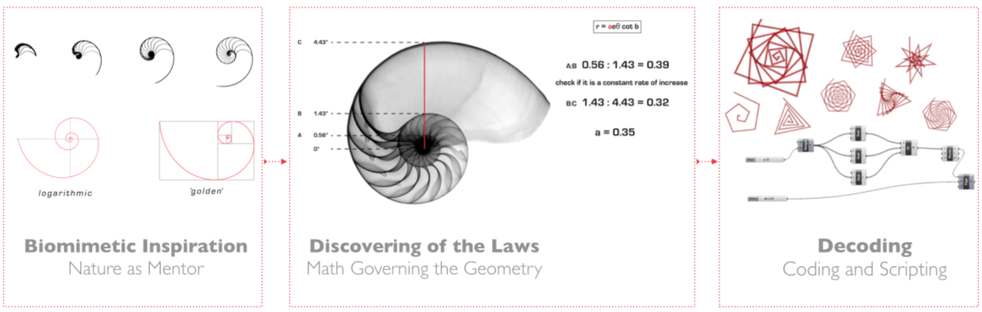

Figure 3. Decoding Nature’s laws

3. Form-Finding

3.1 Physical Form-Finding

This traditional method is reintroduced by academics through the practice of digital architecture. As Oxman defines “form finding is a significant concept that changes the traditional meaning of performance by integrating formation and generation processes.” (Oxman 2008). In the following design process, students explore and research on the work of initiators of form-finding like, Gaudi, Otto and others based on their assigned structural system, nevertheless, these works are essentially monolithic and emphasizing on lightweight structures. After the research done, they start a hands-on exercise and perform various experiments to explore the structural integrity of their introduced systems. For instance, in Figure 4, a couple of students explore the principles of the self-organization in an inverted shell structure. In addition, the overall geometry and tessellation over the surface are extracted from the molecular arrangement of Radiolaria and the material system used consists of plaster, canvas cloth and compression elements. The following experiments are somehow precise and meticulous but at the same time give more freedom and flexibility to get manipulated. They have been encouraged to execute physical performance prior to the digital computation. This allowed students to have a better understanding of the physical performance of a material towards compression and tension forces in the relation to gravity and also get an overall feasibility of their proposed design.

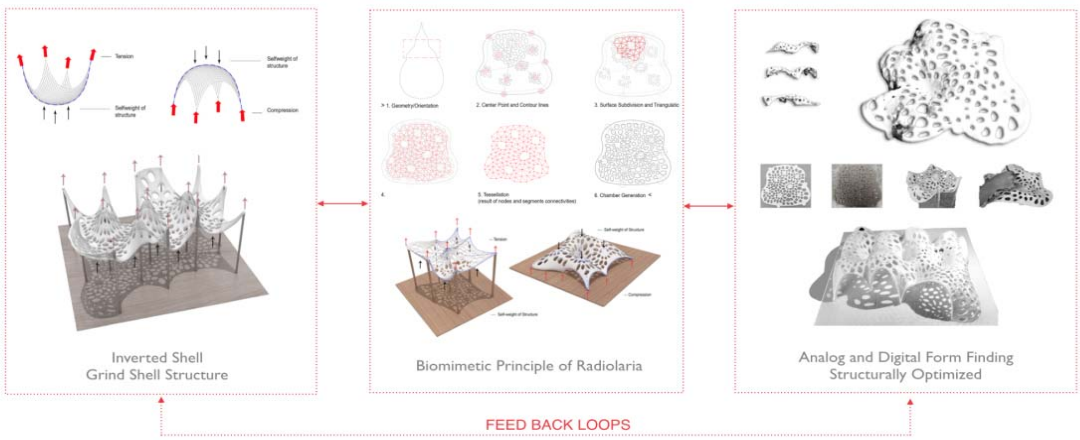

Figure 4. Physical Form-Finding

3.2 Digital Form Finding

Oxman describes that "in digital form finding the designer, rather than creating the one-off design, design an ad hoc project "generative system", a modeling system that includes parametric digital morphing of the topological design space of the model." (Oxman and Oxman 2014). In this phase students transfer a set of parameters obtained from bottom-up physical modeling into digital form-finding software such as Grasshopper plugins (Kangaroo Physics, Karamba and Rabbits), which simulate material behaviour by using physical forces like gravity, tension, compression and elasticity. As shown in Figure 4, this process is followed by extracting the mathematical codes for the initial natural inspiration to create a generative-based design using Karamba plugin, a parametric structural engineering tool which provides accurate analysis of shell structures. Furthermore, this gives possibilities to manipulate the generated form in more precise manners to create variation by simply modifying the parameters.

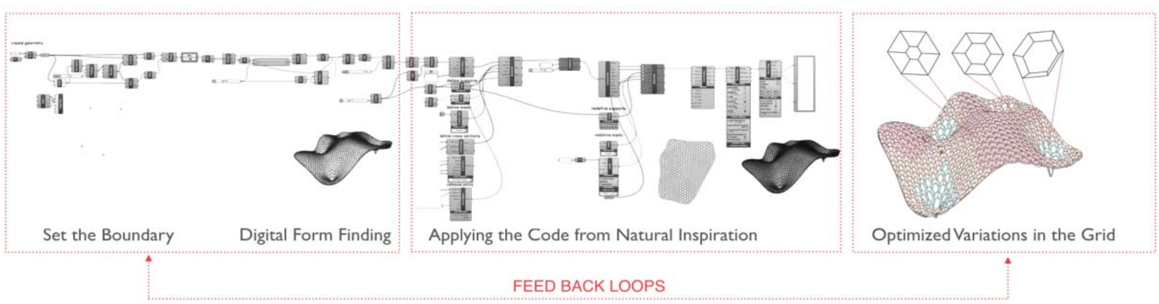

Figure 5. Physical Form-Finding

4. Performance Oriented Design

During the course, students are asked to incorporate optimization strategies into the design by implying the defined fitness criteria that integrates a rigorous process of various assessments on environmentally oriented behavior along with structural stability. In order for students to explore analytical process through computational processes, they are required to have a general understanding about morphological behavior, structural integrity, material performance of the designed form in specific sites with defined environmental pressures. The feedback data taken from environmental analysis, followed by form-found digital geometry have profoundly influenced the systematic strategies dealing with the site-specific project. In this selected project, Figure 6, students are identifying multiple fitness criteria such as structural integrity, requested program and environmental stimuli (solar radiation and wind force) which are the main constraints on the initial generated form to create diverse and site-specific variations. The number of constraints has an impact on the degree of optimization. However, our expectation for the digital optimizing tools and programs has to be faultless and precise, but often they dissatisfy this need due to the deficiency of the software or the lack of knowledge on what to feed into the inputs or even how to analyze the output.

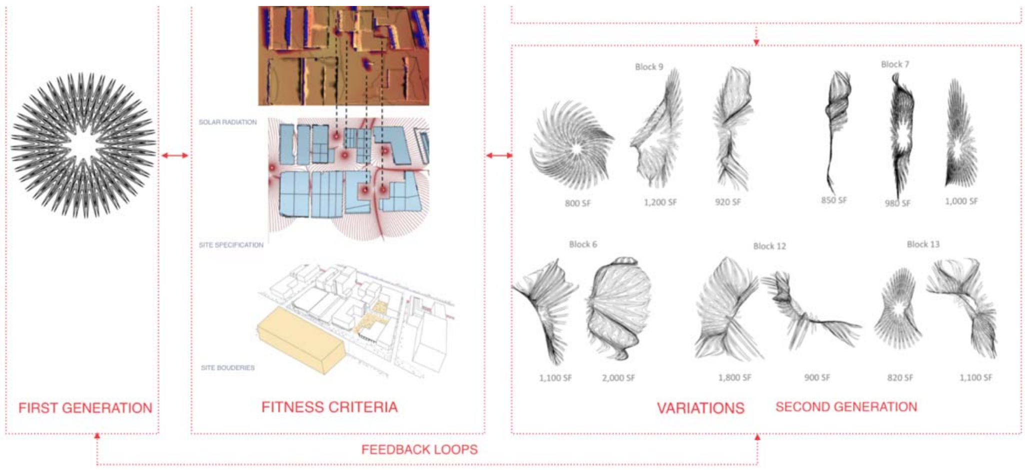

Figure 6. Physical Form-Finding

5. Fabrication and Method of Assembly

Digital tectonics had a critical influence on how to design in the past two decades especially in academic realm. The relationship between fabrication processes and the design intent as well as the geometric form and material properties are the other challenges that students are encountering during production and fabrication. Moreover, it is also clear that a range of new digital tools and techniques are appearing that not only challenge our previous understanding of the term “design”, but also hold out the promise of new, more efficient ways of generating or searching for possible solutions. (Leach 2014). One of the crucial principles in the design process is to embed the fabrication and construction logic at a very early stage to achieve efficient and homogeneous fabrication system. As a result, “they bring the ability to control fabrication digitally, to drive cutting, bending and assembly; to simulate and optimize material performance, to control of the craft of material.” (Glynn & Sheil, 2011). In the following project, Figure 7, the proposed assembly technique for the pavilion is to utilize a waffle framework system to overlay the mesh to construct the computed curvature for the shell structure. In addition, at the micro scale level, students suggest using a lightweight, recyclable and cost-effective material-system which consists of paper tubes, 3D printed joints and recycled textile. Although the process of fabrication appears to be digitalized and less complicated, its design method is linear with a complicated procedure and follows a traditional way of production technique. Whenever there is a flaw in the output, the designer needs to digitally remodel, reprint and test each part until he/she discovers the desirable product.

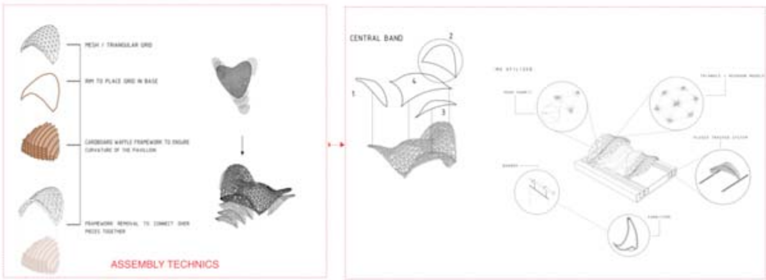

Figure 7. Optimization and Design with Feedback Loops

6.Conclusion

The aim of the course is to establish an elaborate system to manage and analyze various possibilities through series of physical experiments and digital analysis based on the environmental condition. Teaching students through generative design methods helped them to achieve and explore more dynamic design processes which can constantly updates through the feedback loops. This pedagogy method approves Tedeschi opinion: “Algorithmic design enables users to design a process rather than just a single object.” (Tedeschi 2014). In addition, the biomimetic approach gives students the opportunity to learn how to translate natural formation into the mathematical code, as well as, interpreting the monolithic structural principles by using form-finding experiments. Not all algorithms can serve the same purposes and there is no universal algorithm that can serve all types of problems. Also, “algorithmic thinking differs from almost all other forms of thought, in order to create a robust and optimize design, we need to have capability to comprehend the principles of this methodology which is inherited from computer discipline.” (Schumacher 2014). The precision is the key point when it comes to scripting; on the other hand, the method of selecting the specific rules or code, relies on personal decision-making and perception which often result arbitrary and imprecise outcomes. Since, the process of design is constantly exchanging information through analog and digital procedures, it is very likely that some data will get lost during this transition. In conclusion, there is a gap to achieve the ‘ideal’ accuracy within digital methodologies but, at the same time, the impreciseness of the physical material world can promote authenticity and ingenuity in the design. In other words, the challenges of integrating material physics and generative rules and their interactions leads to “imprecision”, i.e. the precision will be lost in transition. Thus, the spontaneity in the realm of artistic ingenuity generates the innate characteristics of the creativeness within the contextual subject matter.

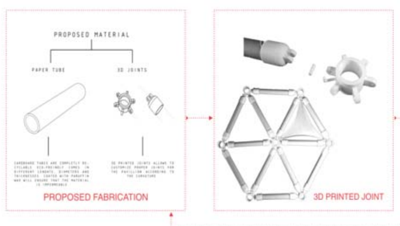

Figure 7. Selected Pavilion Project from the Studio Course

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