Introducing Architectural Design Foundations Through Algorithmic Design And Experimentations With Materials

A methodology for freshman class in architecture

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Abstract. This paper presents a lecture methodology using pattern based and algorithmic design principles for an introductory architectural design course aimed towards students who are not oriented in design practices but in natural sciences. This methodology is built upon eights interconnected steps, starting with analytical pattern extraction from nature - from the unique texture and structure of a plant (seed or fruit) and also from its lifecycle and relation to the existing habitat. The steps include abstract pattern making with the use of software tools and material building of abstracted geometries as standalone structures. Throughout these steps, principles of information design field is demonstrated to improve students’ abilities to analyze visual information.

Keywords. Pattern; Parametric Design; Design Education; Information Design.

INTRODUCTION
Acceptance procedure for Turkish universities is based on a nation wide exam, organized once every year. This examination tests students’ natural and social science knowledge through analytical questions, which are not prepared to evaluate skills or knowledges that a certain discipline may require. In our case, to be enrolled in an architectural department, students need an accumulated maths, physics and literature average grade. Hence, the education system encourages students to study for this examination during their last years of their pre-university years.

Given the circumstances, most students start their education with a lack of basic artistic and design skills and insights. Our attempt is to shift this disadvantage to establish an algorithmic pattern based design methodology that accounts students’ solid foundation in natural sciences - such as biology, physics and mathematics.

Pattern and algorithmic thinking has always been within the human experience of nature and their contribution to the world (Morrison, 1966). Basic embroidery techniques and their industrial productions are examples of the mechanization of the digital abstraction of the human mind. The introduction of the computer created a new conception on the notion of modularity with a reinterpreted look into the nature. The works of Fuller and Otto opened up a strong dialogue between the digital and the analogue, which encompasses the active forces of nature and the strong repetitive computing capacity of the computer (Cook, 2004).
Digital design tools and methodologies have been part of advanced architectural design courses. We present a possible bridge between student’s existing knowledge and capabilities with the current design notions and criteria to form a framework that combines cognitive depiction of nature – their reinterpretation of what is taking place in nature and the design research cycle. Our methodology is an analogical approach that maps existing knowledge and experience of patterns and behaviors in the nature to the design of the physical / digital patterns and behaviors in our man made environment.

The next sections will describe the concurrent curriculum and students’ skills and motives, then introduce eight (ordered) steps. The paper shows the results with sample works and projects exhibited at the end of fourteen weeks period. Finally the process is evaluated with possible rearrangements and suggestions.

CURRICULUM, INITIAL SKILLS AND MOTIVES OF THE STUDENTS

The studio that our methodology took part is called “Introduction to Architectural Design”. It is coordinated by the Digital Design Studies Department of Yildiz Technical University - Istanbul. Tutors of this course were briefed to work with abstractions, patterns and one-to-one material experimentations. The rest of the curriculum consists of introduction to building techniques, basic design, technical drawing and architectural history.

To obtain an overall idea from attending students about their skills and motivations, a questionnaire is handed out on the first day. The results showed that out of the thirteen students:

- Only two students were willing to study architecture prior to the university exam,
- Seven students were positive that they wanted to be part of the education but were not really aware of what they would learn,
- And two students were very unhappy and thought of retaking the university exam, although they were willing to try out anyhow.
- In other facts:
  - One student had drawing lessons in her previous education
  - One student was fluent in German and two students had English as their secondary languages
  - Three students knew basic crafting knowledge through their parents’ work practices.

LECTURE METHODOLOGY

In the following subsections, eight steps that the authors of the paper followed during the course will be presented. These steps consist of principles followed by assignments, where the former took place in classrooms as lectures, discussions and student presentations on a given subject, the latter were short or long term projects that required field studies, material experimentations, analog and digital drawings and models.

The amount of time that is spent for each step differed according to the difficulty of the subject (which was measured from the feedbacks during the lectures) and workload for assignments. Although these steps are ordered and presented sequentially during the course, subject wise they are interconnected and do not designate specific beginning and ending times or boundaries. Thus, each step completes another and is valid throughout the whole course. [Figure 1]
STEP ONE - Information design as metalinguage (principle)
Visual representation of information is the basic tool of communication in the design process. These representations can reflect mechanisms, processes, narratives, and causes and effects to reason about, communicate, document and preserve knowledge (Tufte, 1997). Therefore, they are the metalinguage of design, as well as the communication tool between designers and others. When this visual language is well designed (not only visually but also in an informally structured way), it becomes the design dialogue and the design itself, hence information design. All the following steps considered information design discipline as a foundation, which helps how to make sense of the (chaotic and orderly) information that surrounds us, and generate viable arguments in a given context (Dervin, 1999).

During the course, many information design methods - such as labeling, small multiples, layering, or color coding (Tufte, 1990)- were introduced. These methods helped students to better understand the subjects or systems that they are analyzing and explain them clearly to others.

To build-up on this principle, as a short exercise, students were asked to visualize their experiences as a commuter in the city. They were required to collect their own data in a given neighborhood by counting repetitive elements of their choice and map their trajectory to describe a topic or a process. [Figure 2]

STEP TWO - Domain of the grain: Visualization of plants in various scales (Assignment)
There is a thick fraction of groups with digital design strategies that focus on biomimetic concepts as a ground analogy. These concepts are based on the study of nature’s features and functions, and then imitating these designs and processes to solve human problems. (for example, studying a leaf to invent a better solar cell is an example) [1] This is a “look out for an analogous pattern to find a solution” approach and the one-to-one correspondence in a majority of the cases may extend a risk of gimmick in education: the risk of “looks like, behaves aloof”. Therefore in the course of education, gearing towards the relationships between forms, organizations and processes is crucial. (Weinstock, 2010)

In our methodology, we asked the students to work almost as a zoologists and draw/visualize a grain, a seed or a crop, using their hand drawing skills. Students picked their own plant and analyzed it from the seed itself to its upper and lower scales, where 100x would be the field, and .001x would be the cell arrangements on various parts of the plant. This exercise was effective in understanding the scales of existence, organization of systems in different scales, the logic of alignment and sequence. [Figure 3]

STEP THREE - Abstraction as means of construction: Similarity in classification and behaviour but not in appearance (Principle)
The two dimensional geometrical drawings of different scales of the grain were neither efficient in
describing the behaviors of the plant, nor in comparing the grains to one another or reconstructing them. Therefore students were introduced to the notion of abstraction. Abstraction of the relations between the quantities of certain elements of the grain were translated into ratios that described the plant. For example, the root length compared to the height of the tree as a ratio, or to the corresponding widths. To figure out such relations involved abstraction and use of diagrams.

**STEP FOUR - Emergence: Visualization and sample construction of patterns and behaviours in specific levels of existence in the organism (Assignment)**

The study of the grain and its domain is the study of the processes that involved within the plant at one scale, as well as its lifecycle. Relatively, “emergence” reflects the study of any repetitive component or behavior of the plants to define what qualities we could characterize in that structure.

Students were first required to create digital patterns on Processing scripting environment [2] (using a custom application developed by the authors) that would mimic their plants’ details in ratio or geometry. Then, they were asked to model the behaviors and the patterns within the grain in analogue media -using plaster as a time-based form making material, ropes, cardboard and balloons. As an example, a pyramidal arrangement of blown baloons were tied to woven ropes in order, chored, then plastered under gravitational pull as a model of a tree structure. Repeated with changing variables, this experiment is practical in assessment of the qualities of a model, the notions of representation, animation and simulation. [Figure 4]

**STEP FIVE - Range, limits and relativity in patterns (Principle)**

If you would geometrically double the size of a horse, what you get will be a problematic beast (Waddington, 1966). Regarding this anecdote, an important discussion emerged: Which features
and variables of the design elements (plants in this case) were interchangeable or alterable and to what limit? The rational description of species or a model lies directly in the order of its features and their activities. The exercises let the students realize adaptive reasoning behind pattern based parametric design. The fact that magnolia tree is different in China than in America, the limit in the climate zone, and the range that describes ‘magnolia-ness’, prepare the student in the following way: When designing an element, the design of its adaptive variations is part of the process.

**STEP SIX - Structure in a systemic sense and qualities (Principle)**

In the study and abstraction of the patterns and behaviors of the plant as a metaphor, the focus is in the understanding of structure as an outcome of the repeated behavior and component. The notion of structure in the systemic sense is the quality that defines the grain specifically resistant to certain forces and has specific affects in different environments. This is a wide spectrum of qualities, from color to sound absorption, from impermeability to endurance. As an example, a student who examined banana pointed out how its leaves were slotted to uphold winds, how in time they dried up, solidified, and intricately woven to perform as a tall trunk. This is an important shift for the students to understand structures and features that are directly definable in patterns and behaviors.

**STEP SEVEN - Naissance: Digital and material experimentation for structural qualities (Assignment)**

In this step, the aim was to directly experiment in the workshop with materials and model in digital platforms, using Sketchpad [3], Rhinoceros [4], and GEM [5]. Within the cognitive framework, students carried forward from the abstract constructions they had modeled out of the plants into construction of patterns with plaster, timber and paper. Hence, the focus was on the ranges and limits of materials, ways of bondage and repetition. Some students tried to reveal a certain behavior and forced the material to align, some experimented on how the material would behave in various arrangements. Studio sessions consisted of successive trials and errors, constant assessments of patterns (in most cases, symmetry, porosity, and roughness), of the components, its modular setup and the behavior of the whole. [Figure 5]

**STEP EIGHT - Parameters of exchange as an order of generation and growth (Principle)**

During the previous step, students experienced the essential differences between the digital and physical platforms of design. What one could achieve easily in one realm, was not actually relevant in the other. One basic contrast is the concepts of exchange and continuity, which is usually defined as the lack of gravity. However, exchange between organs or elements -for example exchange of minerals, energy, or force- is basically the major difference. In life, what keeps a plant in order is partly the trajectory that is set between the exchange of minerals from earth in one end and the exchange of sunlight and air in the other. In short the exchange of energies as a matter of structure and form is quintessential in physical realm. [Figure 6,7]

Instead of a dichotomy of digital and physical, the focus is more on the digital in the physical and the physical in the digital. To be more precise, digital platforms are practical in the exchange of information that is most relevant in the form and structure.
of our physical constructs and their adaptation to surroundings. Digital platforms effectiveness in carrying out growth patterns that are achieved with a set of rules that define simple recursion relations of modules or components (Ulam, 1966), and therefore enabled the students to design of behaviour, and variations.

DISCUSSION
The main challenge that we encountered during the course was students' perplexity towards the abstract correlations that we tried to establish between architectural features and natural forms and systems. We observed that most students were reluctant in the first several weeks and uneasy about not learning design methods and model creation. From our discussions, we found the majority of the students were expecting to learn practice based design skills from an architectural design course, while not being completely aware of what architectural design is. We deduced that this was a side effect of focusing on analytical knowledge during their prior education which caused a weakness in conceptualization and abstract thinking skills. We tried to augment these skills through information design practices - sketching, diagramming, mapping.

Regarding the end-of-the-year student questionnaire, eight out of thirteen of the students thought that their perceptions were changed in the end of the course, and eleven of them claimed that the studio achieved its goals in learning abstraction, patterns and material experimentations.

CONCLUSION
Architectural drawing is shifting away from plan and section to a more diverse information production platform (McGrath, Gardner, 2007). By setting up our methodology, we tried to create a narrative and a discourse that enables students to think and respond to any structure in terms of concepts such as porosity, roughness, and symmetry. The major advantage of the syllabus was that the students were able to work in analogue and digital media interchangeably in an abstract context, and achieved to...
design and evaluate (tectonic or material) structures as a performance of pattern. Hence, we suggest that information design is elementary in design education, and that analogy from nature is useful in sustaining criteria for comparison rather than a design basis or inspiration.

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