Parametric Thinking [Not Modeling] as a Generator

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Introduction

The field of architecture faces a paradigm shift where it is crucial to develop a series of correlated systems that can be synchronized and applied to and from multiple instances (i.e contexts, drawings, models…). Beginning design studios are the ideal place, a breeding ground of sorts, for introducing such complex ideologies and developing programs needed for a new generation of designers that will be able to seek solutions from information processing or reasoning, rather than intuition. By cognitively engaging with the environment and not by simply acting on it, we are empowering new practitioners to radically change the future of design. Bruce Mau speaks of making the invisible visible and how *our insatiable embrace of the image knows no bounds* [1]. A no boundary approach to designing systems lends itself to processes that parallel those of parametric thinking.

Parametric thinking has recently been the attention of many educators, designers and researchers. The influence of engaging in a thinking process that links, relates, and outputs calculated actions, thoughts, and even directions is hard to understand and analyze at the foundation years. Many of the believers in this pedagogic approach have been able to successfully grasp the potential of this process because of their working with parametric modeling and knowledge of generative design. It is far more difficult to find those who are breaking down the essentials of this approach and introducing them to the beginning design student. Questions such as how to teach complex ideas to beginning design students and what type of studio based projects are appropriate to develop parametric thinking quickly come to mind.

The paper will discuss a pedagogic approach that implements design logic and generative processes to beginning design studios. The approach injects the basic fundamentals of parametric thinking in order to find generative tectonic results. This idea uses *a more systematic framework of new tectonics combining digital and classic elements and processes is needed to explore the digital theory in architecture* [2].

We can define parametrics in order to develop a deeper understanding as to how this action or process can create the paradigm shift that McDonough and Brangaut speak of in “Cradle to Cradle”. The term parametric is typically related to the computational world, when in actuality the ideas of defining principles can be correlated far beyond those controlled by users and the developed code. Aranda/Lasch speak of parametric as a *boundless and inspiring conversation, one that reminds us that designing can be about communication between two worlds: one entirely abstract and coded, the other very real and alive, like what we find through our interactions every day with people, communities, and cities* [3]. The notion of establishing relationships between the act of making and the production of thoughts appears to be analogous in positioning one in the design field to generate solutions to problems rather than simply seeking them. Parametric thinking may be the defining elements or rationalization that forms our beginning design students’ future.

Exploring parametric thinking in the design studio

Parametric Correlations is a studio based project that was assigned to three sophomore studios and one entry level graduate course. It explores the generation of space(s) by regulating a series of parameters and the relationship to one another. In this investigation the students gained valuable insight into their understanding of space by discovering how parameters affect the overall tectonic quality and character of a spatial artifact. Organizational and spatial systems can directly influence the relationships of points and lines - the basic elements that make space and affect the way in which we experience it.

Parametric Correlations builds on the idea of extracting information from natural forming life systems, such as the petals of a flower or the growth rings of a tree, in order to develop spatial and organizational systems. Farshid Moussavi argues that *causes and concerns that are immanent in the environment are combined to generate forms, enables us to harness the transformative power of contemporary reality. Moreover, it enables us to incorporate greater levels of complexity within built forms, allowing multiple inputs to interact simultaneously on the same place to generate a multitude of novel forms, each with unique expressions, sensations and affects* [4]. It was essential for students to realize the interplay between action and reaction with these natural systems but also how the environment becomes the connecting element between the individual and the form.

Students were instructed to investigate the workings and formation processes that nature permits in order to formulate a generative system of their own. This was accomplished by translating data into sets of parameters that will define order and allow for an exploration in a derivative process. Students realized that this design process has strict sets of relationships between operations and variables.

Since a large portion of natural systems can be explained through folding, whether that is the branching pattern in leaves or the folding of sound waves, students engaged in the simple act of manipulating paper through folds, cuts, and score operations. Realizing how the paper was manipulated through their developed parameters, students began to generate systems and spaces that were found and not imposed in the physical landscape.

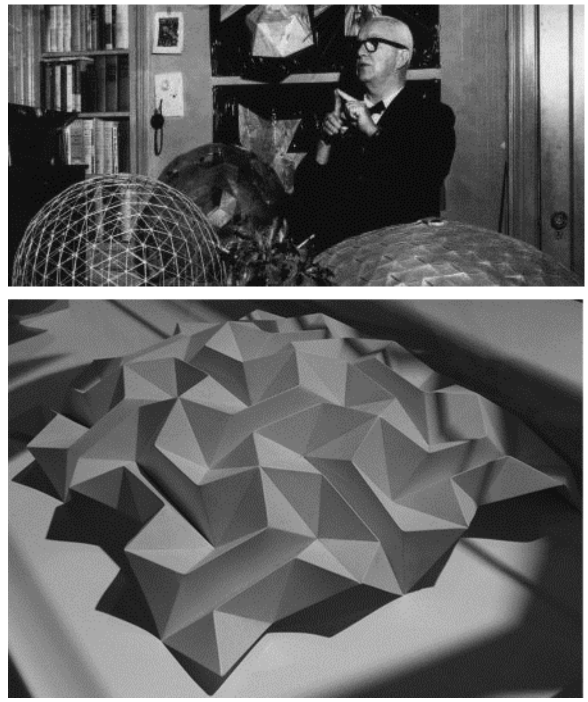

Figure 1: Top: Buckmister fuller working with geodesic dome[i]. Bottom: Ron Resch folded pattern model[ii].

Historically, the concept of folding and tessellating in order to produce space was greatly advanced by two designers/mathematicians/visionaries: *Buckminster Fuller and Ron Resch* (figure 1). We used these innovators as a foundational study to drive form and develop a greater understanding about how these processes manipulate a standard sheet of material with a goal of obtaining tectonic results. Criteria such as scale, proportions, and perception became part of the evaluation process for students. The students' initial investigations explored simple orthogonal actions – fold, press, score, bend, cut, weave, compress, tessellate and unfold. It was imperative to realize how each fold can create space or how unfold instances affect the way we perceive our environments. Moreover, the students were engaged in the creation of space through relatively simple actions that were purposeful and indented.

Each student produced numerous study models that where built on the explorations of the previous instance. Once tectonic form has been created, a set of diagrams was drawn in order to understand the relationships between commands performed and the resulting actions that generated the form. These diagrams explored the two dimensional parameters as well as the third and fourth dimensions. These studies were performed in a manner that related to scale, actions, results, and time. In addition to these aspects, some approaches begun to articulate tectonic qualities by focusing on the relationship between spaces and the human body.

The diagramming aspect in regard to the students work was pivotal in their learning of parametric correlations. A direct response to how a diagram is used in unfolding relationships of hierarchy and patterning allowed the students to understand how step by step processes, much like origami, can convey three dimensional models [figure 2]. When speaking about how it is possible to make natural forming objects through paper and diagram, Robert Lang believes *it doesn't come by accident; you don't find that by trial and error. So I use mathematical and geometric ideas to achieve this goal of a beautiful folded shape* [5]. Students were influenced by the engineering work of Robert Lang and his ability to transfer origami diagrams, of solid and dotted lines, to artifacts far more complex forms than the imagination can prescribe.

As a result of the diagramming investigation, students developed a series of points and lines which controlled the series of interrelated and hierarchical spaces. This demonstrated how an analog parametric mindset enabled the students to generate a relationship between lines, points, and folds as a form driven method.

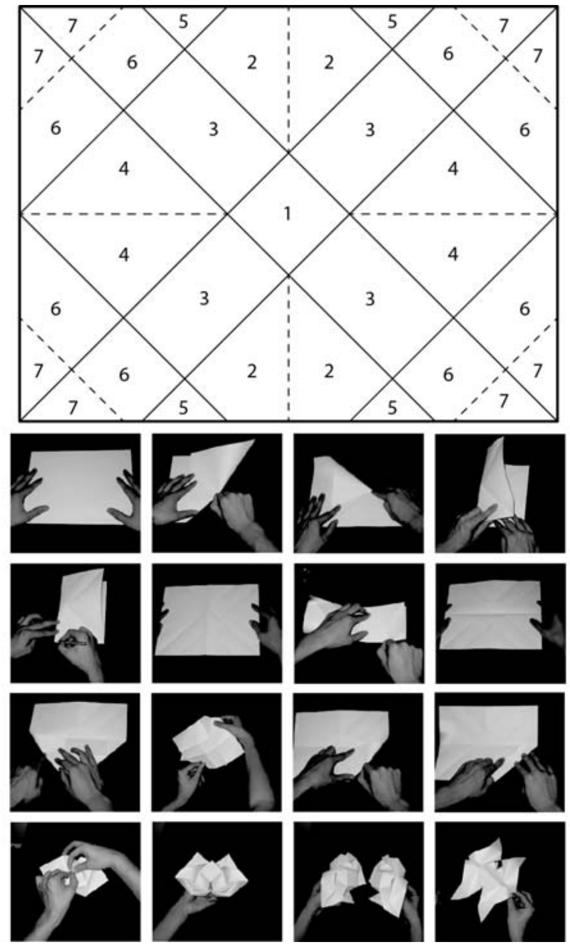

Figure 2: Students work _ Folding diagram and process of generating form in paper[iii].

Translating the physical into the digital

The importance of generating systems through parametric thinking, and not parametric digital models, enabled the realization of dynamic systems. Students thought in a parametric manner where computation was simply used as a means to express the results and erases questions pertaining to the learning curve in software. Students struggled with the complex processes that were introduced to them and were hard pressed to realize that design is a process that requires thinking and developing, rather than a product that is the result of software development.

During this project, students engaged in analog and digital processes [figure 3]. The interplay of these processes marked their design. First, the students were asked to only engage in the act of making through an analog process where folding paper and developing diagrams by hand generates many tectonic representations. The relationship between defined parameters and the actions in which folded spaces were generated was only explored through analog processes, thus allowing the students to physically create space in front of them.

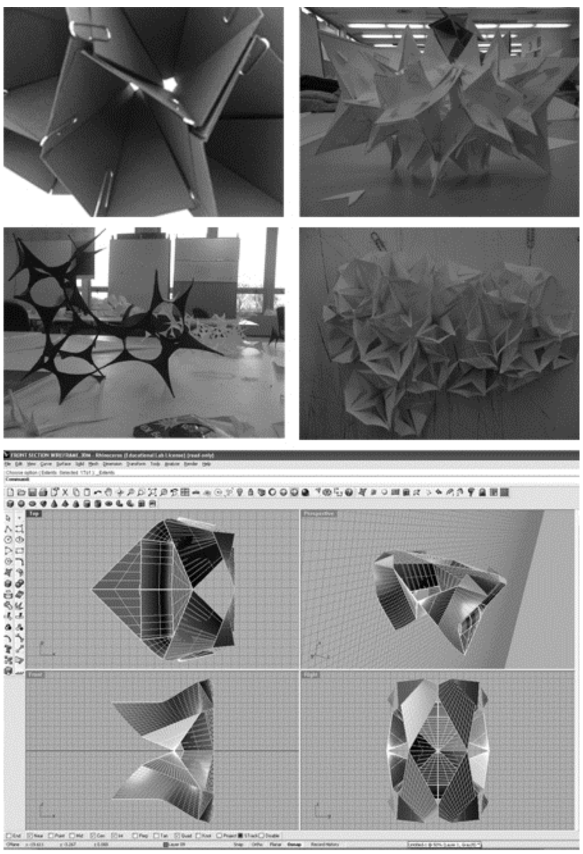

Figure 3: Top: Analog process of student work[iv]. Bottom: Digital process of student work[v].

In order to choose an outcome to develop, students performed an analysis phase that included criteria such as; scale, aggregation, constructability, stability and aesthetics. Once a selection was made, students explored the ways of translating the diagrams into the computational world by correlating various points and lines into CAD based software. The tracing of points and lines constructed the framework of a digital model where surfaces began to define the volumetric space. Digitally generated tectonic components such as masses, planes, and frames began to emerge [figure 4].

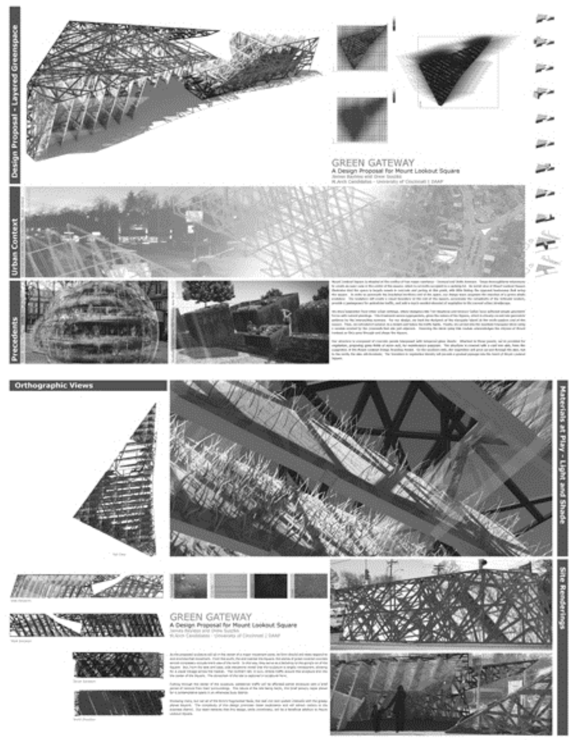

Figure 4: student boards showcasing digital modeling and analysis of generative system that investigated daylight and shading information[vi].

Once realized in the digital realm, each student was instructed to explore new venues that emerge due to the possibilities of digital technologies in creating physical models (i.e. laser cut models, digital renderings, and vector graphics…).

The final product of this studio included the students' explorations in the form of highly crafted models and digitally generated board(s) to accompany the model. These boards were expected to clearly define the design process and information that is not obtainable through model investigations [figure 5].

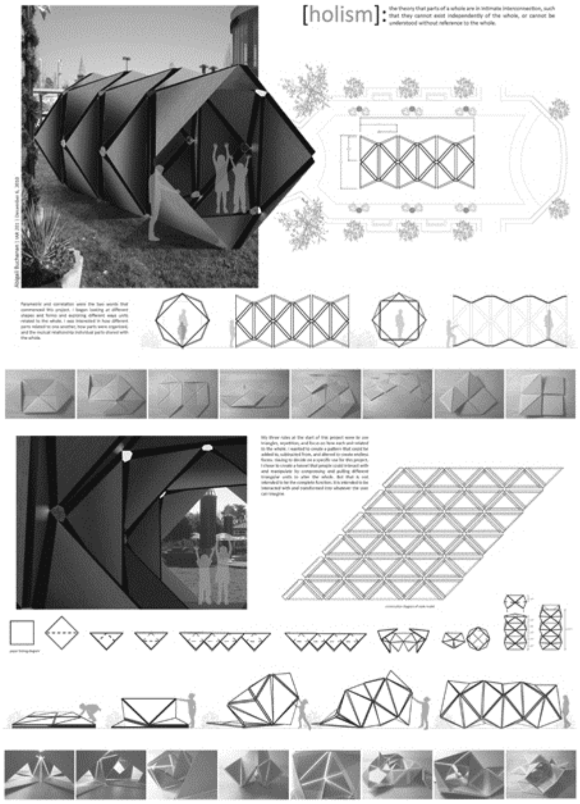

Figure 5: Final project submission as printed boards[vii].

Professors Role

With the complex nature of these ideologies, it was imperative for the professors to convey information to students in a clear and precise manner. The professors did not overwhelm the students with possible directions, but instead allowed the students to struggle and filter information at their own pace. The role of the professor greatly changed per the students' ability to comprehend and think with a parametric mindset. It was not uncommon to find each student at different levels within the design process.

Early in the design phase it was helpful to hold several weekly pin ups that allowed students to engage in conversation with not only the professor but also their peers. Students realize that their peers were able to further their project through constructive criticism. Throughout the studio the sense of community strengthened as the students were able to understand how to think with a parametric mindset. Several students realized that the studio environment could be deemed a parametric design situation where direct and indirect relationships between space and place were drawn up.

Furthermore, the professors' role was to facilitate and challenge the students' use of parameters only as a mean to understand the complex nature of generative systems and to what extent can they be fabricated. The students were often pointed to precedent studies instead of discussing a direction that can be taken with their project. In the end students realized how to not only gather information but how to connect the various components of a design process. It was their own workflow that allowed for the creation of a parametric mindset that rationalized their design.

Results

The development of this project and pedagogical approach has been the collaborative efforts of three Universities, four professors, three studio courses, and one technology seminar. The interest of these professors' lies in rethinking and questioning the ways in which we are educating beginning design students. This collaboration understands that developing a curriculum that focuses on parametric thinking can entice students to better apply conceptual and critical thinking skills to their future design work.

Parametric thinking demands one to engage in multiple design iterations and therefore reinforces design as a non-linear workflow that is a critical and powerful thinking process. This ongoing collaboration has stimulated constructive dialogues and introduced new pedagogic techniques shared by the three institutions. The application of this pedagogy lies within the threshold of breaking and discovering the limitations that we as educators place on the thinking process, design pipeline, toolset and tectonic results.

Although in the early phases, we have already received substantial results in how beginning design students are now questioning the connection and reasoning for their designs. Ergo, seeking solutions rather than using intuition in the formation of their outcomes, students are becoming more consciously aware of how parametrics may impact the environment, landscape and social fabric of our future.

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