

# Beyond Control: Parametrics and Metadesign as a Model for Mass Customization

The power of technology lies in its capacity to amplify human capabilities. Much of the technological space we inhabit in the twenty-first century is data driven, responsive, interactive, and social. Spaces like Amazon, as a marketplace experience, are using data mining, recommender algorithms, and social networking as tools for generating space that responds to individualized desires. Metadesign, through interaction and

individualized evolution, is the hallmark of these technologies.<sup>1</sup> In the design disciplines many obstacles to diversity and individuation of space have been overcome in recent years due to customization processes that use digital coding to allow variety in object formation without adding significant increased expenses in production. Architecture is now evolving to meet the demands of this new type of space.

This paper defines metadesign and mass customization and then describes two projects, one in academia and one in practice that use metadesign and mass-customization strategies to achieve their ends. As an approach that maintains a deeper connection to the type of space that most human beings now inhabit, these projects represent design and production approaches that enable lay people to take a greater amount of control over their designed spaces. Designed objects have been relatively fixed historically because of constraints and economic implications of mass production. The complexities of the production process have also helped reinforce a division between “designer” and “consumer”. This new type of design thinking welcomes flexibility, in lieu of fixity, in the designed object. The distinct line separating designer and consumer blurs as a result of this process. In lieu of designing fixed objects, a designer’s role evolves to be one that provides a parameterized formal language and its rules, and then sets these criteria adrift into the social realm so that it can begin its litany of formal morphologies.

## **METADESIGN AND NEW MODES OF SPACE MAKING**

There has been an explosion of social and user-generated media on the Internet in the past seven to ten years.<sup>2</sup> During these years we have begun moving away from forms of media wherein users are passive receptors of

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delivered content, toward a paradigm that favors interactivity and user creativity. Web-based software abounds that allows users some control over their delivered content. Pandora and Last FM, among others, are new types of music listening experiences wherein the users gain more control over the content being delivered to them. These stations collect information about the user's listening preferences to create "stations" that will introduce you to new music that aligns the station with your taste. A new way of architectural space-making, and a process some have referred to as "metadesign," is alluded to in this Web environment.

Metadesign can be defined as a "mode of integrating systems and setting actions in order to create environments in which people may cultivate creative conversations and take control of their cultural and aesthetic production."<sup>3</sup> Metadesign focuses on the "design of general structures and processes, rather than on fixed objects."<sup>4</sup> This approach allows lay people access to tools that can be used to evolve spatial solutions within a framework provided by an original designer. The effect of this would be variety and continual evolution in product outcome. When translated into an architectural design realm this approach has specific implications for the role of the architect or designer. In lieu of designing objects or spaces, the architect now provides working tools to lay people. Parametric thinking is a way to connect architecture to this emerging digital realm. Parametric properties will be established by design professionals to provide the framework and constraints for individual objects or spaces. Once these parameters are established, the design space becomes morphologically diverse but still has boundaries or limits that ensure its manufacturability.

### **MASS CUSTOMIZATION AND TWENTY-FIRST CENTURY MANUFACTURING PROCESSES**

Industrial production techniques have evolved considerably over the past two decades. In "Flexible Manufacturing System for Mass Customization Manufacturing", the authors define three types of manufacturing concepts. The first type, known as a *standardized product*, has predefined attributes, giving the consumer no choice except whether or not to purchase the product. The second type, known as a *configured product*, allows customers to choose from limited options which the manufacturer has specified. The configured product indicates a trend toward mass customization but limits the extent of that customization for cost purposes. The third type is called a *parameterized product*, and the process to arrive at this product outcome is referred to as Additive Manufacturing. This product is built using parameters and as such allows the consumer to significantly modify its features. The parameterized product is mass-customizable.<sup>5</sup> Joseph Pine defines mass customization as a "strategy that [seeks] to exploit the need to support greater product variety and individualization".<sup>6</sup> The goal of this manufacturing strategy is to give the consumer more choice while maintaining the cost advantage of mass-producing the same object.<sup>7</sup>

Over the past decade a number of major corporations have experimented with allowing users to have greater control over product outcome. This signals an evolution from "configured" to "parameterized" products. Toyota's Scion cars, for instance, were based on the idea of considerable user



customization. A number of large shoe companies have experimented with allowing users to drastically affect the material and pattern choices of the shoes they were buying as well.<sup>8</sup> Similarly, The Lego Group has created software that allows you to design your own objects digitally and have the pieces shipped to you so you can build the physical construction at home. In an article titled “Variety is Free: Manufacturing in the Twenty-First Century,” Joel D. Goldhar and David Lei cite examples of companies providing increasing user choice through digital manufacturing processes. In one example Levi Strauss offers “made to order” blue jeans that are built by entering a customer’s measurements into a computer, after which a pattern is sent via phone lines and cut by a robot.<sup>9</sup> Digital tools in this case allow highly personalized information to be translated into a constructed product. In another case Vought Corporation, an aerospace manufacturer, can produce 600 different designs using the same equipment.<sup>10</sup> In this case, understanding the manufacturing parameters and ensuring that each newly designed piece falls within those parameters is essential to Vought’s business. These are examples of metadesign practices already in place that are evolving from a “configured” to a “parameterized” process wherein individual users are given more opportunity to make decisions about a final product.

In a Ted talk titled “A Primer on 3d Printing,” Lisa Harouni describes Additive Manufacturing, as a process whereby lay users manipulate parameterized digital data to arrive at unique products that meet their specific needs and desires. This differs from the variant production process described above in that there is an allowable formal morphology within given manufacturing constraints as opposed to a simple exchange of specific product attributes.<sup>11</sup> In another Ted talk Paola Antonelli describes furniture that users will be able to customize from their homes and print at a local manufacturing station.<sup>12</sup>

There are numerous software strategies being developed and used that are helping manufacturing processes evolve from the *standardized product* approach, wherein success is determined by uncovering specific user needs, to a *parameterized* approach that invests less in specific user needs and more in tools that users are given to arrive at a product that is desirable. One such approach, described by Eric von Hippel and Ralph Katz, is that of “Toolkits for User Innovation.”<sup>13</sup> Toolkits for User Innovation are “design tools that enable users to develop new product innovations for themselves”.<sup>14</sup> These Toolkits allow users to “create a preliminary design, simulate or prototype it, evaluate its functioning in their own use environment, and then iteratively improve it until satisfied.”<sup>15</sup> The application of Toolkits or their equivalent in the architectural realm represents a transition from an object-centered approach to a design approach that favors the generation of operational structures that allow individual lay users to transform the design space, within a set of manufacturing constraints, to arrive at a desired customized product.

As part of a graduate seminar at the University of Idaho a group of students experimented with creating a parameterized product that would be transformable through a social network. The project was titled “Drift,” which

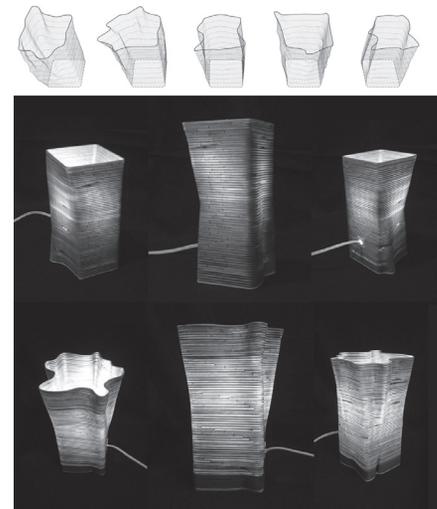
alluded to the eventual product's ability to formally evolve as it drifted over time through their social network.

### DRIFT LAMP PROJECT DESCRIPTION

The Drift Lamp project was assigned at the University of Idaho as a graduate seminar. The intent of the seminar was to have students construct the definition for small-scale, parametrically designed, objects whose form could be easily manipulated by individual lay users. This meant that "rules" had to be established within each object's parametric definition that would constrict lay users from choosing a formal variant that falls outside the object's manufacturing constraints. If successful, this process would allow lay users the ability to change the formal nature of the object to fit their needs and desires but would not change the inherent method or process of manufacturing. It also suggests that design could evolve from the making of a static object, and a fixation on that object, to a process that is seen as the creation of a formal language and an establishment of the rules of that language. In this scenario designers remain vital in creating form and order in a broad sense, and lay users become vital in iterating the language to suit their specific needs and desires.

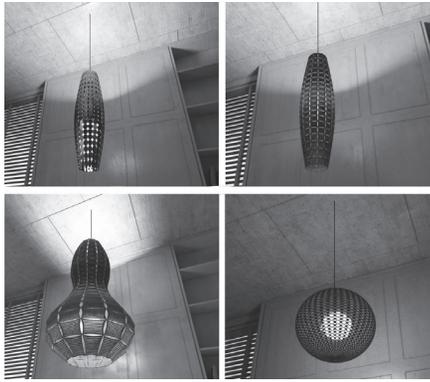
The students in the seminar had a number of learning requirements to deal with. First, they had to design a lamp that was parametrically significant. Parametric significance was defined by how meaningful it would be for someone to change an object parameter. In other words, if the parameter was simply length or size of a member then it probably was not parametrically significant enough. Second, they had to ensure that the object could be built (by them) in two to three days to ensure relatively rapid iteration. It was discussed that if the lamp were to be mass customized then the production time would be greatly reduced: even potential methods of production that fell outside of our technical capabilities were discussed in great detail. Third, most of the students had to learn Rhino/Grasshopper to build the object definition. Last, once the object definition was built, the students were to have their colleagues adjust the formal qualities of their design using basic sliders in Grasshopper. The eventual goal of a project like this would be to create a user-friendly interface through which lay users could manipulate the object's qualities.

Physically constructing the object helped the students create an affective definition and set of parametric constraints. By laser cutting parts, for instance, the students discovered the constraints of the laser cutter bed, the constraints of the materials they had chosen, and the effect of assembling the particular material. In addition, knowing the exact function and use of the object, such as whether it was a wall or desk lamp, and what it was attempting to cast light on, helped generate particular object definitions. Determining, for instance, the type of bulb one wanted to use allowed the students to think of functional constraints like the ability to reach one's hand in the lamp to loosen or tighten a bulb. These functional constraints became the constraints of the parametric definition and the part of the built-in "rules" that lay users would have to abide by. Figure 1 shows an example of one of the lamps. The original form of this lamp is an extruded rectangle.



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Figure 1: Drift Lamp Morphology



Height, breadth, and shape were transformable to a specified extent within the object definition itself. Within this figure the lamp shown on the bottom left is an example of minor changes made to the original form made by a lay user while the lamp on the bottom right indicates major changes to the original form made by a lay user.

Another important factor that helped determine object constraints was a desire (by the designer) for lay users to adhere to an object language. For instance, if while building the parametric definition the designer allowed too much flexibility within the rules, then the certain iterations of the object could become distorted beyond the limits of the object language. In other words, in extreme cases the object would no longer seem as though it belonged to the same family, as its formal language in relation to that family would be destroyed. After numerous iterations of the physical object the students had established enough rules to build (or expand on) their object's parametric definition. Once numerous iterations of their object's parametric definition were explored, the students emailed the digital file to colleagues and friends and allowed them to manipulate the definition, creating new objects that maintained the formal language of the original but that hopefully satisfied the specific needs of the individual lay users.

The designer intuitively deals with a formal orchestration within a series of rules. For instance, lamp bulb dimensions, distance from edge for wear, and fire-safety purposes. Rules that are implicit to the object but that would perhaps go unnoticed by a lay user must be established by the designer if the lay user is to become part of the design team. Figure 2 shows a lamp that consists of a faceted assembly. The facets are flat planes whose shape can be easily transformed parametrically. The user has control over the number of planes along the vertical axis and the number of planes that make up the circumference. Choosing the number of plates and then altering their shapes parametrically results in a variety of holistic formal changes that affect the lamp form. In this scenario a user can adjust the lamp to fit their particular spatial needs or formal desires without drastically affecting the cost of the lamp or how it will be manufactured.

#### **AT THE SCALE OF BUILDING: ANALOG PARAMETRIC AND METADESIGN STRATEGIES IN ARCHITECTURE**

Mass customization and "metadesign" emerge as a result of new capacities brought about by advanced technologies and digitalization. Unquestionably, parametric design techniques offer the potential for manifold variations and iterations of objects to be produced economically with rapid-prototyping and digital manufacturing processes. But unlike the automobile and product-based industries, the role of the parametric in architectural design strategies has been to produce non-standard, highly configured, products that are implemented and installed in conventional ways to that imply the appearance of complexity. As Michael Meredith has observed:

To the extent the profession has used parametrics today, there is very little to instigate complexity other than the mind numbing image of complexity, falling far short of its rich potential to correlate multivalent

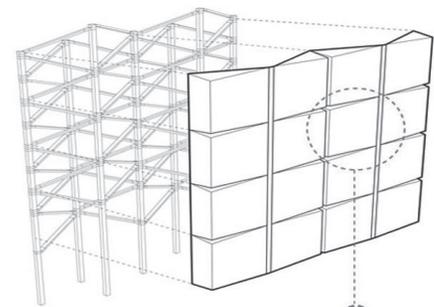
Figure 2: Parametric Lamp

processes or typological transformations, parallel meanings, complex functional requirements, site specific problems, or collaborative networks.<sup>16</sup>

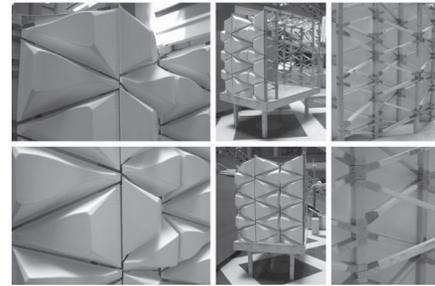
This suggests that the parametric in architecture has worked to predominantly simplify the complicated, allowing architects to further fetishize their collective desire for an excess of control throughout the design process in the service of architecture's tendencies toward novel superficial treatments. On the other hand, the potency of considering metadesign in relationship to the parametric is the possibility that through the architect's design of the rules and limits of an aesthetic system (as opposed to the outcome), a relaxation of control in the final product occurs, suppressing aesthetic preconceptions, allowing for the prospect of unexpected forms and spatial effects.

Metadesign by users of architecture has been considered in projects such as Hou Minn's *OSWall*. The *OSWall* offers a glimpse into the potential of architecture developed similarly to a software package that is a "modifiable, customizable, platform" by its users.<sup>17</sup> While this project results in an elegant, highly configurable component-based wall system, one must consider whether a user-based approach is appropriate for the contingent and site-specific variables that architecture must engage. The demountable wall, brought to market in the 1960s and 1970s, offered a similar promise: a highly re-configurable, customizable spatial system. One need only survey office interiors from that era that remain fixed to this day as evidence that, due to scale and speed with which change can be made in construction and user preference of space, architecture is somewhat incompatible with, and thus should not be conceived similarly to a product. Furthermore, are users the best-equipped constituency to make architectural decisions? If not, who might be the best audience for considering applications for metadesign in architecture?

Architecture is ultimately conceived for public use and consumption; however, its manifestation is mediated by the contracting industry. To date, digital processes have maintained the stable relationship between architect, maker/constructor, and product. Notwithstanding advances in digital manufacturing technologies in the development of complex and variable construction components, buildings remain primarily constructed and assembled manually (i.e., analog) by contractors using repetitive techniques. Often considered more labor than craft, conventional construction using standardized components, even in the most mundane design, always requires contractors to make value judgments while installing and assembling materials. The imprecision of construction materials (even computer controlled outputs)—coupled with the instability of site atmospheric conditions—forces masons, carpenters, and tile setters quick, fine-tuned decisions in order to control quality without sacrificing speed when performing their trade. To perform their work, contractors interpret drawings and specifications for performance criteria and develop means and methods to implement the idealized vision of the architect. By re-positioning construction labor as integral and generative to architectural designs in passive ways



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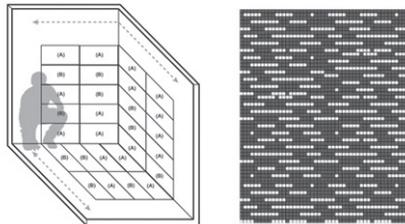
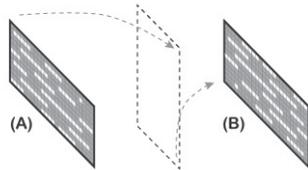
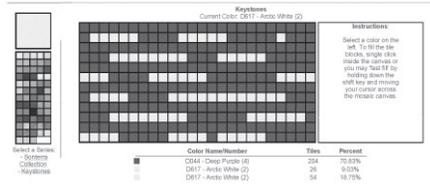


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Figure 3: Oswall, Houminn



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Figure 4: Tile Module and Pattern Diagram

Figure 5: Canton Cultural Center Renovation Photos, Robert Maschke Architects, Marc Manack

(i.e., does not make their job harder), architects can engage with an industry typically resistant to the high level of execution and attention to detail that architects often command.

Repetitive analog assembly and construction techniques, when considered parametrically, offer fertile territory for the exploration of metadesign strategies that engage contractors. To implement such a strategy, privileging specifications over aesthetic representations in construction documents becomes critical. The typical documents an architect provides that establish the criteria for construction, an image in the form of a construction drawing, establish the holistic aesthetic of a fixed final product, which is then supported by specifications that provide standards for the installation and performance of its components. Re-examining the role of the specification as generative to the design process is critical to implement an analog parametric strategy. This exploration requires an investment and knowledge of the architect in the “how” of construction, its means and methods, typically avoided by architects for liability exposure and lack of construction expertise.

Scripting algorithms form the basis of parametric digital design and allow for variability within the establishment limits. Scripts efficiently automate the execution of a specific task while linking it to other parameters and variables that can affect the way the task is completed. The performance specification is the analog precursor to the script. By designing strategies for implementing repetitive tasks imbedded within specifications, architects can harness the power of material effects variation and complexity in unexpected ways without sacrificing efficacy. The promise of providing the rule-based specification to the contractor as the act of design in a project, is to liberate labor from the constraint of a preconceived product, providing flexibility for the act of assembly to enhance the design outcome and assume collective authorship in an architectural object.

### CANTON CULTURAL CENTER PROJECT DESCRIPTION

A restroom renovation of an existing art museum proved an opportunistic test case to experiment with an analog approach to parametric specification. This project was completed by Robert Maschke Architects, with Marc Manack as lead designer and project architect.

The project consisted of the predominantly superficial renovation of an existing restroom. Conceptually, the project sought to reinvigorate the space of the public restroom through the introduction of an enveloping pattern that would act globally to imply a sense of perpetual movement through the space while maintaining a localized variation within the mosaic pattern.

The budget and schedule limits of the project meant that despite the fact that the design called for a complex surface pattern, the implementation could not adversely affect the project’s logistics. Consequently, along with qualities and effects desired for the pattern, a specification had to be developed that wouldn’t be more difficult (more physically demanding), slower, or most costly than setting the standard mosaic tile budgeted for the project.

The constraints necessitated that a standard module be developed that could be repetitively put in place by the tile setter. Potentially, the modulation would undermine the field condition desired for the pattern. Working with a manufacturer's standard design tool, a single 12"x24" custom patterned mosaic module was developed that would be used and repeated on all tiled surfaces of the restroom. The specification was developed for the contractor to choose the orientation of the grain direction to reduce material waste. To minimize effort by the tile setter while still achieving a maximum amount of variation, the single panel would be repeated with the option of being rotated at 180 degrees during construction. The specification was written for the contractor to have the liberty to rotate the tile at will. This rotation, in concert with the dimensional constraints and configuration of the existing site as well as the work point the contractors chose on each wall captured the desired motion, but did it in a way that produced unimaginable and incongruous localized variations that amplified the effect of motion only passively suggested in the design of the specification.

## CONCLUSION

The space of digitally designed environments, both interactive and evolutionary, alludes to new patterns of making in architecture and product manufacturing that favors flexibility and engages new audiences in the design process. The Drift Lamp Project and the Canton Cultural Center Project are examples of new types of design strategies that relinquish some of the controls over individual spaces or objects that the designer once held, and allow lay people a greater capability of transforming the designed space. For this to happen, designer's roles must evolve to include a greater focus on the construction of manufacturing frameworks and the establishment of object languages instead of merely being purveyors of fixed objects and spaces. This design method suggests that designers will learn about an individual problem in order to understand its necessary constraints, and then design the parameterized rules and formal language around those constraints. This process accentuates design as a social activity and aligns with many of the spatial types we interact with today.

In the mid-twentieth century Michel Tapie, Reyner Banham, and others became proponents of *un art autre*, a movement which strived for a "dynamic and persuasive alternative to the conventional thinking and operational lores," that in Banham's view, "blighted most contemporary architecture and design".<sup>18</sup> During this time Banham also predicted a "triumph of interactive software that would have the flexibility and rhetorical force of futurism without the baggage of style".<sup>19</sup> The early twenty-first century design environment seems ripe to take on this challenge. The potential of parameterized design as a social activity would afford a new vibrancy in architecture that would break with conventional thinking about design and the architect's role. If this potential is reached, the outcomes of design will become more fluid, dynamic, and evolutionary. ♦

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