Formal Mutations

Designing a Transformative Experience

by Andrzej Zarzycki

This series of projects, titled *Formal Mutations*, explore tectonic possibilities in architectural form and space. They combine my personal design and research practice with lessons learned during a recent architectural digital design studio at the Rhode Island School of Design Interior Architecture department titled "*Formal Mutations; Designing a Transformative Experience*." This article highlights findings and discusses students' and my design journey.

This studio focused on the dynamic aspects of architectural environments that adapt and interact in a similar way as life forms need to do in nature. While other similar approaches often limit themselves to tectonic expressions in architecture, our studio also stressed spatial and experiential dimensions—as signaled in the subtitle for the design studio--designing a transformative experience. Students were expected to apply digital tools to simulate morphological variations in architectural forms while considering a space's functional and perceptual requirements.

My interest in studying tectonic evolutions and simulating form mutations in design comes from the observation that these operations are natural ways to manipulate data and models. Editing already existing data is more native to digital environments than inputting new data. Architecturally this could mean that transforming already existing forms is a potent and effective way to derive new forms, ideas, and designs. This comparative approach is already present in architectural theory and history, but is slow to enter a design field where it has an opportunity to redefine creative relationships from individualistic drives to interdependent landscapes. This tendency is also evident in our civilization progression and particularly history of science, where progress is realized through iterative refinement of the past paradigms such as the Newton's Law of Gravity to the Theory of Relativity. In a broader conceptual sense, this means that creating new ideas from scratch is almost always more difficult than arriving at new ideas by gradual transformations of the old. This brings us to the main natural precedence for this method—biology and the emergence of life.

Figure 1: An evolving particle form, Andrzej Zarzycki.

Studio Methodology Origins

The Formal Mutations studio design approach grew out of an academic necessity— the need to educate students with good visual judgment and often-limited technical skills. It is the type of situation, when faced with limited time and a wide diversity of student skills where one has to improvise. My past experience with script-based design in studio settings showed me that it requires a major amount of dedicated time committed to teaching students the intricacies of programming and debugging. While scripting is a very promising design approach, it is usually hard to achieve more comprehensive architectural results that call for more than a tectonic solution while try to engage experiential as well as narrative component within a semester's time.

Figure 2: A transformed cube forms a digital landscape, by Nick Brunetti.

Thus, the Formal Mutations studio approach emerged. It mimics what one would do if given the ability to topologically transform physical objects, not unlike children do with clay (plastelin). This approach is a comprehensive take on the issue of transformation-based design and combining tools in a larger design methodology framework with ability to animate these transformations to derive new designs. In many aspects it mirrors what can and is often done with script modeling, but it keeps it on a user-friendly interface. It provides a designer with instant feedback regarding shaping of a form. Consequently, this allows for channeling design toward more promising solutions and, not necessarily, being over-committed to a particular approach.

Formal Mutations is an alternative to the script-based design approach focusing on the intuitive use of digital tools, shifting the balance from an emphasis on tool knowledge to intuitive explorations of form and space. It introduces poetry in form finding along similar explorative paths as when investigating light and materials.

The design is executed by applying simple rules and behaviors to the original form. Each of these rules represents limited vocabulary and produces very recognizable effects, like the 'bend' transformation. However, by compounding even a small number of simple transformations, the forms' complexity and design possibilities are growing exponentially and escape predictable visual patterns. The phenotypic results of a single transformation may often appear not to change qualitatively its resultant form, but the transformation is still present in its genotypic definition of an object waiting to emerge. This dormant transformation may be later responsible for a rapid emergence of the form/design once other transformations are applied leading to complex and sophisticated forms. This rapid form emergence results from narrowing the difference between the phenotype and genotype potentials.

Studio Theme

Students were given an existing architectural environment and asked to design a space that could be a home, a workshop and a museum. However in this case, we were not looking to design a generic multipurpose space that could accommodate all three program components simultaneously. On the contrary, we were looking for three separate, highly specific, idiosyncratic spaces. Although sharing some common threads, each space would have a unique character. Later, we looked into ways to digitally transform these spaces (map one onto another) using their common threads as morphing trajectories and explore 'in-between' solutions that often emerge as 'missing links' in architectural environments. As a result, these three spaces (home, workshop, museum) formed distinct stages of a single architectural metamorphosis not unlike many organisms undergo in nature. One simple analogy in nature would be larva, cocoon to butterfly.

"Out of the Box" Designs

To jump-start the design process, the main studio project was preceded by a sketch problem that focused exclusively on the exploration of advanced **form•Z** and Cinema 4D modeling and morphing tools in context of architectural environments.

For this assignment, each student started with a simple model of a cube (Figure 3) as a set of six bounding square plates and explored its morphological possibilities. These cube transformations were executed with a limited set of software commands—transformations such as bend, taper, bulge, and translations such as move, scale, and rotate using objects' various topological levels.

Figure 3: The original cube given to students.

This singular and directed focus helped students to work exclusively on form related aspects of architectural spaces, while developing an intimate feel for the parametric design intricacies of digital tools. Intricacies that emerge from compounding parametric functions and, in some instances, transformation non-linearity.

The final result was a transformed cubic form-space that offered a visually new architectural reading distinct from the original cube. In addition, students produced a number of animations that investigated the in-between forms. These investigations and design methodology became a foundation for the main studio project.

This preliminary exercise was designed to get students acquainted with digital tools and level out the differences in computational knowledge among them. It helped to develop awareness toward digital technology's ability to achieve innovative results with a limited toolset and fragmented knowledge. This helped to shift students' attention from chasing the "newest and coolest" software features and hiding behind technicalities of digital tools, toward a careful and thoughtful use of these tools as modes to express architectural ideas. It also emphasized the point--while knowledge of computational tools is crucial, it is secondary to students' ability to imagine possibilities and visually judge their digital designs.

Software we were using, **form•Z** and Cinema 4D (the strength of the interface and intuitive modeling commands), worked well in this assignment since I was able to identify and limit my students to a small number of computer tools (commands) while not necessarily limiting their design outcomes.

Figure 5: A transformed cube, by Laura Lister.

The reduced number of tools helped students not only to limit the software's learning curve for the purpose of the sketch assignment, but also helped them to focus exclusively on the design challenge.

Sketch Outcomes

Students followed various design paths, some of them incorporating one or more additional tools to their design repertoire, resulting in a visually distinct architectural language. Laura Lister's cube transformation preserves its identity of individual components, while developing a space with a strong sense of light. It is a relatively subtle gesture, but it effectively redefines the original object's reading. This is how she talks about her design: *"Using the cube as a starting point, I worked to create soft and feminine forms from each side. The mutation of the cube gives a normally rigid object a new life that is reminiscent of robust curves of the female figure. Each piece was given weight and substance to fatten the texture of the object and smooth the harsh lines. The active mutation in the animations gives the cube a more dynamic and romantic character."* (Figures 4,5)

Han Seok Nam experiments with form fragmentation resulting in unique material expressions. While animating elements' fragmentations, one observes the emergence of textual qualities out of smooth forms. (Figure 6) This excises introduces an interesting ability of fragmenting transformations to populate design with newly emerged geometries. At the same time, Hye Young Yoo is pursuing a fluid space as a result of mesh displacements with chaotically behaving functions. (Figure 7)

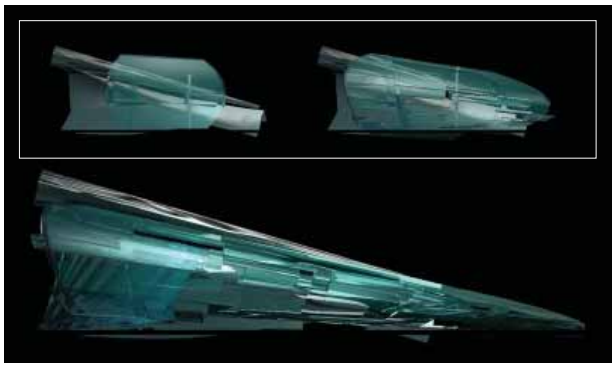


Figure 6: A texture emerges from a surface transformation, by Han Seok Nam.

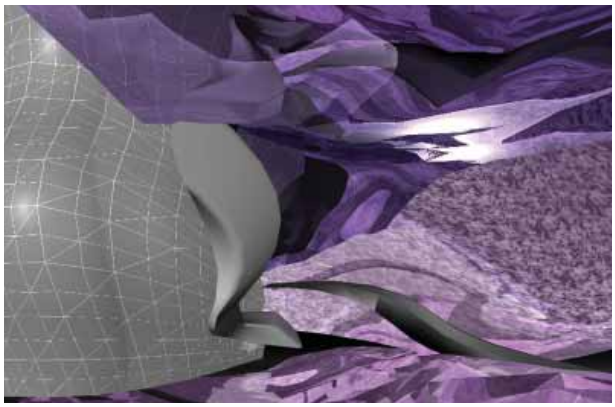


Figure 7: Orthogonal forms are no longer recognizable after the introduction of random functions, by Hye Young Yoo.

Figure 4: The stages of a cube transformation--top view, by Laura Lister.

All the above examples were successful in achieving a purely architectural reading, both as an object and as a spatial experience. However, the same method can be extended to other virtual designs used to develop virtual landscapes as well as sculptural forms (Figures 9,10). Illustration 10 shows an evolution of an original cube into an organically behaving form. These cube transformations while shown here with still images are best experienced and judged with animations where one can observe not only a progression of an evolution but also dynamism, rhythms, and punctuated blossoming of forms. In seeing these animations one quickly realized that, while we often speak about design continuums, interesting solutions are distributed randomly and often emerge unexpectedly. There seems to be gravity to the distribution of design solution that becomes evident once these solutions interpolated with animation tools.

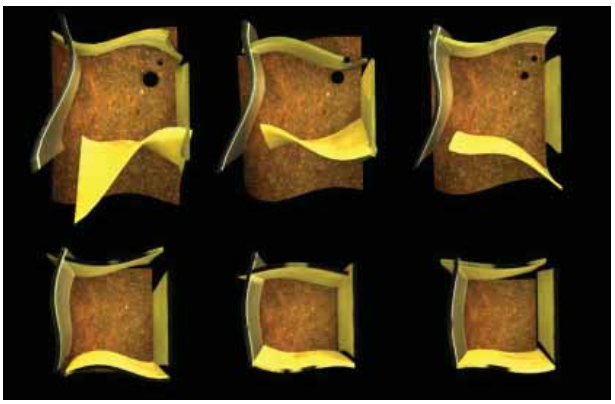


Figure 8: The stages of a transformed cube—reflected ceiling plan, by Amy Song.

Figure 9: A transformed cube with light as a space positioning device, by Andrzej Zarzycki.

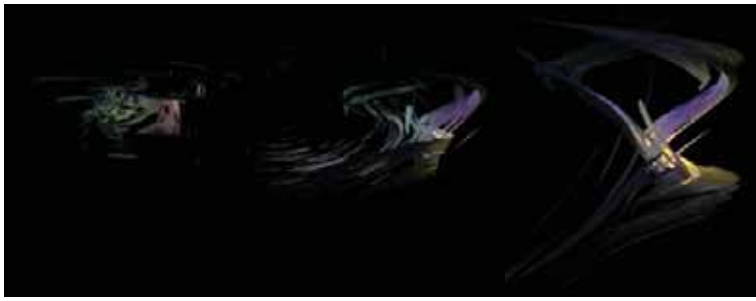


Figure 10: Three phases of form emergence, by Andrzej Zarzycki.

Lessons Learned:

We learned from this sketch assignment that the combination of simple transformations such as bend, twist or taper; combined with tools like move, scale and rotate operating on various topological levels became a potent and effective way to derive sophisticated designs. Design complexity emerges from a relative small number of transformations and rapidly escapes predictable visual patterns. It is the way these transformations are being applied not necessary a number of them that has a decisive impact on form characteristics. In most cases, the order of applied transformations is critical. Different orders will produce different products.

There is a subtle but direct connection between the form of an object and its texture—facture. In this use of the term, texture is not a material bitmap associated with an object but a three-dimensional surface topography. Form and facture are two scale polarities of an object's continuum in a similar way as physical objects are in nature. In digital environment facture (texture) is related to tessellation and lower topological levels such as points, edges and faces. Finally, the sketch became an opportunity to discuss the conceptual framework behind morphing and form emergence as well as a look at precedence in other creative disciplines.

Based on these observations, we were able to postulate some broader implications of transformation-based design methodology and apply them to the main studio projects.

Toward Transformational Design

Since change and transformation become the norm and basic building element in the creative process. The new set of instructions is necessary to direct these design agents. These instructions may involve simple form transformations and topological changes including object discontinuities as well as exotic entities like meta-formz or particles. These objects respond to dynamic and kinetic [1] stimuli and often are associated with behavioral properties. These behavioral properties allow for the interaction between ob-

jects. For example, particles can respond to gravity, friction, as well as other objects. Emergence of these new design agents was welcomed by students who quickly adopted them into their design concepts. The meta-particle experience examines spatial transformations resulting from particle dynamics associated with material and light changes (Figure 11). The spatial enclosures, while continuously changing, are further realized through morphing material characteristics such as fog to air to glass. In another project, animated meta-objects (meta-formz) are used to simulate spatial variations of the Home|Workshop|Museum design (Figures 12,13).

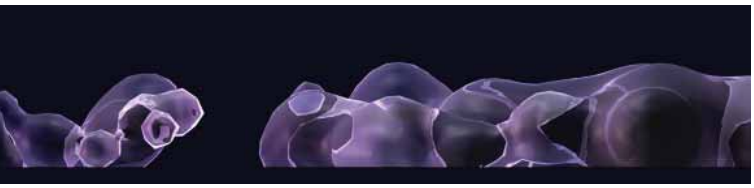


Figure 11: Metaball-particle evolving forms, by Nick Brunetti.

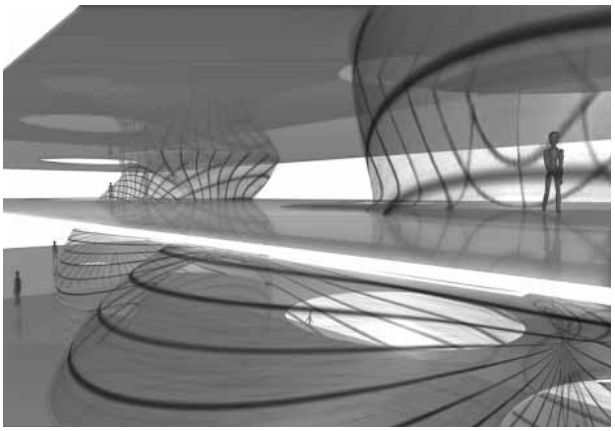


Figure 12: An interior perspective of a museum space, by Kazy Umeki.

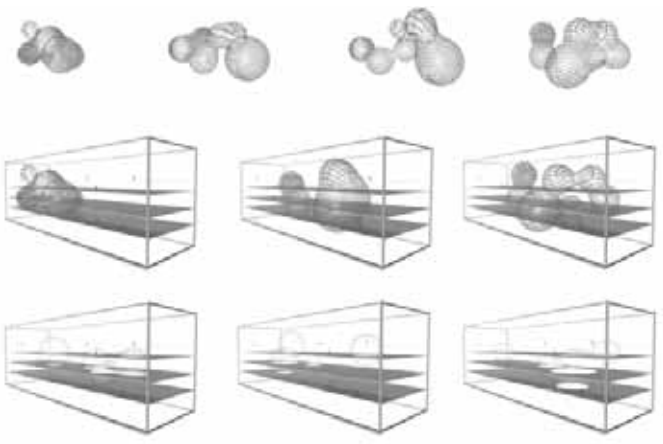


Figure 13: Stages of metamorphosis, by Kazy Umeki.

Figure 14: Museum spatial trajectories, by Han Seok Nam.

Design Versus Context

With an introduction of animation into design, two classes of transformations emerge: form and space deformers. Form deformers change the object's geometry, which is a permanent change even if it only exists for a short period of time. This new form is an attribute of an object and is not location dependant. Form deformers are reacting only with particular objects and do not interfere with other objects that are in the same locality.

Space Deformers, also called Space Warps, are the properties of space and affect any object that is within a space unless specifically excluded from the operation. They allow transformations that are only relevant to space or context not, a particular object. Furthermore, their influence is location-in-space related, which means that the form of an object is dependant on the location within a space warp and will change if the object is moved. This distinction, to form and space deformers, is particularly applicable for architecture since space deformers can be seen as the design context or environment. Ability to assign properties to space, not much different than in real life, allows for a global and holistic treatment of design. It also creates favorable conditions for the simulations of form mutations and dynamic systems.

Other Morphing Approaches

A classical morphing method is similar to parametrically driven tectonic interpolations and extrapolations. It relies on two parent objects as "genetic" sources with the new resulting form being placed somewhere in-between parental phenotypic characteristics. This design approach was under utilized in the past because of the limitations of digital software placed on parental forms. In the past, both parental forms required the same number of vertexes in order to be morph-able.

The only pragmatic way to achieve both parent objects having the same vertex number was to take one of the original forms and transform it into another without changing the number of vertexes. However, this very action defeated the purpose of the creative use of a morphing tool,

since for a designer to create the second parent object he would already go through transformation and investigate in-between possibilities.

These days, with tools like **form•Z**, we are able to morph between two objects without a concern for topological or vertex consistency. Software does it for us. One could feel a bit uneasy about deferring a small amount of control to the program that does follow a particular procedure and as such could narrow tectonic possibilities. However, I feel that the rewards are greater than possible losses. Perhaps we could hope for some level of control over these morphs by, for example, applying functions to interpolations. While some of these morphs are predictable like a hybrid between a cube and a sphere—we all can immediately tell the outcome, others are less predictable like a morph hybrid between a star and a cube. I often find myself nicely surprised especially in moments when I dare software with more complex objects.

Again, the same rules apply to these morph-based transformations—a complexity and individualism rapidly emerges through compounding simple gesture/transformations.

The Form Future

Introduction of morphing tools into design defines a form as a continuum of all its possible implementations. This new definition sees a form not as an object (being), but rather as a process (happening), which further changes how we qualify the object from its physical properties of shape, etc. to form potentials and capacities. When we say that a form is defined not only by what it is but what it could be, appropriately or not, we relate it to concepts of quantum mechanics where we often say that a particle would travel through all the possible trajectories—suggesting it could be in two places simultaneously. Since form morphing approach is specific to digital creations and emerged through them, perhaps, it reconnects conceptually the products of computational tools (morphing form) with the very physical laws that govern processes on microscopic levels within microchip architecture—quantum mechanics logic. However, this connection is more allegorical than causal, at least at present understanding of computational issues.

Figure 15: A transformed museum space, by Laura Lister.

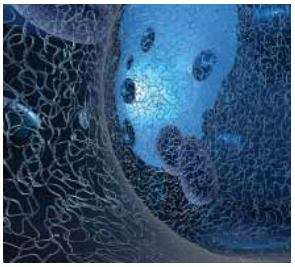
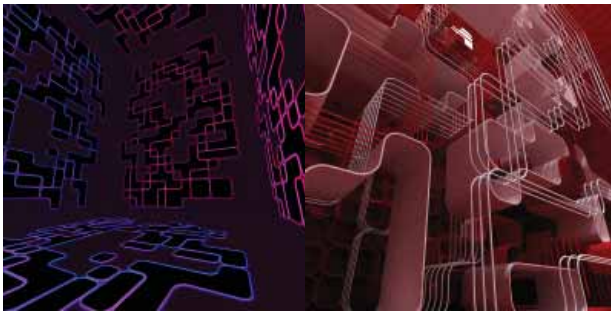


Figure 16: Cell-like space as a metaphor for home, by Hye Young Yoo.



Figures 17, 18: The emergence of forms from shapes; museum space transformation stages, by Sun Kyu Koh.

To learn more on the Formal Mutations topic including theoretical discussion with technical detail as well as to preview digital motion pictures of students' and my work, visit *www.FormalMutations.com* and *FormalMutations* channel on *YouTube.com*.

Notes

[1] "Dynamic" refers to what is routinely called Dynamics and "kinetic" refers to what is called Inverse Kinematics (IK) and Forward Kinematics (FK).

References

George Hersey and Richard Freedman ; Possible Palladian Villas (Plus a Few Instructively Impossible Ones); The MIT Press.

Makoto Sei Watanabe; Induction Design: a method of evolutionary design; Birkhauser 2002;

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Andrzej Zarzycki is a Boston-based architect and educator who employs digital tools to create experiential architectural spaces. He brings more than 10 years of design practice combined with design teaching in the Interior Architecture Department at the Rhode Island School of Design. Research and experimentation is important component of Zarzycki's practice. Since 1996, he was part of the Architecture, Representation and Computation group at MIT. While there, he produced video presentations of Unbuilt Monuments for MOCA, Siggraph, and other venues. At R.I.S.D., he teaches advanced digital design studios. Zarzycki has also published several design process and digital conceptualization essays. His speaking engagements include: *Formal Mutations*; Bauhaus Colloquium 2007; *Cinematic Approach to Spatial Narration*; Build Boston 2006; *Abstracting design, designing abstractions; Use of computer graphics in early stages of architectural design*; Siggraph 2004; *Digital Technology and Design Process*, Build Boston 2001. E: zarzycki@alum.mit.edu | W: www.FormalMutations.com.