Making as a Way to Construct Design Thinking

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INTRODUCTION

In The Craftsman, Sennett argued that engagement with things, tools, and procedures could facilitate leaps of imagination.[1] These engagements are a way to improve qualities of experiences, or the craft of experience, by understanding their forms and procedure, or techniques of experiences. In pedagogy, it is a form of learning-by-doing. Our awareness of the properties of materials, the ways tools perform, and the techniques we work with can help us explore possibilities in transforming a thing into another. In this vein, we are interested in developing a design pedagogy that starts from engagement with things, tools, and techniques. We set design problems that problematized observations, procedures in drawing and modeling, properties of materials, and artifacts. We applied this problem in studios in different years with increasing complexities. Findings from these problems serve as a starting point for designs of habitable spaces. Of interest here is the way students transpose engagements to an artifact, a type of material, or a production technique to generate a design process. What would be teaching methodology to facilitate the growth design thinking in this context? How did students go about finding solutions?

LITERATURE REVIEW

Sennett referred to Arrendt's distinctions between ***animal laborans*** and ***homo faber***.[2] ***Animal laborans*** did somthing for the sake of doing things and concerned with doing things in repetitive and mechanical manners. Conversely, ***homo faber*** referred to the mental and conceptual dimensions that preceded doing. It concerned with reasons, meanings, end goals, and consequences of such actions.[3] Arrendt argued that animal laborans would not understand what they were doing. Against this separation between doing and thinking and privileging of thinking over doing, Sennett argued that doing things could inform and shape the way we think.[4] Desires of doing things well could lead to efforts for improvement, forming a habit of a dialogue between practice and thinking, bridging the hands and the hand. Hence, doing things could turn into a form of knowledge. There are three conditions for this phenomenon to emerge.[5] First, skills are knowledge acquired through bodily practice, repeated haptic, and kinetic encounter with the physical world. Second, as we encounter challenges and difficulties, we try to describe the way we do things to make those more intelligible to us through verbal and visual languages, which could lead to imagine ways to do them better. Third, the development of skills benefitted greatly from sustained efforts rather than talents.

This argument of learning-by-doing could be mapped to the theory of experiential learning. Kolb argued that human acquired knowledge through experiences.[6] This process occurred through a repeated cycle of experience, observation and reflection, abstraction, and experimentations. Our activities formed our experiences, from which we identified findings, hence observation and reflection. The ability to observe and reflect on our experiences was critical since it led to the formation of conceptual models, hence abstraction. We experimented with testing these abstractions, forming the next set of experiences. Experiential learning resonated with heuristic thinking, a mode of problem-solving.[7] The designer would engage in a series of design moves or design decision processes without prior knowledge of whether those moves or processes would lead to successful solutions.

Further, Sennett argued that human beings got interested in changes that we imparted on things and the world around us.[8] These changes occurred through metamorphosis or changes of form, presence, or traces that we left through our activities, and anthropomorphism or imbuing values to those changes. Metamorphosis happened in three ways; the first was the evolutions of generic objects, such as varieties of typologies of houses or household appliances. The second was the conjoining of two or more different elements that led to a new thing, such as fusions of different minerals or metals that led to the inventions of glass or bronze. The third was domain shift, applying principles from one domain to different ones. Our ancestors learned to weave threads to create fabric, yielding a principle of tight connections of vertical and horizontal at a right angle. This principle transposed to connect two-piece of wood yields a mortise-and-tenon joint. Further, it informed the grid layout of ancient cities. It was a domain shift from weaving to carpentry to city planning.

The way Jean Prouve worked set an architectural precedent. Damisch pointed to the distinctions between an engineer and a bricoleur.[9] An engineer develops a plan to govern the design, including the elements and their relationship to the overall system. A bricoleur works from elements they encounter and then proceed to find ways to assemble them. The engineer mode was comprehensive and top-down, while a bricoleur

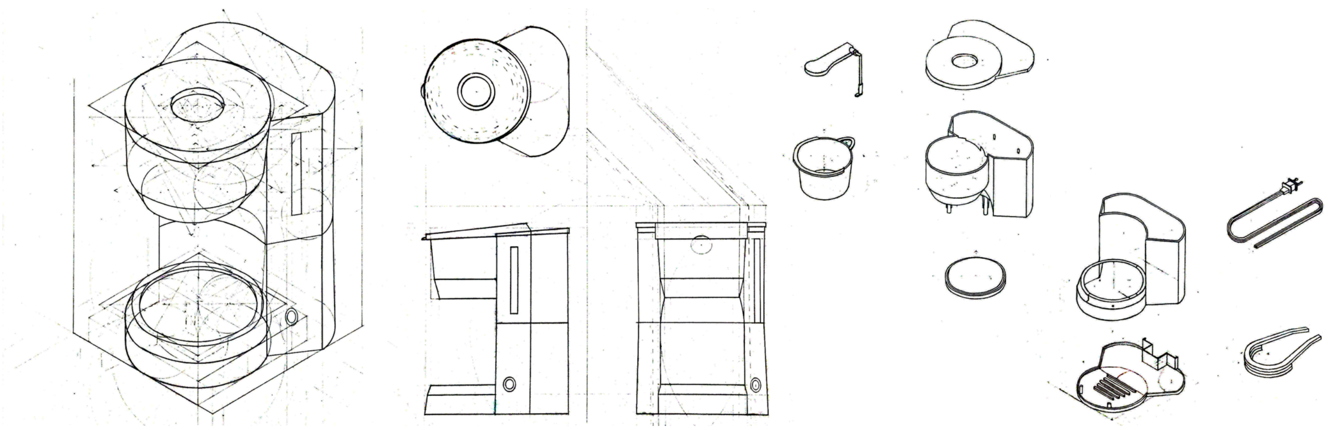

Figure 1. Observation - Manmade Object (student: Kathryn Folger)

was incremental and bottom-up. Prouve started by learning and observing the manufacturing of metals, including bending and folding sheets of metal, fabricated metal parts, and ways to assemble. This understanding informed the ways Prouve designed his buildings, starting from parts to form the whole, instead of starting from an overall idea that would govern every aspect of a design. Indeed, Dahmisch argued that this was Prouve's contribution to design thinking, problematizing the relationship between parts and the whole.

METHOD & MODELS

The method of inquiry for our pedagogical approach of linking making and thinking centered on first- and third-year studios, allowing for increasing complexity of design problems and opportunities to analyze outcomes. Of interest here is the way students transpose engagements of an artifact to generate a design process. In both cases, we distinguished operative rules, a set of procedures to execute a task, from generative rules, rules to organize design elements, including ordering systems.

FIRST-YEAR STUDIO OBSERVATIONS | ARTIFACTS | CONSTRUCTIONS

The exercise covers a two-semester investigation broken down to a series of modules; observations, artifacts, materials, and tools, all leading to final built constructions. In the fall semester, students explore and document textures of surfaces and then use their findings to generate a design, translating two-dimensional phenomena into three-dimensional constructs. Students learn to work with tools in the woodshop using the properties of materials and tools to inform their design decisions. In spring, they continue learning in the woodshop, focusing on basic techniques in joining wood. They analyze patterns to understand the morphology and extract structure as repetitions of basic elements following a set of rules. They observe, document, and then regularize, identifying essential elements from the surface phenomena, articulating the rules that govern those elements to generate their iterations.

MODULE 01- OBSERVATIONS

This module challenges students to learn through seeing. The intent is to translate three-dimensional to two-dimensional and then back to three dimensions. Students transform observations to drawings applying filters to reinforce further the notion of abstraction and methods of extracting information. Students learn a method of distilling views into lines and planes. Short lines capture shapes, while long continuous lines build up the scene. Charcoal drawings allow tones and shades to document planes. These drawings became the basis, providing a model of how to extract elements and develop rules. For instance, short lines could be translated into planes, long continuous lines into ribbons, while planes could be folded. Rules emerged as actions, push-pull, extrusions, lofting, and folding. Drawings were translated into models looking at the spaces created. Students learned that the result was not the form, but the cavities inside the models.

MODULE 02 - ARTIFACTS

The next module moved beyond phenomena to more tactile objects; specifically, students observed hand-held objects that are easier to measure, allowing for a more close, intensive engagement. The goal was to introduce the notion of morphology by identifying or extracting the formal structure. Following an inductive logic, students generated basic shapes from their observations. Diagraming and orthographic projections provided the scaffold for representation and understanding. They must understand the morphology from their observations as the notion of order is extracted and discussed. Alignment, proximity, modularity, and similarity represent transformations in the morphological studies as a starting point of a design process.

Further refinement of the structure continues with ideas of axis, hierarchy, and repetition. As the drawings develop, the process of moving to 3D begins with sketches to speculate on the geometry which the students build physically. The model is used as a framework to measure and introduce proportionality. Students constructed axonometric drawings to connect

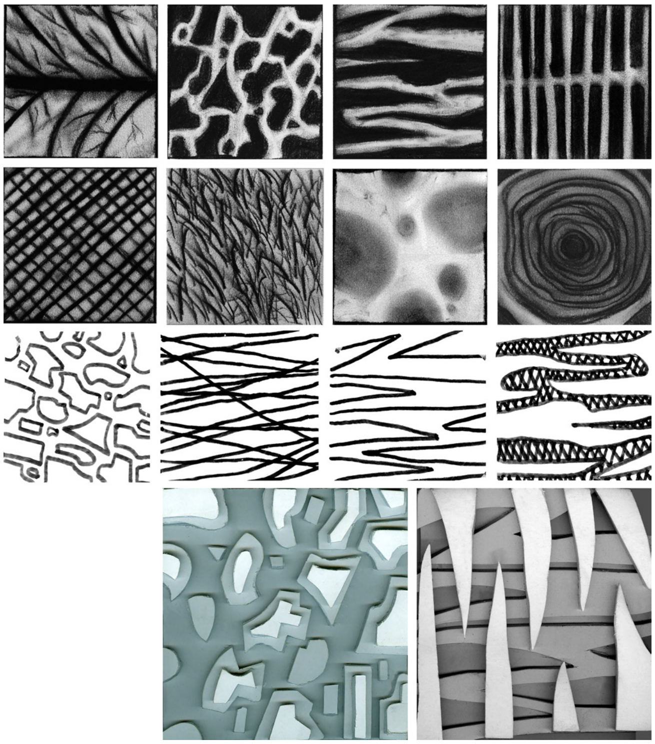

Figure 2. Deciphering Phenomena (student work: Sam Walden)

and visualize three-dimensionality. The project concluded with a presentation of the models, diagrams, and measurements used to produce representations.

MODULE 03 - TEXTURE AND CARVING PROJECT

Module 3 is a hands-on approach to learning about tools and materials that starts with the students in the woodshop. Students experiment with manual and powered tools to understand how the tools interact with the wood. They question the strengths and limitations of both tools and materials and try to understand their specificity. After experimentation, students are charged with transforming drawings to wood tiles. The intention is not just to replicate but to decipher the drawings, to translate their diagrams to capture the elements and rules into a set of instructions.

Different line weights lead to different cuts. Planes provide the logic for cutting depth and layering. As the exercise progresses, students expand on these ideas, replicating the tiles from one tile to three, first extending along one axis and then extending along two axes going from three tiles into nine tiles. They reflect on how the transformation affected the material. What effects did the carving process create with light and shadows, transparency-translucency, or even changes in the visual density of the material from hard to soft? Much attention centers on creating a dialogue between the geometry, tools, and materials.

MODULE 04 - JOINERY PROJECT

Within the joinery project, students learned the basics of flat and corner wood joints. They applied these techniques to create flat-panels and cube-shaped artifacts. Following their diagrams as precedent, they expanded and transformed their original ideas into more significant artifacts. Again, they are required to reflect on the effects created by the joinery over a series of iterations. The first iteration requires the use of all the joints learned to assemble four tiles into a flat object. The second iteration requires students to explore two joints to create a box or a W-shape. The third iteration requires twelve tiles to create a 3-dimensional artifact. The artifacts as constructs help to reinforce their ability to produce design responses. At the same time, the hands-on engagement in the woodshop serves as an armature for inquisitiveness, allowing students to explore the ways properties of tools and materials can inform design iterations.

FINAL MODULE: INTEGRATION

The final module integrates learning experiences from each module to construct a personal (fall) and a multi-person space (spring). In the personal space, the artifact and the drawings, both orthographic and paraline drawings, served as the starting point, meaning the formal structure from these drawings would inform initial design moves. The habitable space used geometric shapes linked back to the earlier module while planer elements, were used to generate and define the enclosure of the personal space. The spring semester asked students to integrate their explorations of joints, flat panels, and volumetric artifacts into a multi-person space. Crucial to these modules is the understanding that design problems are multi-layered problems. First was the transformation from three- to two- and back to three-dimensional. The second layer was designing from a part to inform the whole. The third layer was the integration of effects created by the elements and the transformation process. The goal is to develop the skills and ability to create a method for the design process.

THIRD-YEAR: INTERACTIVE INTERFACE

The third-year studio addresses the issue of ecological, urban, cultural, and economic sustainability of the built environment. The increased emphasis on façade performance and issues of sustainability, contemporary façade systems are increasingly designed with greater interactivity and responsiveness to the environment. The studio project investigates the connection between kinetic systems and a building enclosure to more effectively respond to issues of solar shading, thermal comfort, and energy generation. The facade becomes the interactive interface between inhabitants and the environment moving beyond the notion of a static membrane or a shell. The project followed a similar path as first-year, observation, analysis, and constructions with a compressed time frame of only a few weeks.

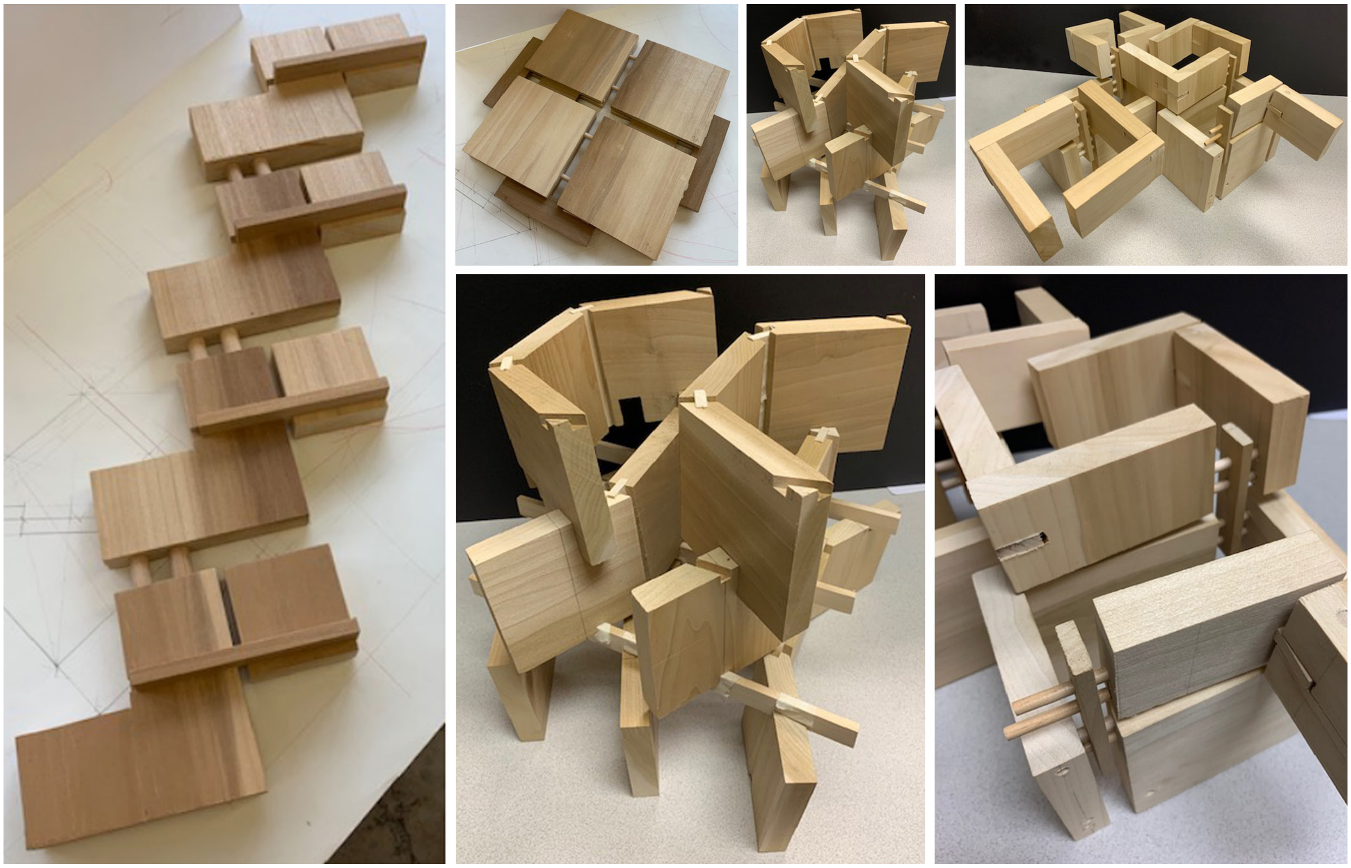

Figure 3. Constructions – Joinery (student work: Erin Machado, Sergio Nino de Rivera, Grant Kennedy)

The exercise ask students to design an enclosure system that is conceptually part of a building façade system. First, they observed kinetic systems defining the typology describing the elements architecturally through drawing plan, section, and elevations. The drawings focused on the five principles of architecture: form, space, program, tectonics, and performance. Analysis of the drawings was vital to understanding and identifying how the systems operated. They analyzed and extracted principles of the elements and organizational structures. This analysis leads to the development of a component piece that would provide the basis for developing the broader framework for the whole system. Conclusions provided a synthesis of the information gathered, resulting in a module that incorporated various technologies, materials, and devices in the design of the building's skin.

FINDINGS AND DISCUSSIONS

The module on observations introduced abstractions, guiding students on what to observe in seeing and what to document as drawing. In translating these drawings into models, the default mode was to create forms. Looking into cavities inside the models using camera and class discussion of those images facilitated the introduction of the notion of space-making. Students started to discover by themselves lines and planes as space-defining elements, hence abstract principles of space-making. Challenges from this module included developing the ability to distance from pre-conceived notions in observations, such as the name of the object and its associated ideas, drawings, and making models. Once students were able to grasp these notions, the development in drawings increased significantly. Hence, the repetitions of similar exercises were crucial. Also, the introduction of vocabularies of spatial conditions, although very helpful in stimulating students to start conceptualizing space, proved to be challenging. Direct engagement with the objects furthered the notion of self-discovery of formal properties and structures. Some students achieved this objective immediately, while others took time. The understanding of the morphology of an object helped them tremendously in constructing various types of architectural drawings.

The module on the texture, carving, and joineries, played out in a slow pace since handling tools and materials took up a significant amount of time to allow for students to acquire a degree of familiarity. The degree of comfortability with procedure, techniques, materials, was crucial in setting up the stage for experimentations. However, the slow pace allowed for more extended observations and reflections of the engagements with tools and woods. Reflections through class discussions allowed students to develop an awareness of technical possibilities of tools and materials and to improve their skills. The understanding of constraints and limitations of

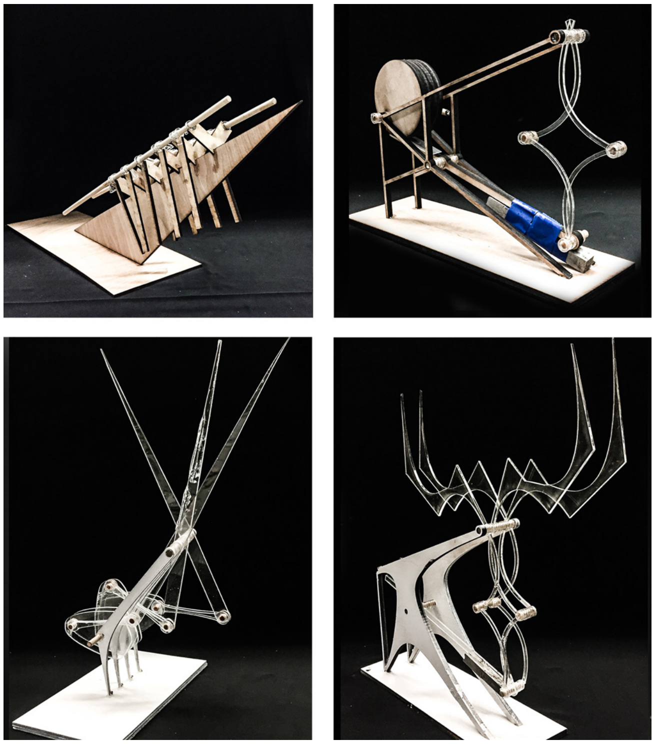

Figure 4. Artifact Study Models (student work: Noah Bieber)

tools, techniques, materials, and time became an integral part of the process of formulating design intents and form-generating principles. For example, they transformed design features, such as geometry, scales, and order, based on those understanding in the joinery project. Students also learned ways to handle challenges: working with or fighting against them. Some students kept on instilling their designs, regardless of the time taken or the difficulties with tools and materials. Other students evolved their designs, changing geometry to take advantage of tools and procedure, incorporating properties of materials, or changing types of basic joints. These design moves turned constraints and limitations into a set of design opportunities.

The value of experimentation appeared most clearly in unexpected results of engagement and explorations with the tools, materials, and techniques. In the texture project, students discovered new patterns of lines and colors as a result of the carving techniques, which they incorporated in subsequent iterations. Another finding was the effect of lights, opacity, and transparency. Closeup photographing of the joints allowed students to re-calibrate the scales and re-imagine as a building element. The power of metaphor helped students to make a leap of imagination in developing design thinking, imagining textures as topography, perforations as openings in buildings, gaps in joineries as a point of entry, or building aperture. These experiments and reflections led not only to the discovery of well-established abstract principles, such as geometry and order but also personalized findings. Challenges surfaced as students internalized the properties of tools, techniques, and materials, to inform design intent and create form-generating principles. Language, such as metaphor and analogy, helped to facilitate a domain shift and leap of imaginations.

In the final module, self-discovered abstract principles and associations, including metaphor and analogies, provided a path to develop design moves and decisions. The former provided a scaffold for scale increase and dimensional transformation of the formal structure of the objects. The process of experimenting through making small-scale study models allowed students to discover techniques of space-making and spatial organization. Words on spatial conditions of observations of models helped them to articulate their ideas of space. Desk critiques became a means to reflect and extract abstract principles in space-making. However, the challenge of comprehending the logic of abstraction resurfaced as some students struggled in playing with this abstraction. Some students still latched into pre-conceived ideas of the object, instead of sticking to the morphology. However, in some cases, pre-conceived ideas, such as the object's function, could help in developing metaphors or analogy to formulate an idea about a specific spatial condition. This metaphor sharpened design intents, which leads to more elaborate design principles. The integration of texture and joints into the task of space-making focused on recreating and elaborating effects and phenomena that created by the texture and joint artifacts.

Within the third-year projects, the process of observation translated to artifacts through prototyping provided the students with a good grounding in analyzing and developing strategies for kinetic envelope systems. Following the same methods as first-year allowed students to deciphering the formal structures in their artifacts to find the embedded logic. Iterations in the analytical drawings lead to many permutations and scaler transformability. As students reflected on their design moves, they discovered the possibilities and potential for their enclosure systems in relationship to the human body and spatial experience. For most students, the process remained on the surface as the building outcomes showed less spatial understanding than surface treatment.

In terms of moving from operative to generative rules, we instilled the discipline and habit of following proper procedure in constructing drawings and models in order to build up their skills and aptitude. However, we designed the studios and structured our teaching deliverables to go beyond perfections in executing a procedure. We utilized these procedures to stimulate the thought process by developing design problems around the questions of "what if." For example, the brief challenged student to transform lines in drawings by pulling, pushing, or extruding them into three-dimensional space. In this line of thought, Setiawan, in discussing the formulation of design intents and structuring design moves, proposed a distinction between methodical and axiomatic thinking.[10] Methodical thinking was a thought process that applied rules and principles, which were often exported from externalities. Axiomatic thinking problematized fundamentals in design that allowed for the formulation of new rules and principles. This

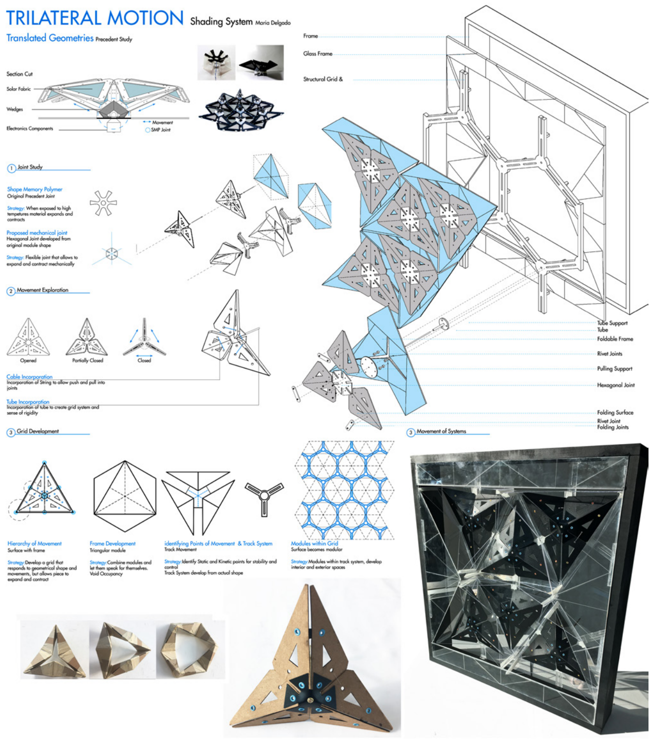

Figure 5. Trilateral Motion (student work: Maria Delgado)

concept applied to design learning, methodical thinking was a repetition of a set of formal procedures, while axiomatic thinking was critical of fundamentals in design. These studio exercises attempted to instill the habit of problematizing findings from various design moves and encouraged students to discover rules and principles by themselves.

PEDAGOGICAL CONTEXTS

Salama categorized four models of design pedagogy that appeared historically.[11] The first was the academic model that emphasized formal concerns, including the notion of beauty, and theories of composition. The second was the craftsman model that focused on the proficiency in building trades and concerned with practical sides of architecture. Similar to this was the engineering model, which integrated technology and scientific principles into design thinking. The last was the social science model that focused on the users of design. Historically, modern pedagogy in design originated from the Ecole-des-Beaux Art, the Vkhutemas, and the Bauhaus.[12] The pedagogy of the Ecole emphasized the academic approach to design, focusing on formal design principles. It also institutionalized the model of master-apprentice. Vkhutemas aimed to develop new design principles based on novel techniques and materials and to integrate rational thinking.[13] It viewed the design studio as a laboratory searching for new forms. The Bauhaus turned to craftsmanship, developing design thinking from engagement with materials and techniques. We develop our pedagogy in the spirit of learning-by-doing and studio as a laboratory.

Surveying design pedagogy, Salama identified ten pedagogical models that emerged from the late 1960s to the mid-1990s.[14] In mapping and contextualizing our pedagogy, we found resonance with the Concept-test Model.[15] It was based on Jean Piaget's thoughts of learning as a developmental process that connected conjecture and testing. The premise of this model was the role of drawings or models as a means for testing and evaluations. It subdivided studio projects into small design problems; the results of each would inform the whole project. Some of its characteristics included starting each exercise by producing something to be tested, incrementally delivering information, and using analyses of tests to formulate strategies in form-generations. In the development of architectural design pedagogy from the late 1990s till mid-2010s, one of the growing interests was the integration of critical inquiry and empirical approach in constructing design studios.[16] Salama cited Kevin Mitchell, who advocated critical thinking that is discipline-specific, in which inductive methods and practical inquiry informed a pedagogy that aimed at cultivating independent inquiry.[17] This mode provided a scaffold for students to discover and unpack abstract principles from real objects or applications through analyses. This approach related well to learning-by-making, which has a root in heuristics learning.[18] Hands-on learning reflected in the emergence of learning-by-doing or learning-by-making as a pedagogical model in architectural education. Instead of developing design in conceptual terms, this model approaches design education in interactive ways, linking conceptual thinking with experimentations with materials and techniques.[19]

CONCLUDING REMARKS

In analyzing the outcomes, we admit the bias, both in the artifact and space. First, the importance we place on "making" as the means to investigate each problem and the particular dialogue developing between procedures and critical reflection, including diversity, in every aspect, thinking, making, interests, culture. Second, is the bias on operative rules and axiomatic thinking. Our emphasis is on making offering a way to transform operative into generative rules and from methodical into axiomatic thinking. This approach aims to foreground the agency of students to take significant role in shaping a design.

ENDNOTES

1. Sennett, R. (2008) ***The Craftsman***. New Haven, Yale University Press
2. Ibid., p. 7-9
3. In architecture, it would be analogous to the distinctions between architectural design and constructing buildings. Architecture defined design as a mental and conceptual activities producing plans for building in the form of drawings and models, while activities in constructing buildings, such as laying brick or pouring concrete, could be considered simple as repetitive, mechanical work.
4. Sennett, R. (2008) ***The Craftsman***. New Haven, Yale University Press, p. 10-11
5. Ibid., p. 10-11
6. Kolb, A., Kolb, D., (2014), ***The Kolb Learning Style Inventory 4.0: A Comprehensive Guide to the Theory, Psychometrics, Research on Validity and Educational Application***, 2014. P 6-7 https://learningfromexperience.com/downloads/research-library/the-kolb-learning-style-inventory-4-0.pdf accessed Oct 13, 2019
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10. Setiawan, A., (2010) ***Modernity in Architecture in Relation to Context***. Ph.D. Dissertation, Atlanta, Georgia Institute of Technology, p 235
11. Salama, A., Wilkinson, N., "Introduction" in Salama, A., Wilkinson, N, ed, (2007) ***Design Studio Pedagogy: Horizons for Future***. Gateshead, UK, The Urban International Press, p. 4-5
12. Salama, A, (2015) ***Spatial Design Education: New Directions for Pedagogy in Architecture and Beyond***. New York, Ashgate (Kindle ed.), p. 59-67
13. See also Cooke, C., "***The Development of the Constructivist Architects' Design Method***," in Papadakis, A, Cooke, C, Benjamin, A., ed. Deconstruction: Omnibus Volume, New York: Rizzoli, 1989, p. 21-25
14. Salama, A, (2015) ***Spatial Design Education: New Directions for Pedagogy in Architecture and Beyond***. New York, Ashgate (Kindle ed.), p. 119-41
15. Ibid., 131-33. This model was developed by Stefani Ledewitz at Carnegie Melon since 1985
16. Ibid., 175-78
17. Ibid., 175
18. Ibid., 180. An example of this approach in Salama's book was from Ryan E. Smith who proposes a design process that started from construction of an artifact then unpacking it through multiple architectural means. Smith referred to Peter Zumthor' argument that a design process should start from "physical, objective and sensuous examination of architecture, its material and its form."
19. Ibid., 243, An example that Salama cited was the teaching of Jeff Haase from OSU, Department of Industrial, Interior, and Visual Communication Design. Haase points out that through this model, students also contribute in producing knowledge and they became more well-rounded, equipped with conceptual and physical aptitudes.