From Beginner to Experienced: Computing Designedly Form with Visual-Spatial Schemas in Basic Architectural Education

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"I start from some aesthetic experience which in my world I do through various games I play with some rules that I set up a long time ago and which has been transformed since. But I know what I am doing, and as I try and develop that, I ask questions which take me back into, if you like, a reflective mode."

Lionel March, 1996 ***To the memory of Lionel March***

In the early years of their education, beginner design students simultaneously develop various perceptual and intellectual skills. Their learning goals in the first years are primarily focused on composition and basic design: to increase skill in recognizing perceptually what design elements they are seeing, and to understand how these elements come together in their ongoing compositions. As students improve in the hands-on activity of composing, learning goals begin to expand to include inquiries about process, creativity, imagination and style: to understand what it means to be creative in processes and products, to improve imagination in and through each design iteration, and to start developing individual style through understanding what resonates viscerally and intellectually with them.

In this quest, the integration of computational design methods – here specifically the shape grammar theory and formalism – can provide beginner design students a procedural and rigorous, yet open-ended and indeterministic framework to formulate design processes. It can rigorously guide them in introspecting into their own design sense and becoming reflective in their practices (Schön, 1983). In this framework, this paper discusses the teaching of visual-spatial design as the teaching of artistic and designerly processes understood computationally. Computational design theories structure holistic design processes into algorithmic steps, which are also designed by the designers themselves. In a computational design process, each step corresponds to a design action that designers take – a frozen moment in the temporally continuous design activity. The continuum is punctuated by the analog or digital application of rules. Rule applications momentarily and temporarily discretize the process, which then again resumes in an open-ended manner.

This paper elaborates on creative and imaginative situations in the design process that were especially highlighted by basic visual-spatial schemas through three case studies – three student projects in the beginner architectural and landscape design studio run at the Wentworth Institute of Technology (WIT), Boston, MA in Fall, 2016.[1] In the development of these projects throughout the semester, design reasoning was systematized, either by the student, collectively in the student-instructor conversation or by the instructor. The development of form, use and structure can be traced with these recordings and field notes. The rules and schemas capture students' explorations in form – partly from their verbal or visual statements, or explicitly schematic statements, and partly from the eyes of the instructor. Hence, the notes also record the desk conversations and critiques that arise in this interaction. This paper also posits that these specific didactic (learning) moments constitute the fundamental skills to be developed in architectural design and landscape design, and that these didactics can be captured by visual schemas (Stiny, 2006; Stiny, 2011; Ozkar, 2011; Arpak, 2016).

Visual and Spatial Schemas at Play

Design understood computationally through shape grammars involve a basic knowledge of visual rules, visual algebras, Boolean operations and visual schemas (Stiny, 1972; Stiny, 1976; Stiny, 1990; Knight, 1994; Stiny 2006; Stiny, 2011; Ozkar, 2011; Economou and Kotsopoulos, 2014). Visual schemas are generalized groupings of visual rules; in other words, schemas encompass and group various kinds of rules. In this paper, I refer to schemas as visual-spatial schemas to highlight the spatiality in architectural design and computation. While visual-spatial rules are specific and, as highlighted, apply visually or spatially, the schemas are generalized abstract classifications of types of rules that are articulated in traditional algebraic expression. We can formulate a step in a design process and articulate design reasoning in the form of schemas. By combining and composing schemas, we can explain a design structurally or a design process itself algorithmically.

Stiny identifies several schemas that lie at the core of artistic and designerly endeavor (Stiny, 2006; Stiny, 2011) and they capture experiential, perceptual heuristics and operational knowledge therein. Correspondingly, Oxman (2000) recognizes a design schema as "a visual form of generic design knowledge" and Ozkar (2011) postulates that "foundational design knowledge" can be conveyed through visual schemas. As highlighted by many, like Ozkar and Derek Ham in his talk at the NCBDS 2018, we already represent this knowledge in the design studio by talking and pointing at shapes and form. Ethnographically traced, we also have particular words that we use to represent perceptual and operational knowledge. These words and verbal expressions are currently the language of our reasoning, talking, explaining and providing feedback. We can incorporate the algebraic expressions into this language, opening design reasoning to mathematics and computation. As Ozkar stresses (2011: 114), talking about design in a formal manner through computation "helps the student to observe what they are doing, to accommodate it within one's own sense and to develop it further" and the means for it are fundamentally visual rules and schemas. Some of the specific schemas that are discussed in this paper are as the following, the details of which are elaborated through the case studies in the following section:

Schema a: $x \rightarrow x$

[1] The architectural and landscape design studio – ARCH 2000 Studio 03 – was taught at the sophomore level at the Wentworth Institute of Technology (WIT), Boston, MA in the Fall semester of 2016-2017. The studio was led by professors Lora Kim and Meliti Dikeos and taught together with the instructor team Asli Arpak, Myrna Ayoub, Bumjin Kim, Jack Cochran, Michelle Hobbs and Elen Zurabyan.

Schema b: $x \rightarrow t(x)$

Schema c: $x \rightarrow x + t(x)$

Schema d: $x \rightarrow \sum t(x)$

Schema e: $x \rightarrow div(x)$

Schema f: $x \rightarrow prt(x)$

Schema g: $x \rightarrow prt^{-1}(x)$

In their basic design reasoning, students often follow a fundamentally additive, subtractive or divisive manner as they compute with form. The design process often starts with the generation and identification of some geometry. This step can also be described with the identity schema $x \rightarrow x$ (Schema a), which we often refer to as the "identification" or the "articulation" of shape or form. After identifying shapes, students start to compose with them. A common strategy here is to create a number of copies of that shape and move them. This step can be algebraically expressed as $x \rightarrow t(x)$ (Schema b), a shape goes to a translation of that shape, in other words, is subjected to a Euclidean transformation. If we have one copy of the shape, we can add the two shapes up with $x \rightarrow x + t(x)$ (Schema c); if we have multiple copies, we can create a sum of all the shapes with $x \rightarrow \sum t(x)$ (Schema d). After creating a composition with additive reasoning, some students move onto a divisive reasoning to create new shapes and create increasingly finer articulations. On the other hand, some students directly start working with the schema $x \rightarrow div(x)$ (Schema e), after determining a broad outline (perimeter) for their buildings. As we write and re-write rules, we take parts of shapes and complete missing parts of shapes by using $x \rightarrow prt(x)$ (Schema f) and $x \rightarrow prt^{-1}(x)$ (Schema g).

In this line of thought, I elaborate that these schemas are representative of the foundational design skills that a beginner design student is expected to develop in their first semesters of pursuing architectural projects. Ozkar (2011) has elaborately shown the articulation of visual rules and schemas in basic design education, which many design students customarily take in the first year of their education. I further elaborate here on schemas for beginners in the context of architectural design. Students work with abstract form in basic design education, whereas they work with architectural form in the following years in increasing complexity. They learn to gradually translate basic skills into the computation of architectural form, in addition to building new knowledge and insight in that realm. In the following three sections, I exemplify the uses of visual-spatial schemas in three architectural studio projects, especially in computing form in architectural plan and section drawings. With the schemas, I highlight design reasoning and moments therein that were successful in project development and significant in students' learning pertaining to fundamental and beginning design knowledge.

Computing Form in Architectural Plans and Producing Spaces

The ARCH 2000 Studio 03 programmatically asked students to design an ecological sanctuary and situated within that, a conservation and an education center. The site was the historic Chestnut Hill Reservation in Boston, MA, overlooking the Chestnut Hill Reservoir. The studio prompted sequential design exercises "with particular emphasis on site as it related to topography, orientation, and how by thoroughly understanding existing conditions, one could discover how to shape the landscape. Each exercise explored basic spatial, material, structural, and site concepts in the making of architecture."[2]

(a) (b) (c)

Figure 1. Tucker Durant's design iterations

The design idea that Tucker Durant began to explore (Figure 1.a) was a central axis that traversed the site, beginning to organize the spaces and functions attaching to it. This linear progression on an axis from the designated entrance (northeast) towards its connection to the lake (southwest) was an important narrative for Durant. During our desk conversations, Durant's interest landed on a square or square-like geometry for the main functions, which could be articulated in relation to the topography. He began to explore the linear narrative through smaller groupings of form.

Figure 2. Identifying and recording a shape, with the schema x → x.

Firstly, Durant iterated on simple compositions by grouping 4 squares. The simple compositions with squares were explored by producing and recording a set of visual rules and visual schemas. The identification and articulation of a shape – here the square geometry – was recorded by a rule: a square goes to a square (Figure 2), and a corresponding visual schema: x → x. Although this rule may appear redundant at first sight, it is a fundamental schema in which the designer identifies a shape and records the identification as a design step.

Then, a second rule was established: a square goes to a square plus a translated adjacent square with same dimensions (Figure 3). This rule would start to clarify the design vocabulary and start to impose order and logic into the composition. The visual schema utilized here is x → x + t(x), a shape goes to a shape plus a Euclidean transformation of that shape. The rule quickly captured Durant's initial design idea and yielded a successful design through computation, in this case, by the recursive application of the rule we generated. Once we tested this rule, we also discussed variations of this rule under the same schema x → x + t(x), with the same shapes but varying spatial relationships. The Euclidean

[2] Excerpt from the studio description in the course syllabus.

transformation t(x) – here translation – occurs at varying degrees. This formulation allowed us to systematically explore the grouping and observe different design possibilities.

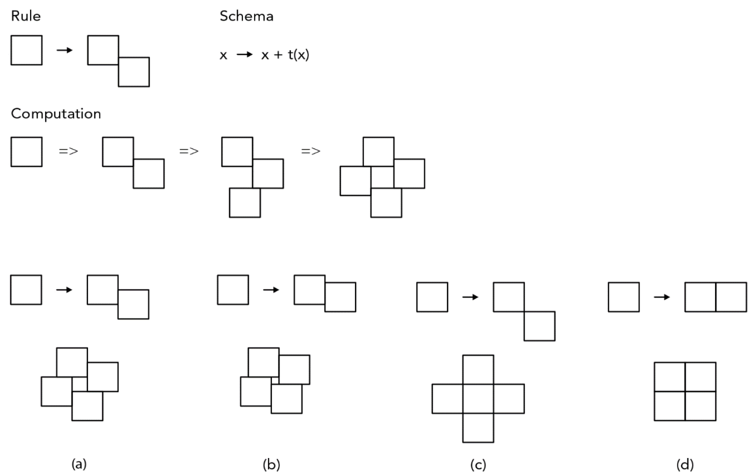


Figure 3. Organizing 4 squares, utilizing varying rules under the schema x → x + t(x), and computing new designs.

In these organizations, we obtained designs by adding squares. However, after a few steps, we observed that many new squares started to emerge. When we applied the rules recursively in a [point] rotational manner, the squares formed a smaller square at the center. We generated various designs by adding the squares recursively, as in Figure 3.a and 3.b; but we also generated many others that utilized the newly emerging squares at the center or elsewhere, as in Figure 3.c – 3.g. While the first batch gave us more ideas about expanding volumetrically or in the landscape, the second batch began to inspire the articulation of circulation and architectural spaces. For instance, the square that emerges at the center, the size of which varies according to the spatial relationships and the rules, could be articulated as a courtyard or a circulatory space. Or, the smaller squares that are connected to two larger squares could be articulated as ramps, stairs or walls.

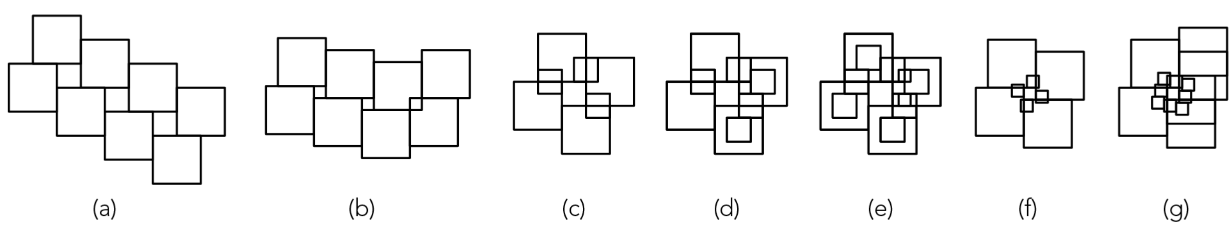


Figure 4. Exploring new designs and seeing new shapes.

After stipulating on this central shape, we also began to see the designs and the generation of these designs differently. A central way the schemas serve us are to be able to redefine our processes, to tap into *algorithmic ambiguity* rigorously and use it creatively in design. In Durant's design, we articulated a central shape as an organizational tool, which holds the potential to govern the assembly of squares (Figure 5). Four squares – architecturally interpreted as spaces – could be organized around this new shape. We did not have this shape beforehand; this new polyline emerged at the center of our design from the initial exploration in the schema x → x + t(x). In addition to giving the new options discussed in Figure 4, it also now organized the design in an alternative way. With the use of the schema x → ∑t(x), Durant assembled multiple linear transformations of a shape into a sum in a step-by-step manner, informed by the spatial relationships the polyline afforded. This polyline reminisces one of the opening design moves in the Chinese ice-ray designs, using different polylines (Stiny, 1977: 97). These particular arrangements that has the cyclic (rotational) symmetry and "locked joint" has been investigated by Earl and Jowers (2015) as the "pinwheel" geometry. The cyclic symmetry manifests with the recursive use of the rules around the pinwheel. The pinwheel can also be understood as a parametric shape, with the square at its center changing its size and the connected lines changing their lengths (Figure 5.b – 5.e).

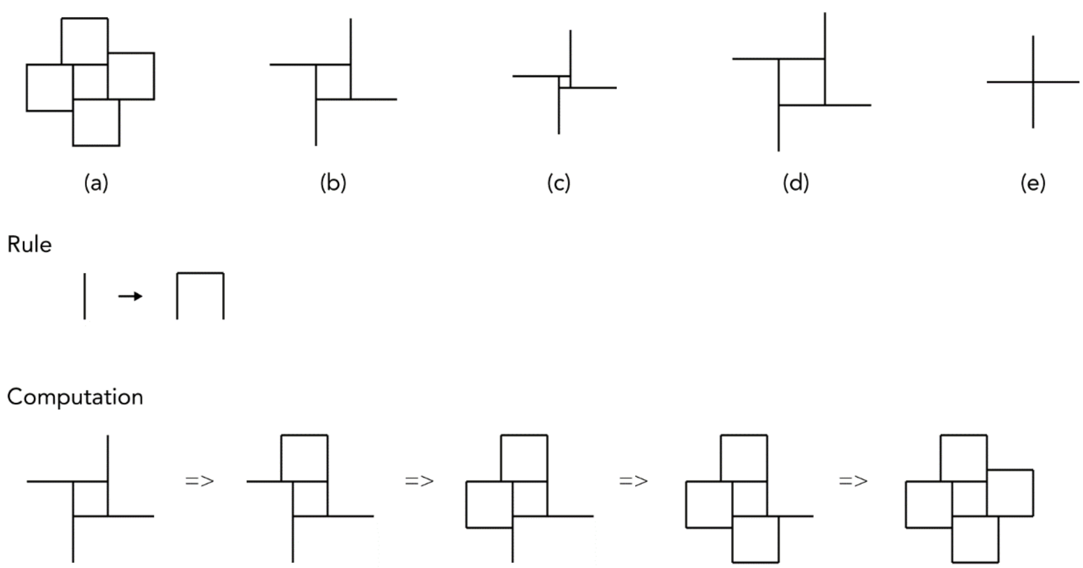


Figure 5. Investigating the pinwheel polyline as an organizational tool.

Similar computations were carried out by Durant on groups of 3 squares, this time exploring the composition with the organizational tool of another polyline that features an equilateral triangle at the center (Figure 6). He decided that 3 square clusters lent themselves better to accessing the view at the specific site and produced interesting local conditions in their conversations with each other and the topography. He continued this exploration with the use of a now more familiar shape and familiar schemas but was able to alternate the organizational tool. He continued to work with the square that gets combined with translations of itself under the schema x → ∑t(x), but altered the pinwheel from a square quadrilateral to a triangular one (Figure 6.a – 6.b). The triangular pinwheel can also be understood as a parametric shape (Figure 6.b – 6.e) and variations can be explored.

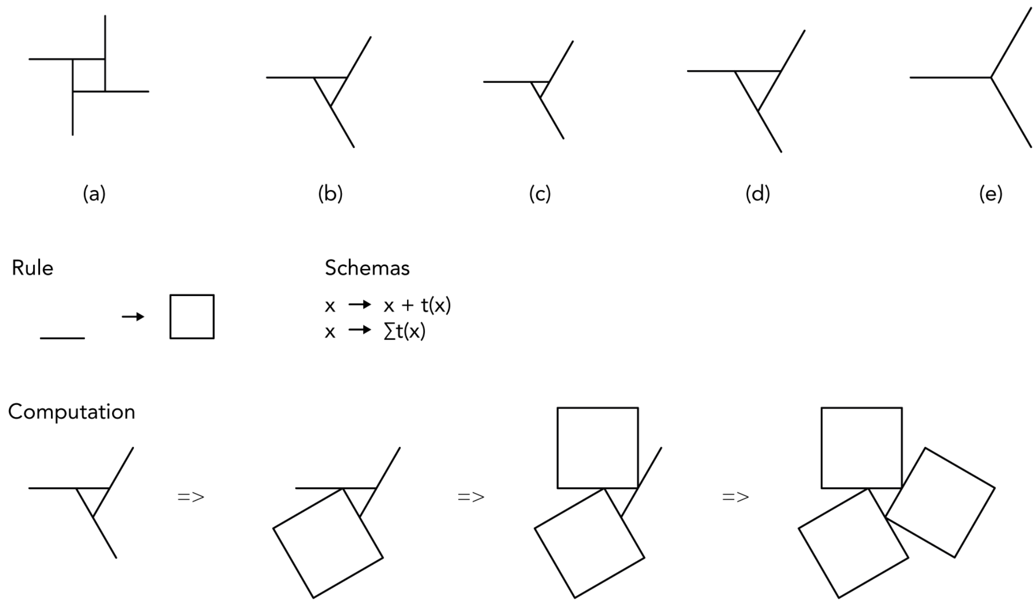


Figure 6. Adding a familiar shape using a familiar schema – x → ∑t(x) – but alternative organizational tools: alternating polylines.

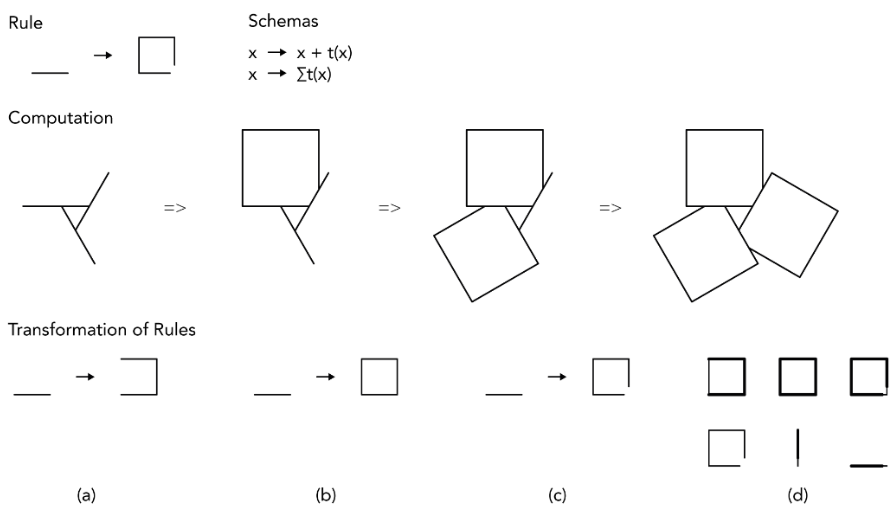


Figure 7. Adding a familiar shape using a familiar schema – x → ∑t(x) – but investigating new rules with new schemas – x → prt(x) and x → prt^{-1} (x).

Geometries with point to line (vertex to edge) relationships may not offer good spatial organizational affordances in architectural composition. To increase spatial prospects, Durant explored another iteration on the rule (Figure 7). Compositionally, he continued to assemble square-like shapes with the schema x → ∑t(x). This understanding now allowed him to be able to produce more nuanced iterations on the geometries, manifesting both in the rules and compositions. In investigating this iteration on the rule (Figure 7.b), coming to it from the previous step (Figure 7.c), Durant utilized the schema x → prt(x) to see the new shape: a new polyline with 3 vertices. Durant was able to embed this polyline in the square that was in the previous version.

By seeing this new shape and altering the rule, he computed a new design in which the squares appear to be woven. The square at the top appears to overlap the one on the bottom-left, the one on the bottom-left overlaps the bottom-right, and the bottom-right overlaps the top. This composition is not only visually more advanced but also architecturally more operational. The pinwheel here was interpreted as a courtyard, around which 3 spaces were organized. The line to line relationships, instead of the point to line relationship, afforded successful circulatory moments in between the spaces. They were also interpreted as walls and other architectural elements like desks, for instance for a library function.

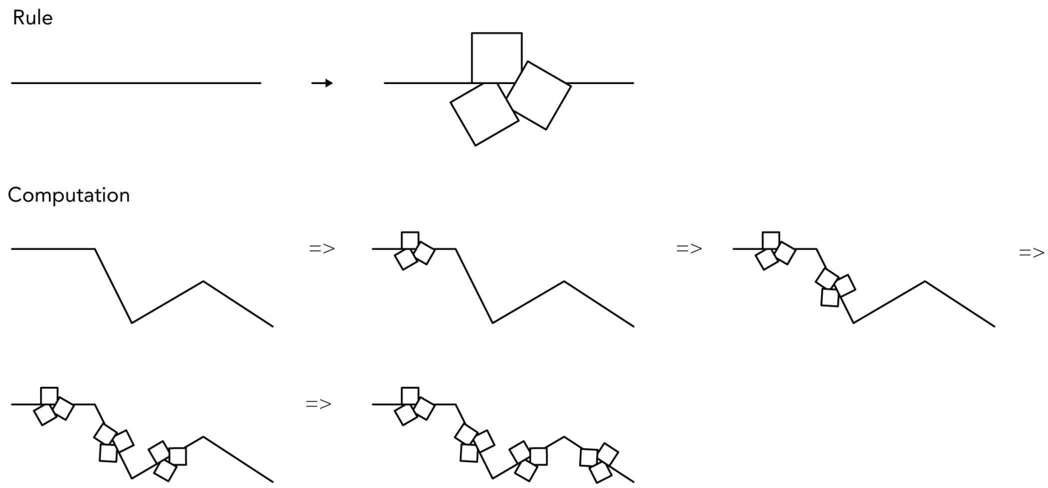


Figure 8. Computing architecture's relationship with topography.

This cluster configuration also allowed Durant to deliberately experiment with architecture's relationship with topography. He skillfully established a spatial relationship between the cluster and a line, aligning a segment of the pinwheel parallel to the longer line (Figure 1.c). First, he computed a string of four clusters on a long straight line, applying the rule once straightforwardly and once in reflection. Then, with the logic established, he investigated various polylines with varying number of vertices, angles and segment lengths (Figure 8). Durant expertly reasoned that these polylines correlated with the line contours of the topographic map of the site. He was able to explore different polylines by embedding them into the contour lines, especially with the use of tracing paper.

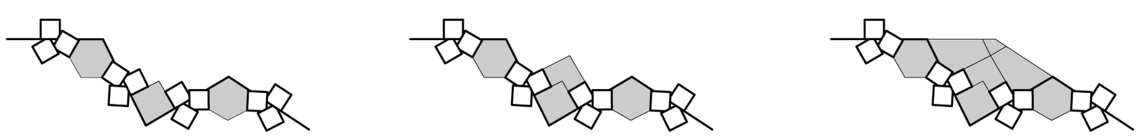
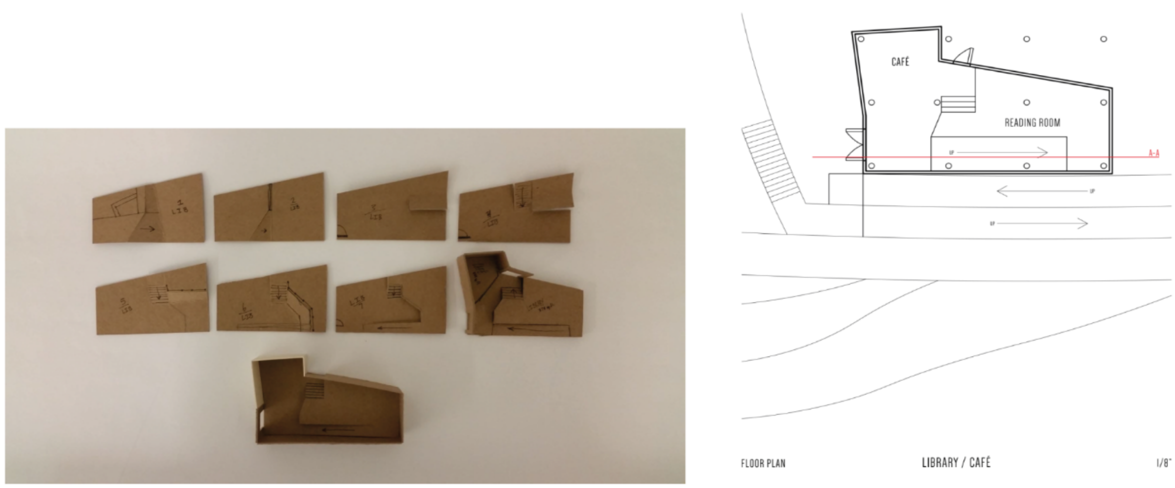


Figure 9. Establishing novel topographic formations using $x \rightarrow prt^{-1}(x)$, gradually completing lines into new shapes.

He settled on a satisfactory result once he considered a number of parameters: the spaces' access to the view, the relationship of the spaces to the topography, and the spaces created in between once the clusters were organized. These spaces produced good logic for the design of landscape architectural spaces and elements as well. Utilizing $x \rightarrow prt^{-1}(x)$, he could extend some lines to establish novel topographic formations. In this section, I covered a design process in extensive detail. The following 2 sections feature similar processes, with the employment of rules and schemas. However, I only highlight some parts of the design process that were computationally different and presented the use of different schemas or applied the schemas in diverse ways.

Computing Form in Architectural Plans and Producing Floor Plates

In another project from the studio, Casey Clement also worked on computing architectural plans but with an emphasis on designing floor plates. Based on the program, he first articulated a relatively large shape as the boundary of a building (Figure 10). Differently than Durant's strategy of unitizing spaces and adding them, Clement worked with larger boundaries and subdividing them into smaller spaces. This strategy reminisces artistic approaches on how to organize canvases, like those of abstract expressionists (Knight, 1989; Arpak, 2013), or crafts approaches, like those of Chinese ice-ray lattice crafters (Stiny, 1977). This reasoning can be represented by the schema $x \rightarrow div(x)$: a shape goes to a subdivision of that shape.



(a) (b)

Figure 10. Casey Clement's design iterations and plan solution.

For one of the main functions – the library – Clement had a quadrilateral outline (Figure 11.a). He then recursively subdivided the large floorplate into smaller and increasingly intricate articulations of smaller floorplates. Clement operated with a set of rules that initially generated this particular building. However, over the course of the semester, these rules were increasingly repeated throughout the building complex, strengthening design language and displaying Clement's comprehension of the process. Once the schema $x \rightarrow div(x)$ was grasped, he was able to use it in progressively complex design reasoning.

Clement's rules principally denoted division operations of the initial shape. These rules can be extrapolated in multiple ways, but I followed the procedural reasoning of the student. Starting from a straightforward subdivision of the main space, Clement moved onto introducing a set of circulatory elements. These moves were recorded as transformations of a line to another shape, like numerous polylines or rectangles. For example, the first rule states that a line goes to a specific polyline (Figure 11.a). Architecturally interpreted, this polyline represented a staircase, but also acted as a major organizational tool both in plan and spatial composition. Similar to Durant's organizational polylines, this shape reminisces one of the subdivision rules of the Chinese ice-ray designs and pinwheels. The polyline here however does not extend in all directions as in Figure 5.b, but only extends in 2 directions. In another rule (Figure 11.d), a line goes to a longer polyline with a vertex and an angle between the line segments. A line can also be deleted (Figure 11.e).

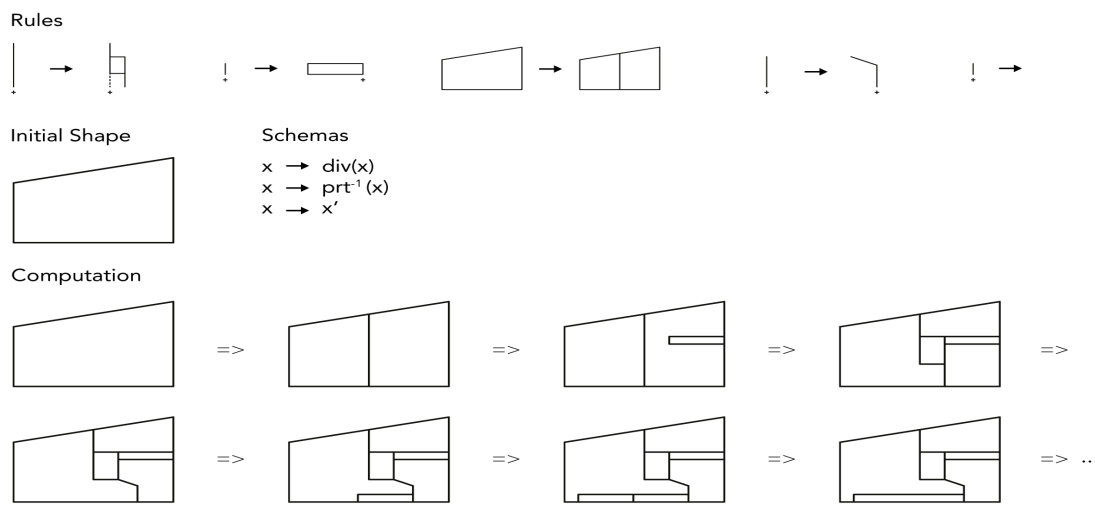


Figure 11. Recursive subdivision of the floorplate with the schema x → div(x), represented in plan drawings.

Using these rules and primarily the schema x → div(x), Clement was able to successfully design intricate articulations of the spaces in plan, as floorplates and in 3-dimensions. The process was recorded predominantly in 2-dimensions. However, the composition became increasingly complex in plan as finer details were introduced and studied. Indeed, 3-dimensional relationships of planes in space were considered as these subdivisions took place. As divided, these floor planes obtained new elevations with relation to each other and to the topography. As Clement studied the forms, he tailored divisions in a manner that correlated the new shapes with the topography lines.

Computing Form in Architectural Sections and Producing Spaces

In the architectural design process, beginner students often prefer to study spaces and the program in plans, gradually moving onto sections and elevations. Some students, on the other hand, prefer to start with computing form in architectural sections. Dreux Santos-Quesnel, one of these students in the studio, conducted extensive experimentations in the architectural sections and section models, generating plans subsequently out of these resolutions.

Santos-Quesnel's spatial explorations predominantly took place in a series of architectural sections (Figure 12.a – d). Functional requirements were initially addressed in the form of relatively separate nodes on the site, some of which were landscape design elements, while some became small scale and some large scale buildings (Figure 12.a – c). The form and design language of the main buildings – the observatory (Figure 12.a) – certainly inspired Santos-Quesnel as he sought ways to understand this language better and to expand its application to the other buildings as well as informing site manipulation.

As Santos-Quesnel sought ways to go from relatively disparate nodes to an integrated design, he transferred his sections (Figure 12.a – c) onto tracing paper. This way, we identified his sections as the elements to repeat, using $x \rightarrow x$. In our desk conversation, we translated and reflected the observatory section until we decided to copy it and combine it with the original (Figure 13). In using $x \rightarrow t(x)$ and $x \rightarrow x + t(x)$, Santos-Quesnel not only used shapes and forms, were able to compute with entire drawings. In doing so, he was able to go to an articulated section (Figure 12.d) successfully, iterating through interesting designs. This also provided him to integrate sectional to 3-dimensional reasoning, more rapidly too, hence more immediate opportunities presented themselves in being creative in 3-dimensions. This approach interestingly led him to be bolder in his interventions on the site compared to other students' styles.

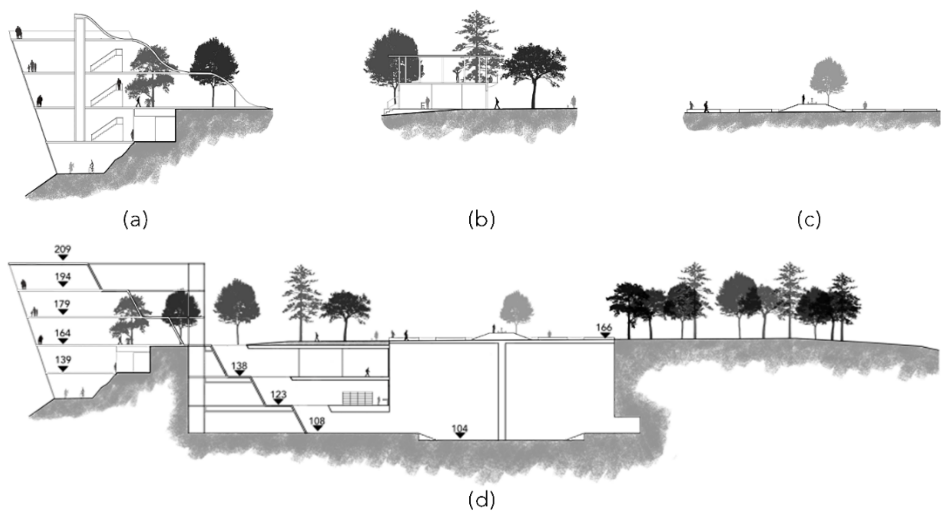


Figure 12. Dreux Santos-Quesnel's sections iterations.

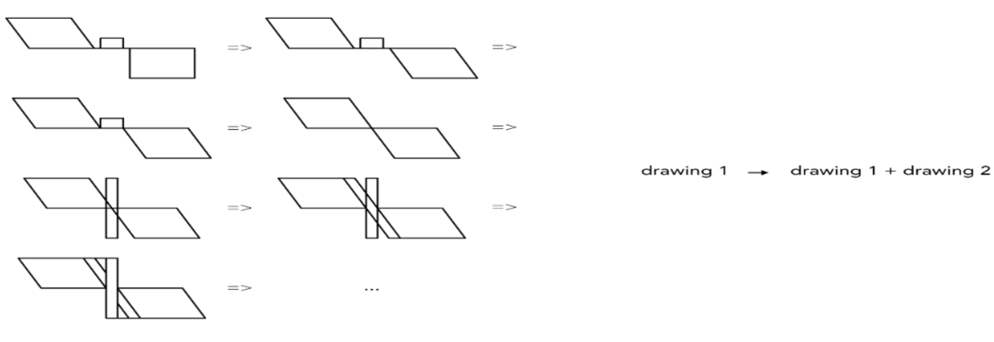


Figure 13. Computing sections with $x \rightarrow x + t(x)$, in this case, using entire architectural sketches and drawings.

Conclusion

Using visual-spatial schemas open up new design possibilities to beginner students and while doing so, allow them to be explicit and reflective in their practice. This skill helps them to identify patterns within their design reasoning, sense and sensibility, and repeat their successes in iterations. The schemas convey the necessary design knowledge and propose to students paths in how to go from being a beginner to experienced. With schemas, students can also learn how to deliberately identify, use and translate their skills: from basic design to architectural design, from plan drawings to sections, from 2-dimensions to 3-dimensions, from empty canvases to weighted terrains (topography), from parts to wholes, and so much more. In studio conversations, rule and schematic expressions enhance the language and hence collective design reasoning both for students and instructors.

Reasoning with rules and schemas grant students new ways of looking at their projects: the capability to utilize shape ambiguities in visual reasoning beyond combinatorics, and algorithmic ambiguities in computational reasoning beyond recursion. Understood computationally as unique processes that unfold in a given time frame, students are able to increase control over their design activity. They learn how to structure it, organize it and measure it - in form, quality and time. They comprehend that a structural and logical understanding underlie the production of form. It gives designers a valuable tool not only to understand design computationally, but also inform computation when understood designerly.

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The Moment of Beginning

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The beginning sentence of Edward Said's Beginnings defines the problem of beginnings as one that would "confront one with intensity" (Said, 1985); at the levels of both theory and practice. The beginning of architectural education is the same. In this paper, two foundation design instructors will carry on a dialogue to interrogate the what, when, and how of such beginnings in terms of both fundamental and current issues. This paper intends to formulate a teaser rather than an investigation to address a complex situation. The objective is to present conflicts rather than to find solutions.

The Complexity of the Discipline

The what, when, and how of beginning design are challenging questions due to the complexity of the architectural discipline. In Complexity and Contradiction in Architecture, Robert Venturi promotes an inclusive approach beyond the "oversimplification" towards architecture, arguing in favor of the complexity. Although directed to the architectural object and its design processes, Venturi's perspective reflects the essence of Architecture as a discipline.

Architecture is both a discipline and a non-discipline. On one hand, vernacular architecture illustrates the formation and refinement of architecture derived from individualized and collective understanding of everyday life as well as the available technology and skills for building. Evaluation of architectural design can be personal and does not require any professional qualification. On the other hand, the rise of star-architects who claim a new era or stand for an ideal coincides with the specialization and even exclusivity of architecture. Through manifestos and designs, such as Le Corbusier's Towards a New Architecture and Rem Koolhaas' Delirious New York, architects seem to have the power to influence the masses on how to think and live. The architectural discipline seems hyper-controlled by the professionals.

The complexity of the architectural discipline also resides in the varied but essential mediums that architects work with to explore ideas and design strategies, such as drawing, text, abstract sculptures, and installation. Although the ideas developed in these mediums will triangulate and focus back to buildings, the artifacts created outside buildings can become works in their own right. Further, architectural design may depart from an existing work or process outside the field of architecture, such as music, dance, medicine, biology, film, and literature. These translation processes both facilitate a deeper understanding of the medium of architecture and emphasize the ambiguous boundaries between architecture and non-architecture.

In the mid and late twentieth century, the increased exchange between philosophy and architecture elevated architectural conceptualization, which increased the discipline's complexity. One of the critical impacts of philosophy to architecture is literary theory. In "From Object to Relationship II: Giuseppe Terragni," Peter Eisenman explored the question: can architecture be studied as a language? In A Pattern Language, Christopher Alexander borrowed Chomskyian linguistics which also led to the development of George Stiny and Terry Knight's shape grammars. In The Eyes of the Skin, Juhani Pallasmaa referenced phenomenology in reading, thinking, and making architecture. What is even more complex is the fact that mis-readings of Jacques Derrida's investigation of the interplay between language and the construction of meaning defined an architectural movement, Deconstructivism.

Regardless how intellectual the discipline of architecture may appear, it can never escape its social meaning and impact. French philosophers, such as Jacques Derrida, Gilles Deleuze, and Michel Foucault, treated social and scientific topics in their work that permeated the architectural discourse during the Post-structuralist and Postmodern period. In a double negative tone, Venturi argues that architects "can exclude important considerations only at the risk of separating architecture from the experience of life and the needs of society." That is why both Rural Studio, a structured architectural education program, and the slums in Caracas, Venezuela, an autonomous urban phenomenon, are both of critical value for architectural studies.

Although a discipline whose changes are always delayed relative to technology, Architecture is undergoing a digital revolution. Digital tools are changing the computation and fabrication processes of architecture. More importantly, they not only have facilitated a physical existence that impacts primitive human sensations, but also have created and supported the cyber existence of architectural space. The expansion of Architecture in digital space only increases its level of complexity.

The complexity of the discipline of Architecture demands an open-ended learning structure. Perhaps, the foundation of beginning design studios can be framed by discipline and non-discipline at the same time. The theme of the 2008 National Conference on Beginning Design Students was "the presence and absence of disciplines within beginning design." Sabir Kahn, the chair of the conference, believes the paradoxical presence and absence of disciplines index "unspoken or explicit assumptions and anxieties about disciplinary turfs and thresholds. That beginning design education is considered a distinct terrain compounds these anxieties further as its status as a discrete discipline and as a threshold into other disciplines is put into question." (Kahn, 2008) The following conversation between two beginning design instructors documents a fragment of such debate at this threshold.

Dialogue

What are the foundations of architectural studies?

Figure 1. Critical Thinking versus Abstraction: student work from authors' studios. Images owned by the authors.

AB: Critical thinking.

In my beginning design studio, the main objective has two folds. First, it contributes to the definition of the architectural space by emphasizing the commitment between the object and its generative process while maintaining a global notion of various aspects that work in such relationship, such as: physical, historical, technological. Second, it includes research in architectural design by introducing precedents as a critical component in the design process. The research is based on the study and analysis of relevant work, reinforcing the notions of architectural themes and programs.

Critical thinking represents a linkage in all design decisions made. The studio must be a place for discussion of the different ideas and attitudes generated by individual processes of students and a place for confrontation as an academic strategy. Each project is an opportunity to investigate a particular theme or concept. Through critical thinking we develop a conceptual framework which is the fundamental base for the studio. Theoretical foundation is an essential part of the dynamics of the studio and the development of critical thinking. Each studio is enhanced by a series of fundamental readings with the purpose of constructing a solid base from which to operate.

WH: Abstraction.

To think critically, students need to challenge their pre-existing motivations for design by pondering what to investigate, and develop problem-solving skills by learning how to cultivate stimulating questions. Abstraction is a vehicle for critical thinking. Focusing on observing relationships among and within objects, abstraction is a de-familiarizing process for students to detach from the conventional perceptions about the built environment and progress towards conceptualization. Visual abstraction may be the first and most obvious step to take. That is to see non-objectively. In my studio, for example, students were invited to photograph everyday sceneries, crop the pictures to make square units, exaggerate the unit's graphic contrast, and make a new composition from the units. Through the process of transformation, everyday figures give place to recursive compositional flow between the black and the white spaces. Through abstraction, space becomes an organization of point, line, surface, mass, and void; the formulation of space becomes operational processes of folding and carving. The abstraction process helped students challenge their preconceived idea of architecture and make them realize the existence of architecture outside "building" both literally and metaphorically.

AB: The problem with abstraction is the challenge it represents for students to make connections between abstraction and the notion of "building". In my experience, students tend to see architecture and building as two separate things. I have developed a series of exercises that help them to link both aspects as a continues process. Students need to analyze in details a series of relevant projects in the history of architecture with the idea of exposing and interpreting the diverse conceptual and design operations present in such projects. Through a detailed set of drawings of plans, sections, elevations, digital and physical modeling we can understand the basic principles of composition so we can re-interpret them in the individual projects.

WH: What you are emphasizing is to tie abstraction back to building; what I am emphasizing is to push abstraction to conceptualization. Architecture can mean multiple things. Engaging ideas from multiple disciplines can instigate architectural designs that are personal, contextual, and further extend our environment into increasingly dynamic places. This is when abstraction is critical because it helps students explore spatial meanings. For example, examining paintings by Mondrian, Braque and Picasso helps students understand the three-dimensionality of space in relation to the flattened space on paper. Movie narratives and music rhythms/volumes provide students unconventional environments to investigate new ideas of non-linear relationships. Together, these techniques of abstraction lead to metaphorical conceptualization of space and structure.

Where to start?

Figure 2. The Unfamiliar and the Uncertain versus Sequence: student work from authors' studios. Images owned by the authors.

WH: The Unfamiliar and The Uncertain.

Design studio is a special learning environment where students confront intellectual challenges with some degree of personal uncertainty. The nature of a design process is to find inspirations and solutions within the unfamiliarity and the uncertain. Through such a process, studio projects become both an extension of one's inner self and a reflection of one's environment.

The first project on the first day of the semester is literally the beginning point of academic architecture education. It is a threshold where students compartmentalize their existing experiences in built environment and project into future practices. The critical point of departure in my studio was a one and a half weeks' warm-up exercise engaging students in a fast-forward experience in architectural design. The project invited students to use disposable everyday plastic objects as modules to design and construct a backdrop for a red-carpet stage. Through the process of communicating with clients, visiting the site, and resolving real construction issues, students formed a renewed first impression about architecture.

AB: The Sequence.

After the de-familiarization and the acceptance of uncertainty should be a methodical and carefully designed sequence that leads students through the design process. Two aspects are fundamental in my studios. First, design is understood as research where relationships between the space production process and its resulting consequence of a certain attitude or intention are explored. Second, the methods and techniques used in this exploration are developed in order to identify and reflect upon the architectural artifact's inherent spatial and structural orders.

One of the most difficult concepts to be introduced to students is space, a critical topic for beginning design studios. The objective of the sequence developed in my studios is to make students detach themselves from their preconceived notions of architecture, in order to be able to introduce the basic principles of spatial composition. Hence, the introductory exercises are about composition and spatial approaches such as: proportion, hierarchy, grid, positive / negative space, notions of poche and figure ground among others. These approaches are abstract.

Another important aspect of the learning process is the notion of phenomenal transparency. It represents a mechanism of understanding space not as an object, but as an intangible and simultaneous condition. My studio develops this essential concept through a series of exercises which range from simple figure-ground compositions to more complex problems of tonal value and color theory with the idea of establishing direct connections between the visualization of space in two dimensions and its three-dimensional reinterpretation.

WH: The realization and acceptance of unfamiliarity and uncertainty is a process. Perhaps the difference between our approaches is the degree of uncertainty in such process. In your case, the learning sequence is determined, and hence, provides a level of certainty and security; in my case, the design problem is presented as a comprehensive shock and hence the seemingly improvised learning sequence.

Another de-familiarizing strategy is to create projects that re-direct students to fundamental design issues from an unconventional angle. The project seems out of the architectural context at first but, while moving through the design process, students gradually develop sensitivity to various architectural issues. For example, in a project producing wall diagrams based on the work of a French artist, Felice Varini, the objective was to project geometric shapes onto architectural and urban spaces so that a single point of view became the only position in which one could see a complete shape superimposed upon actual architectural space. Varini's artistic language demonstrates tectonic architectural concepts such as spatial depth and embodied experience. In another example, students designed movable structures around their bodies, performing physical transformations of the structures' parts in a runway fashion show. Students learned to integrate understandings of the body's movement in space with the tectonics of materials.

AB: It is not that simple. I agree on the importance of uncertainty as a strategy. I would argue that even though there is a precise structure of the exercise sequence, the results may be very different depending on each student. It is essential for me that each student interprets and develop their projects based on their interpretation and not mine. It is not predetermined outcome in spite of the fact that there are some approaches more frequent than others. Is on this point that is useful to understand what Jung's theory on projection argue. Every perception is a projection of an inner reality. The sequence of exercises I introduce operate from this perspective. The goal is to make students interpret through visual perception what they see and what they feel and use those perceptions to think about concept and space. The certainty that you mention is in the sequence, but not in the results.

How to start?

AB: The Relationship between Art and Architecture.

Art and Architecture operate on common foundations. Architecture first exists as representation. Its ultimate purpose is to exist in the physical world where it can be experienced as a manifestation of certain social conditions. Art is a concept that encloses all creations in which a sensible vision, either internal or external of the world have been developed. It is a vehicle that allows ideas, perceptions and emotions to be re-presented through plastic [visual or not] resources. Architecture is the interaction between reason and emotion. Everything that is part of the architectural process is a consequence of these two forces. Reason and emotion create a discipline that is the result of both right and left parts of the brain acting together in a singular motion. Basic design composition principles are introduced within the context of architectural representation in order for the students to internalize the relationship between spatial thinking and its implications in architectural programming.

In Art and Architecture, there is an exchange of emotions and associations between the work and the observer that depend on specific experiences and particular interpretations. A work of architecture is not perceived as an isolated collection of images, but rather, as an integrated haptic series of perceptions and emotions. Architectural space is the place in which physical structures, tectonic elements and external perceptions are overlapped with internal images and symbols, conscious and un-conscious mental sensations that, together, create a coherent experience with specific meaning. Rather than producing objects of visual seduction. But the question of creativity needs to be addressed. Can we learn to be creative? Can creativity in architecture be developed towards a new kind of spatial thinking? In such a creative process, we must recognize two aspects: what is produced by an architect as a consequence of an awakening of ideas and the impact on their conscience, and the particular visions and concepts derived from his / her direct interpretation. These ideas represent the principle that underlies in all created forms. Every form is a symbol and every symbol is thus the external-visible expression of an internal and spiritual reality.

Figure 3. The Relationship between Art and Architecture versus Thinking Medium: student work from authors' studios. Images owned by the authors.

WH: Thinking Medium.

Comparing art and architecture is a strategy for creative thinking where art becomes a context and a reference for architecture. Within such a context, beginning design students also need to learn mediums, such as drawing and physical modeling, to facilitate design thinking. Skill levels of these mediums could empower or limit students' explorations of architecture.

AB: Drawing is a mechanism of communication of design intensions. It is not pure representation of an architectural object, but rather it is the expression of a conceptual intension to solve a problem. Pérez-Gómez has said that the distance between architectural drawing and building has always been opaque and ambiguous. He analyzes how Vitruvius, for instance, understood the drawing as a minor part of the practice and how during the renaissance, architect's drawings signified a symbolic intention to be fulfilled in the built space while remaining an autonomous object of representation.

My studio focuses on the idea of a concrete definition of the architectural object as a product of a spatial and programmatic synthesis process, allowing it to set a coherent relationship between the conceptually determined as genesis of such architectural synthesis, and its transformation to an object built with a high level of site specificity and development, also how we establish those connections between representation and its concrete physical manifestation in order for students to learn meaning.

WH: Meaning is medium specific. How meaning is constructed in a medium varies from one to another. When architectural drawing becomes the medium to think and develop meaning, it is no longer a representation but a diagram. A diagram registers a thought process, invites interpretations, inspires design formulation with embedded ambiguity, and clarifies design intentions. To emphasize drawing as a design tool, I would not hesitate to introduce diagramming to beginning design students.

Diagramming expands their understanding of drawing not merely as an observational medium but also as an analytical and formative medium.

AB: Is digital drawing being used as a diagramming device or something else? There is an understandable fascination with digital technology and visualization of the architectural object. In spite of its infinite benefits for architectural project development, computer imaging tends to generate a simplification of our extraordinary, multi sensorial and simultaneous possibility of imagination by transforming our creative process into a passive manipulation of visual experience. Digital technologies tend to base the understanding of space through perspectival manipulation. This happens today especially in our schools. Architecture students tend to understand the design process as the learning of particular programs and applications, and as the immediate experience of self-gratifying visual objectives rather than focusing on a more haptic sense of design thinking and cultural specificity.

WH: I have similar concerns. With the increased accessibility of digital tools and the prevalence of digital fabrication, the moment of beginning is in question again. Have we entered a world where we naturally think digitally? Is manual drawing merely a nostalgic performance? This is not merely a debate on digital tools versus manual tools or what is the best timing to teach them, but an investigation on the media themselves: how they function as design tools and how they convey meaning in their specific ways.

AB: The contemporary tendency of architect's and architecture is to be part of the world of architecture as mass-media in which Instagram, Face Book and the web is the ultimate goal. Renato de Fusco in his book "Architecture as Mass Media" put forward the idea that architecture is part of the systems of communications that define culture not only from its functional aspects, but also as a container of image/meaning. Prof. Mark Jarzombek analyzes how modern society is determined by what he calls data exhaust - an invisible anthropocentric ether of ones and zeros - as a consequence of "our digitally monitored age". The tools have changed, but the objectives of architectural education [should] remain focused on the role of architecture as a social art. It is not about the tools, it is about what we can do with them. What kind of impact we want to have in an ever-changing society. The central discussion is culture itself. Tools represent mechanisms of mediation between society and the discipline. Today we have computer programs that will be rapidly out of date and will be substituted by others. Therefore, the question is not if we teach a particular program, but how we teach them to think. That is, to use any tool, from a sketch on a napkin or sketchbook to an animation or VR to communicate intensions clearly.

The Complexity of Conclusion

This paper has no conclusion other than acknowledging the complexity residing in the moment of beginning for design studios. Perhaps there is no best way to begin architecture education than a vision of what Architecture is and the agreement on the unavoidable core of "building." We cannot forget that the architecture's role remains socially impactful and its fundamental existence is in the physical world. Hence, the education of an Architect, especially in beginning design studios, must address the core and the complexity of our discipline and develop conceptual approaches and skills necessary to push it forward along with the constant change in our society.

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