IMPERATIVES OF CRAFT: PEDAGOGY FOR EMERGENT TECHNOLOGIES

JAMES FOWLER ECKLER, JR.
Marywood University

KARL WALLICK
University of Wisconsin, Milwaukee

"Precision is not a synonym for rigidity; instead it is the instrument necessary for exploring and establishing the limits of ambiguity in a project. Only a remarkably precise expression can become a plane of reference for varying meanings, raise varying interpretations, and therefore create a different collective meaning for the architectural work." (Gregotti)[1]

INSTRUMENTALITY AND SPACE

Expectations of craft, both digital and manual, situate drawing as the primary agent of synthetic investigation for architecture. However, with constantly evolving software, scripting, databases, and various other analytical programs added to the architect's media of brain and pencil, both students and curricula face choices about how to position design and skills curricula between broad exposure to many tools or narrow specialization in the media of the moment[2]. Attempting to locate a school's position along such a gradient means that one is forever playing catch-up to the latest software updates. But in comparison to technology, fundamental design principles mostly remain constant. The pedagogical outline must be robust in principle but malleable in structure so that digital and manual tools can evolve with the industry while architectural principles stay intact. In this paper we show such an approach within the context of an undergraduate foundation studio. Our approach to digital processes as generative tools involved defining spatial qualities through the lens of edge, zone, and assembly tectonics in a carefully sequenced series of cumulative design exercises. In addition to comparing the types of knowledge and skills generated through this method, we must ask: how does this knowledge compare to the tectonic questions pursued in practice? Furthermore, are our expectations for architecture too limited with such a narrow focus on the lineaments of organization and drawing? Do tectonic sensibilities provide sufficient linkage between the different steps in the studio sequence? The studio examples will show that as a pedagogical tool, keeping spatial fundamentals stable, we are better able to keep up with the dynamic pace of technological evolution.

DIGITAL CONTEXT

In developing pedagogy to respond to this emergent condition we identify two positions to avoid. The first is a technical training that prepares students to compete in the job market but has not activated the agency of drawing as a research tool but only as a visualization media. The second involves defenders of nostalgia rejecting inevitable disciplinary changes in favor of so-called tried-and-true approaches to beginning design studio. They produce competent designers that find it difficult to find a place in a profession that continually places more emphasis on speed and digital fluency. In all but the most critical practices, digital craft is relegated exclusively to visualization. This is a far cry from realizing its potential to foster discovery in the design process, or meet the demands for design production.

Instead, we propose a studio pedagogy that seeks to reconcile the introduction of fundamental design principles with an exploration of emergent digital technologies. Its primary products are hybrids between these two modes of making. It recognizes the advantages of virtual craft that permits continuous editing and iteration as a factor of cognitive development for architects. However, our responsibility to teach students to critically evaluate their design is not absolved by the use of digital media. With that in mind, it also recognizes the necessity of manual craft for fostering an understanding of material behaviors and a responsibility to the realities of the actual environment. Manual drawing and modeling plays an important role in teaching students to see space in terms of scale, proportion, proximity, and context. Instead of technology, the focus must be on architectural technique and craft.

This model was employed in the development of a second year design studio. It is responsible for addressing content typical of an architecture studio in the second year of a curriculum. To accomplish this, making is introduced as a form of inquiry. The act of joining, folding, carving, stacking, or marking can yield discoveries that inform concept, and are therefore of intrinsic value in the design process. The hybridization of manual and digital craft allows students to explore issues of spatial and formal composition, organizational logic, and aesthetic sensibility in a way that exploits the disparate advantages and limitations of the two environments. The computer was viewed as a tool for making and investigation just like any other at their disposal.

The studio begins with a directed formal analysis exercise. The next stage of work focuses on generative design processes. It concludes with the design of an institutional building based on the students' earlier analysis and generative designs.

TECTONIC FOUNDATIONS OF SPACE

Content in this studio was predicated on craft of form and material (or non-material), along with several assertions.

- Form acts in service to space.
- Assembly is the primary means by which the architect is able to configure and compose space.
- Character of space, created through assembly, is the means by which experience informs architecture.

The reason why we are interested in form is not only for its ability to shape space, but also its responsiveness to external conditions. Our definition of form is not that of fantastical objects generated purely from the imagination. It is not that of grand schemes invented by the intellectual machinations of self-proclaimed masters. Instead it is a medium shaped by the understanding of forces acting upon it.

Form that utilizes external forces in its shaping is the type that anticipates architectural circumstances of structure, site, culture, and program[3]. It controls and defines the perception of space. Such form can be manipulated, modified, and reformed to circumstance. Form that is dependent on an internal definition may be less malleable and potentially less accepting of other content[4]. This is not to say that the idea of an individual architect is not without merit, but that it comprises only a little of the compositional equation.

For these reasons students are introduced to tectonics as the elements of formal composition[5]. In Greek architecture, *tecton* referred to elements assembled piece by piece such as carpentry while *stereotomy* dealt with elements that are cut or carved such as masonry[6] or in Semper's terminology, the mass. All four elements are understood through specific expressive circumstances such as cutting, joining, wrapping, folding, etc. While these qualities are not inviolate conditions, students are encouraged to think about what they are trying to accomplish or communicate before attempting to undermine conventional readings. For instance, before a student decides to suspend a mass, which runs counter to conventional logic that dictates that it should be in the lower portions of a composition, they must first consider the implications of gravity. This does not mean that the students can't challenge familiar notions, but to do so without purpose might be a distraction from other matters. Throughout these tectonic studies, the joint and inter-relations between components are considered with higher priority than the objects themselves.

In the building arts, tectonics refers to principles of making that are rooted in a consideration of materiality, craft, and joinery[7]. In other words, that working with design ideas rooted in the tectonic elements pre-supposes the act of construction at any scale of building. Historically, this tradition is rooted in the theories of Semper and Bötticher, most recently and clearly elaborated on by Kenneth Frampton[8]. Whereas for Bötticher, tectonics referred to a system binding forms into a single construction, Semper anticipates the disassociation of enclosure and structure by envisioning the mythical primitive hut[9]. For Semper, the tectonic elements compose a four-part taxonomy: mass/base, frame/structure, enclosure/plane, and hearth/programmatic center. Frampton merges both sensibilities (which are really not all that different) by referring to stereotomic (of the earth, heavy) and tectonic (carpentry – frame, light). Critical to any interpretation of this historical and still relevant view of constructing space is that a designer has an attitude towards joinery. Heavy or light, maybe is never so important as the connection between the two different systems.

PROCESS VERSUS VISUALIZATION

The studio concerns itself with the development of compositional skills and the manipulation of space. The investigation is primarily formal, not because we value form as a means unto itself but because it is the foundation of spatial cognition. What is space? Is it just any old room? Is it an empty volume, or a big void for our stuff? This seems insufficient. When we remember great spaces, we remember qualities that anticipate specific types of inhabitation. This may be because of a certain height or proportion, a specific character of light, or because of another space we can see from the space we occupy. For this studio, space is the intentional result of form-making that can anticipate future activities and occupations – place making. What is space? Space is nothing without an attitude towards the varied characteristics of inhabitation and how one juxtaposes those different sensibilities. Engineers can calculate structural loads and thermal performance. Contractors can construct rooms and buildings. Planners can deploy roads and introduce principles of zoning and policy. But who speaks for space? The task of organizing, prioritizing, and emphasizing spatial conditions in support of human activity is the architect's role.

It is impossible to design architecture without space and form. The two elements are interdependent, neither primary nor secondary to each other but completely reciprocal. By thinking of these two concepts in near perfect alignment, we gird ourselves for thinking about the role of architecture as one in mutual dialogue with other forces. To this end, the studio is structured to guide students in a manner so that the accommodation of programmatic, circulatory, and other forces is embedded within the work. This might be different from an idea of the architect as a mastermind who is able to articulate a single genius vision with a stroke of the pen. Architecture may be figurative or an object, but to be successful, it must respond to multiple other criteria. It extends across sites, histories, and cultures not as singularities, but as vast interrelated systems that have individual characteristics articulated within the whole.

The job of spatial organization is not one of personal expression, but of capturing and channeling the manifold requirements of site, program, and construction into a legible volumetric composition. Despite this, there is a tremendous amount of room for variety within

this structured agenda. Students are invited to consider the variety inherent in manipulating spatial depth, spatial joints (thresholds) between context and intervention or within various programs, spatial overlap, nuances of ordering, programmatic hierarchies, qualities of enclosure, volumetric transparency, etc. The instructional themes taught in this studio are not promoted because they are some sort of 'best practice'; they are not. However, they are a core part of the architectural discipline and an important foundation upon which other design curricula depend. Indeed, even if the students choose to challenge these methods in their future careers, it is useful to have a point to resist and to be able to resist intelligently requires sincere study.

Studio Process: Analyses, Generators, Syntheses

A priority for this studio is to overcome students' expectations that digital craft represents a final outcome. For this generation of undergraduates, manipulation occurs exclusively within the virtual environment and any output is considered immutable. This presents a clear barrier to integrating inquiry as public discourse, iterative design process, and digital craft into the design process. Additionally, this is the student's first exposure to digital media in design, much less digital fabrication. This reality presents a pedagogical problem. How do we structure a project that offers necessary skills based training, coupled with design instruction with an emphasis on integrating manual and digital methodologies? Can this structure be used to reinforce and develop a process of design in which discovery is a result of craft? How can there be tectonic language or even an attitude towards assembly when one is plotting models? How do we formulate a studio structure to deliver content that anticipates construction logics for materials, structure, environment, and organization rather than formal gymnastics divorced from actual limitations? And, within the larger architecture curriculum, how does this project help prepare students to enter an ever changing, technologically diverse, discipline?

The studio has five explicit exercises that, while occurring in a linear sequence, actually encourage development of non-linear thinking through the design process. That is to say that with each sequential iteration new discoveries are made that have an impact on both previous and subsequent versions of a project. The same exercise is repeated several times in slightly different contexts with various subtle changes in scale and orientation. The work is distinct but cumulative[10].

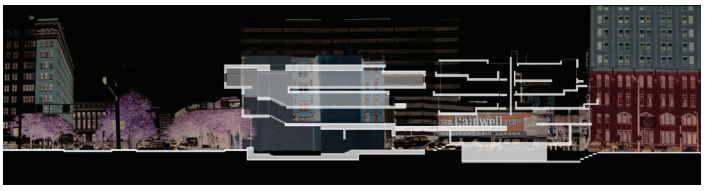

Figure 1. Students document precedent buildings in layers. This form of analysis enables them to study aspects of the buildings independently of other forces. Much is learned in the later synthesis when the layers are combined and interrelationships between compositional systems are made obvious. This image shows the cumulative information in the overlaid drawings.

The studio begins with precedent analysis exercises that introduce an architectural vocabulary of oral and graphic tools for defining space. The task here is to identify the role and effects of various space defining components. The students' thought process and drawings are successive through three different stages of architectural thinking: documentation, analysis, and generative design synthesis. This is another way of describing the gradual accumulation of an architectural position (opinion informed by observation and analysis). Structuring the analysis are three drawings: spatial profiling, spatial promenade, and tectonic components. While initially each drawing stands on its own with regard to analytical content, they are ultimately used cumulatively (Figure 1).

This layered, spatial diagram[11] was translated into a model in which students investigated various possibilities for joint making and spatial configuration. The diagrams provided a set of criteria for the construction. The models were generative constructs; they interpreted information from the diagram, and used it as a catalyst for the invention of something entirely new.

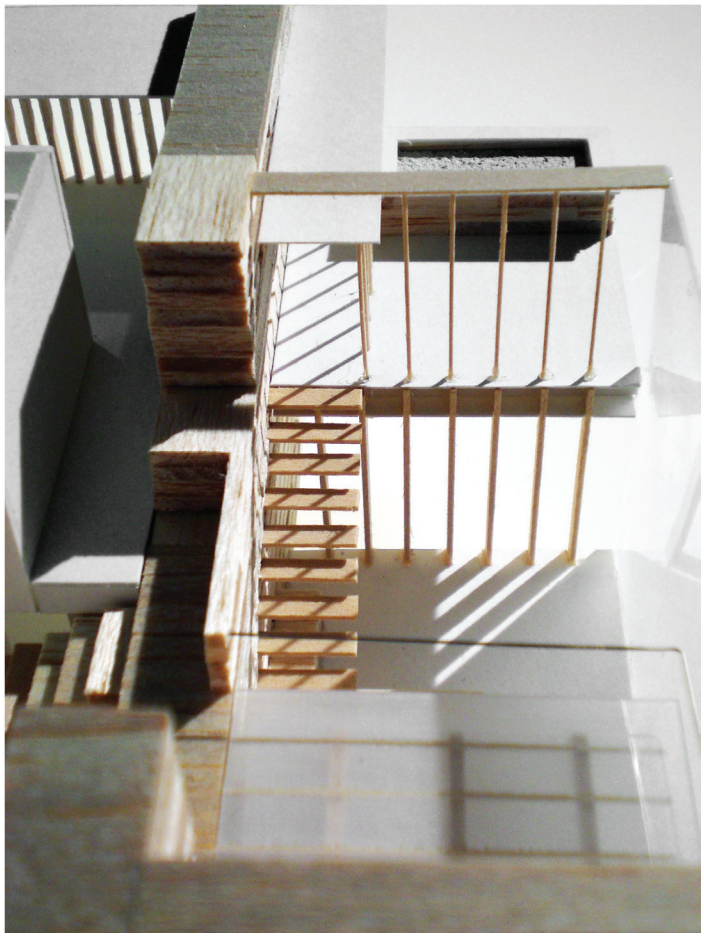

Figure 2. New crafting techniques that span both manual and digital craft provide the students with new skills in representing and articulating spatial information.

As the students move into the next phase of the studio, they are given a contextual field. It was a simple arrangement of masses and voids to serve as environment meant to receive their design. Students used this field as a framework to develop a "digital fragment". It employed tectonic joinery and spatial inflections generated from their contextual field in a digital model leading to fabrication of laser-cut and powder printed model components (Figure 2). This exercise had two objectives: to introduce digital crafting skills and techniques, as well as to apply those techniques in the fabrication of a spatial construct within a set of design criteria. It was not programmed, but was generated based on compositional and organizational logics. And, it constituted a point of departure for the design process.

Students were also assigned an organizational pattern to govern the placement and modification of their project. The class was divided between: peripheral, linear, radial, centralized, and clustered patterns[12] (Figure 3). Within each assigned pattern the students used the grid as a system in which registration lines could be used to regulate composition and render spatial relationships. These organizational logics determined a set of parameters for the next phase of the project in which students were to craft spatial extensions to knit the digital fragment into its surroundings. Students used contextual characteristics of the field to determine placement, orientation, and relationships between elements of the composition (Figure 4). While digital files were being fabricated, the contextual field was developed as a physical carriage or base that would eventually hold the digital fragment[13].

Finally, a third set of spatial profile and tectonic orthographic drawings were constructed digitally and augmented manually (Figure 5). These were working drawings meant to revisit the tectonic character and diagrammatic spatial structure.

The fragmentation of the studio methodology into discrete exercises is both pedagogical and philosophical. Besides breaking the design of buildings into manageable chunks, the fragment is meant to reinforce that architecture should have relevance far beyond the primacy of a single object. In other words, that architecture extends across sites, histories, and cultures not as singularities but as vast interrelated systems that have individual characteristics articulated within the whole. The deliberate progression of gradual development outlined above supports the premise that architecture is about the primacy of performance, inhabitation, and experiential character rather than the hegemony of singular form strategies.

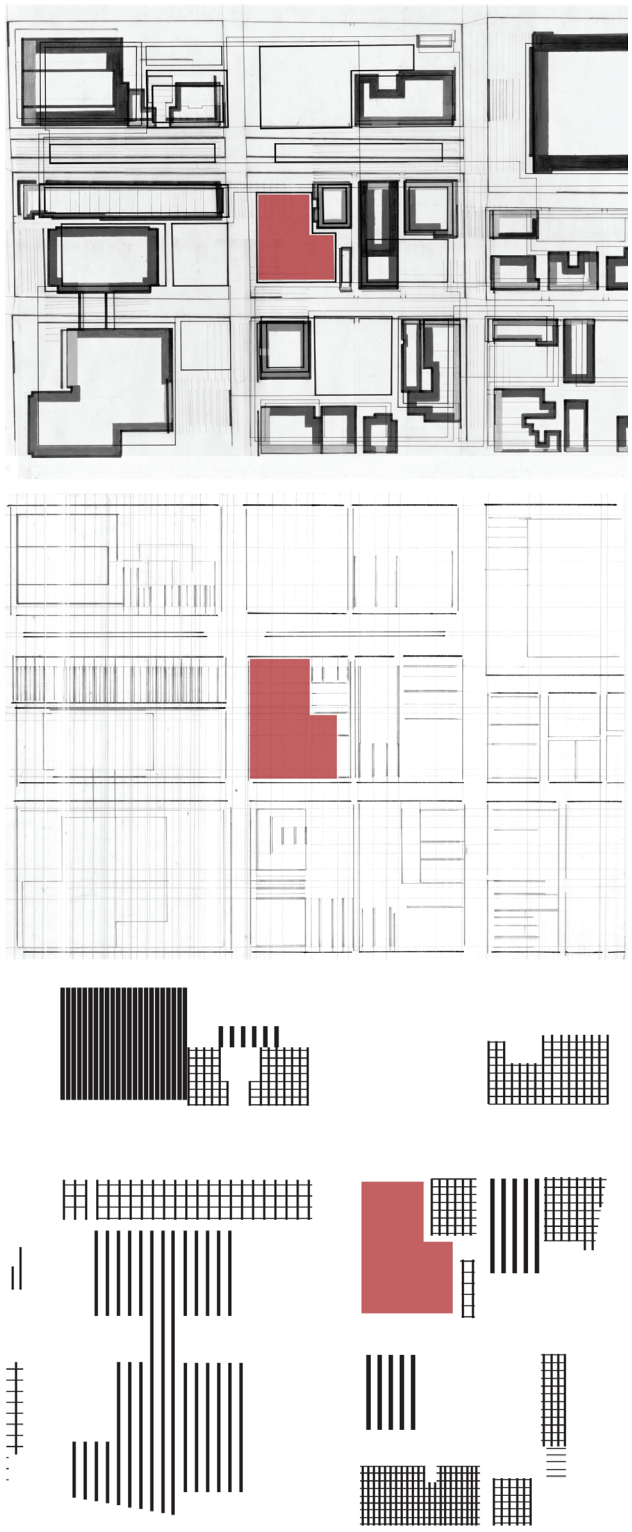

Figure 3. Organizational patterns are diagrammed and used as a guide for composition.

ACTIVATING MANUAL AND DIGITAL TOOLS

Architecture stands in time and space, but it is never still in its creation or in its subsequent existence. Building the foundation for such an awareness of architecture's active condition is an important curricular goal. We must strive to teach students that as architects, we are participants in a wide discipline, but more importantly, that our buildings must flex and change to accept a wide variety of forces in their lifetimes. While such flexibility should be structural to any project

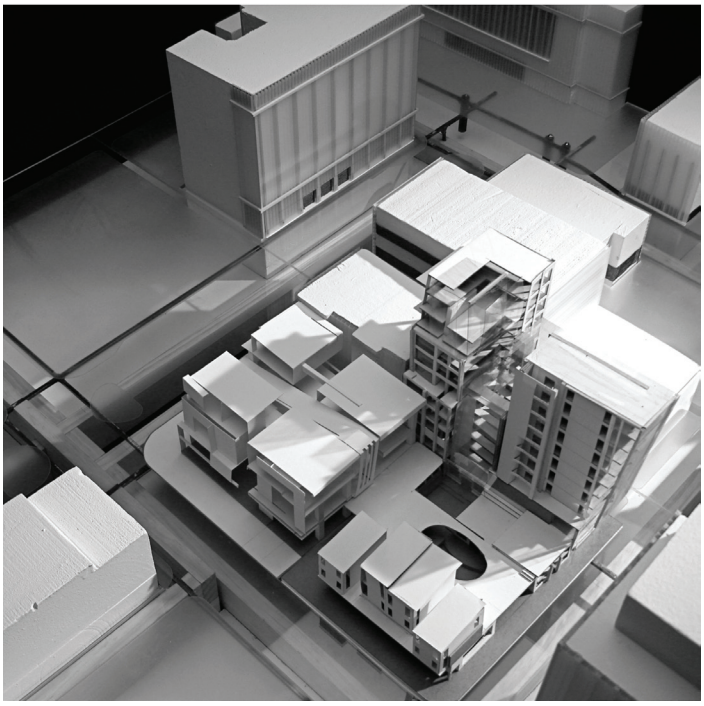

Figure 4. Techniques for making extend into the representation of systems of relation between context and intervention. Spatial constructs are manipulated in response to contextual forces identified in the organizational diagram. Contexts are modified in response to the new conditions presented by the intervention of the new spatial construct.

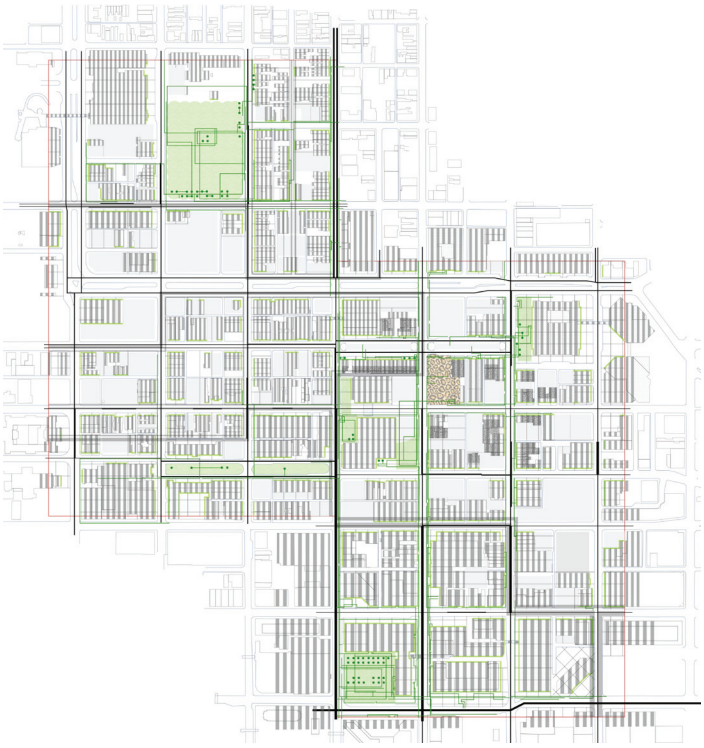

Figure 5. New drawings are constructed to diagram the new spatial construct and evaluate its relationship to contextual conditions that hold it.

one might design, we are not referring to folding walls or to literally expanding spaces. Flexibility is an attitude embedded within design thinking. This attitude should be structural to a project in the way a space or detail can be formative to an architectural order by serving multiple issues without radical reconfiguration. Our job as architects is to reconcile the arrangement of space amongst all these forces. Despite the plethora of cultural, technical, economic, contextual, and program issues present within any one architectural problems, many architects pursue or invent additional forces independent of what already exists[14]. This is not surprising given the nature of architecture as a creative enterprise, but it is unnecessary. Such questions for architecture have in one way or another always been central to our discipline despite many historical stylistic tangents that have distracted the profession and academy along the way. Today, this is even more the case with issues of fiscal, programmatic, and energy sustainability no longer at the fringes of cultural attention.Too often technology and digital processes are used as a false premise for supporting complexity or even worse is symptomatic of poor design choices. However, the appropriate use of technology has rich potential, particularly where it is hybridized with simple conventional techniques. Whatever the technology or media, its generative potential as an active contributor to the design process is essential. The role of the academe is to lead the profession. Students should understand and be prepared for the coming innovations that are shaping the discipline. This would seem an impossible task to predict the future of software development and other digital interfaces – and it is. Every year, there are new and improved programs clamoring for curricular adoption but if we attempt to retool design curricula to accommodate novelty, we risk letting the core requirements of good architecture stray from our attention. In fact, we can choose both disciplinary conventions and the new technical developments. What are needed are studio structures that are indifferent to specific software, but responsive to the different modes of architectural thinking (documentation, analysis, and generative synthesis) students need to develop. This is not about mimicking practices in the profession within a foundation curriculum but about committing to the value of certain intellectual processes. In the case of this studio, those processes focus exclusively on making space using Semperian tectonics. To accomplish this goal it is imperative to redefine the role of the digital tool and to integrate digital craft with manual craft in the application of essential design principles.

ENDNOTES

1 Gregotti, Vittorio; *Inside Architecture*; Trans Peter Wong and Francesco Zaccheo; MIT Press; 1996; p 49.

2 Gervork Hartoonian notes the elevation as technology "defined not only as the process of making, but more important, as the destination of the building itself." in Hartoonian, Gervork; *Ontology of Construction: On Nihilism of Technology in Theories of Modern Architecture*; Cambridge University Press; 1994.

3 This is similar to Sanford Kwinter's definition of form: "What I call true formalism refers to any method that diagrams the proliferation of fundamental resources and demonstrates how these accumulate into figures of order and shape...Formalism demonstrates first and foremost that form is resonance and expression of embedded forces. in Kwinter, Sanford; *Far From Equilibrium: Essays on Technology and Design Culture*; NY: Actar; 2008.

4 Vittorio Gregotti reminds us that "...an interior right in interrelations rather than in form for which simplicity is, above all, a triangulation of the experimental field." in Gregotti, Vittorio; *Inside Architecture*; MIT Press; 1996.

5 Using Gottfried Semper's four tectonic elements aids students in understanding the spatial implications of form without resorting to fantastical formalism. No matter the complexity of form "the original constituent parts can still be distinguished" by virtue of these basic elements. Semper, Gottfried. *The Four Elements of Architecture and Other Writings*. Translated by Harry Francis Mallgrave and Herrmann Wolfgang. Cambridge: Cambridge University Press, 1989.

6 Robert K. Barnhart's etymological dictionary tells us that the origins of tectonics isn't exclusive to the builder or carpenter, but is also relateted to "techne, art, craft" in design. Similarly breaking down the term "stereotomy" provides students with a knowledge of making related to discover as stereo refers to the "hard, firm, or solid and –tomy refers to the act of "incision". Each of these term origins gives the student insite into the relationship between making and discovery. Barnhart, Robert K. *The Barnhart Concise Dictionary of Etymology: The Origins of American English Words*. H. W. Wilson Company, 1995

7 Gottfried Semper provides insight into the extent to which fundamental elements of form influence design at many scales, across the allied "technical arts." Through architecture "we also encounter those simpler works to which the artistic instinct was first applied." Semper, Gottfried. *Style in the Technical and Tectonic Arts; or, Practical Aesthetics*. Translated by Harry Francis Mallgrave and Michael Robinson. Los Angeles: Getty Research Institute, J. Paul Getty Trust, 2004

8 Bötticher "distinguished between the Kernform and Kunstform; between the core of the timber rafters and the artistic representation of the same elements" in his understanding of tectonic "as signifying a complete system binding all parts of the Greek temple into a single whole." In contrast Semper's tectonic taxonomy divided the building into multiple built systems and distinguished only between "two fundamental procedures: the tectonics of the frame and the stereotomics of the earthwork." Frampton, Kenneth. Studies in Tectonic Culture: The Poetics of Construction in Nineteenth and Twentieth Century Architecture. Cambridge: The MIT Press, 1995

9 Semper, Gottfried. The Four Elements of Architecture and Other Writings. Translated by Harry Francis Mallgrave and Herrmann Wolfgang. Cambridge: Cambridge University Press, 1989.

10 In the same way that Hutchins describes the multi-step structure of ocean navigation, we use the accumulation of drawings by the students as a roadmap to the work during the quarter. "In an external representation, structure can be built up gradually--a distribution of cognitive effort over time--so that the final product may be something that no individual could represent all at once internally." from Hutchins, Edwin; *Cognition in the Wild*; MIT Press; 1996.

11 This is the sort of diagram that design can be extracted from that Kwinter refers to: "The diagram is an invisible matrix, a set of instructions that underlies--and most importantly organizes--the resevoir of potential [forces] that lies at once actively and stored within an object or an environment. It determines which features are expressed and which are saved. It is in short, the motor of matter, the modulus that controls what it does." from Kwinter, Sanford; Introduction (titled The Judo of Cold Construction) to *The Atlas of Novel Tectonics* by Jesse Reiser and Nakano Unemoto; Princeton Architectural Press; 2006.

12 Ching, Francis D.K. *Architecture: Form, Space, and Order*. 3rd. Hoboken: John Wiley and Sons, Inc., 2007.

13 This is where in the exercise the true manual-digital-manual transaction occurs. "All the major computations in this system are based on procedures that involve measurement (which is analog-to-digital conversion) followed by digital manipulation, followed by digital-to-analog conversion in the plotting of results on a chart" from Hutchins, Edwin; *Cognition in the Wild*; MIT Press; 1995. Hutchins is referring to navigation, but the process of observing a site and its physical factors, transferring those observations to narrative form, translating the narrative form to a diagram or sketch, and then translating the abstract sketch to a coherent and organized building plan is the exact same type of manual-digital-manual procedure that Hutchins is describing.

14 James Turrell notes this when he says: "One of the things in architecture is that, generally, people are making forms and not spaces." quoted in Birnbaum, Daniel; James Turrell: The other Horizon