Learning to Draw Through Digital Modelling

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Abstract

The education of architectural designers begins by learning drawing and digital modelling following the notion that students learn these new modes as instruments of thinking in design process. Curricular arguments persist about which mode should follow the other. Difficulties occur when one mode replaces the other. Students uninitiated to design seem to prefer the more immediate volumetric visualization of digital modelling over plans, sections, and elevations, representational views resulting from the un-real 'viewpoint' of the section-cut, a means only drawn out of reality through a way-of-looking NOT natural-to-experience. Therefore, the primary difficulty in learning to think through drawings is their abstraction from, rather than connection to, realness – a needless initiating ordeal that confuses rather than clarifies. Digital modelling offers virtual three-dimensional images that seem to students, by contrast, not quite as abstracted from natural experience, albeit framed by non-physical, seductive, machine 'otherness'. This paper proposes drawing pedagogy that learns from digital modelling by making connections rather than distinctions that more seamlessly connect abstract to actual. Projects will be demonstrated that manipulate three-dimensional forms to initiate drawing learning experiences. Drawing and its abstractions can thus more readily be drawn out of experience and made ultimately more concrete for design thinking.

Key words

abstraction, representation, learning drawing, digital modelling, design thinking, design education

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This inquiry concerns the initial relationship between learning basic architectural design thinking through drawing and model making with respect to opportunities and difficulties presented to this relationship by digital modeling applications. It is proposed that strategies for early drawing pedagogies can be developed with respect to digital modeling in a manner that can better inform the learning and creative use of architectural representation as a precursor to digital modeling. The premise for this strategy lies in the preference that students uninitiated to design thinking exhibit for the more immediately volumetric appearance of digital modeling over visualizing architecture through plan, section, and elevation. Representational images are drawn out of the actual world of things by abstracting mechanisms like the section cut that intend transform the three-dimensional into two–dimensional representations. Learning architectural drawing, and subsequently using these representations as instruments of design thinking, presents to students new to design as disjointedly extracted from the world of experience. This disassociation of image from experience creates a confusion of abstractions that slows comprehension of employing representation in thinking through design exercises. To the contrary, the author has observed that new design students exposed to three-dimensional digital modeling imagery seem to have less difficulty encountering its abstractions as a correlate of the actual experienced world. Digital modeling imagery appears to students more natural to the spatial nature of the world, and thereby less abstracted, than conventional two-dimensional architectural representations. Can a tendency for greater veracity in digital modeling lead to pedagogical methods for introducing representational drawing that enable abstractions to be more grounded in the actual world and thus reduce the confusion that slows learning design thinking? This paper will explore mechanics of abstraction in representation in hand drawing and in digital modeling in a search for a rationale for drawing pedagogy for beginning designers that better informs the abstract nature of representation while its techniques are being learned while also better anticipating the inevitable use of digital modeling. The goal is to inform both pedagogy and comprehension of representation for design thinking in a manner more drawn out of experience and thus more integrated into design thinking.

Drawing is Abstract Thinking

Learning drawing and digital modeling occurs typically at the beginning of architectural education following a curricular intention that students learn these new modes for use as instruments of design process. Arguments persist about which mode should follow the other. Difficulties persist when one mode replaces the other. Like many architecture programs, the design curriculum at the University in which I teach is structured to first learn to draw and sketch on the premise that learning drawing and sketching imparts a way of seeing the world through representational models as a precursor to using digital applications like Sketch-up, Revit, Rhino, etc. as tools of design thinking. This curricular structure is sequenced in

recognition of the difficulties beginning design students experience in coming to terms with how abstract representation describes the world around them and how representations might then become operational for design visualization and decision making. A primary issue for curriculum structure is that in order to learn to design, students need to learn to think through representational forms and use these forms to communicate imagined architecture. As developed by Alberto Perez-Gomez and Louise Pelletier, architectural representation can be characterized as an instrument of design thinking that ultimately conceptualizes symbolic notions about beliefs about the order of the universe while at the same time serves a functional role of communicating or working out a building's geometric and technical dimensions. (Perez-Gomez and Pelletier, 1997). Comprehending the abstract ordering system of the act of representation itself is necessary before it can be used effectively as an instrument of design thinking or represent more broad design issues.

Comprehending representation as an ordering system is for beginning design students a problem of understanding both the underlying structure of abstraction inherent in representation and how it transforms actual reality. In his book *Visual Thinking*, Rudolph Arnheim describes the act of abstraction in terms of a removal, "since the verb abstrahere means to actively draw something away from somewhere and passively to be drawn away from something." (Arnheim, 1969: 153) Architectural representational drawings are drawn out of the experiential world but are abstracted from it according to particular conventions. In a typical beginning architectural design curriculum, students learn to use physical models and floor plans, elevations, sections, and paraline and perspective drawings " to form models and simulations of future possibilities, as architects work towards something actual – the realization of a building." (Sweeting, 2011: 1159-60) Bruno Zevi, in his seminal work, Architecture as Space: How to Look at Architecture, summarized the problem of using conventional representational drawings as tools of design thinking.

The plan of a building, being nothing more than an abstract projection on a horizontal plane of all its walls, has reality only on paper. The facades and cross sections of the exterior and interiors serve to measure height. Architecture, however does not consist in the sum of the width, length and height of the structural elements which enclose space, but in the void itself, the enclosed space in which man lives and moves. What we are doing, then, is to consider as a complete representation of architecture what is nothing more than a practical device to put on paper specific measurements…. For the purpose of learning to look at architecture [to experience it], this would be more or less equivalent to a method which described a painting by giving the dimensions of its frame, calculating the areas covered by the various colors and then reproducing each color separately. (Zevi, 1974: 22-23)

Plans and section drawings are constructed using the Cartesian coordinate system and by use of the artifice of the section-cut. These are conventions that must be learned as abstractions. The idea and means of the section-cut as generator creates an un-real 'viewpoint' of the section, a point of view drawn out of reality through a way-of-looking significantly NOT natural-to-experience. A primary difficulty in learning to think design through drawings is thus their abstract difference from reality, rather than their connection to reality. Zevi continues in describing a key problem that the indirect, abstract nature of architectural representation presents for architectural design thinking:

All the techniques of representation and all the paths to architecture which do not include direct experience are pedagogically useful, of practical necessity and intellectually fruitful; but their function is no more than allusive and preparatory to that moment in which we, with everything in us that is physical and spiritual and, above all, human, enter and experience the spaces… That is the moment of architecture. (Zevi, 1974: 60)

This separation from the reality of experience requires of beginning design students to first have to comprehend, and then accept, drawing's mechanisms of abstraction. Learning to draw means learning drawing techniques. Learning technique requires the practice of many drawing iterations over time. The increased duration of time accommodates the fact that learning architectural representation also transforms the way one looks at the world. At the same time, learning this new, abstract way of seeing the world opens the world to new possibilities, interpretations, and range of content. This personal transformation is fascinating yet disconcerting. It conflicts with each student's previously known and comfortable yet uninspected way of seeing the world. However, instead of giving clarity, it tends to be experienced as an unwarranted initiation of confusion. This transformation requires of students a period of acclimation and reconciliation, especially as it also occurs in the context of grappling with the newfound complexities of creative design decision making.

Design situations that contain a number of abstract and disparate choices that seem impossible to reconcile, are characterized as "wicked problems" by mathematician and design theorist, Horst Rittel. The 'wicked problem' recognizes a set of circumstances that defy resolution by traditional and formulaic processes and seem impossibly difficult to resolve due to many factors, variables, and complexities. (Rittel and Weber, 1973) Wicked design problems contrast to 'tame' problems, such as in mathematics, where it is clear whether or not the problems have been solved because answers result from finite calculations. Wicked problems, by contrast, contain confusing information and conflicting interests, interdependencies, and values that are frequently difficult to recognize or even identify. In a wicked problem, the ramifications of any solution remains confusing throughout design, with no evidently arising sense of completion, and even resistance to solution. (Rittel, 1988)

If the designer's intelligence and experience is insufficient to the task, as is the case with beginning design students, design problems will fit the description of 'wicked'. Initial design problems are typically encountered as an unwieldy complexity of factors amplified by misguided preconceptions, limited life experiences, and a lack of clarity in the newness of using abstract representations in thinking through design ideas. Beginning design students tend to define any recognition of complexity in terms of ambiguous vagueness, followed by an attitude of uncertainty and the feeling that the design problem is an unresolvable moving target. Confusing encounters with the abstraction of representation are a more confounding aspect of the beginning design learning scenario than is typically acknowledged by both curricular structure and by beginning pedagogies.

Learning Design Thinking Through Representation

In beginning design experiences, inculcating new media into new ways of thinking about the world is a function of the rate by which it can be competently learned, which in turn, affects ability to think using these representations in designing. In order to learn to design, students must learn to make forms of representation into instruments of design thinking. (Perez-Gomez 1997) Learning to draw is a slow process of learning to correlate the mind with the hand in direct engagement with the media of drawing, a skill developed only through the practice of drawing itself. Design thinking skills, however, are dependent on being able to think through representational models, not just as simulations of buildings but as generalizations of ideas. (Hoover, Rinderle, and Finger, 1991) Rudolph Arnheim, in articulating abstraction within acts of generalization, develops in abstraction a conceptual order that is a generative, "act of restructuring through the discovery of a more comprehensive whole." (Arnheim 1969: 187) Learning drawing skills while at the same time learning to think as a designer happens in a manner where one skill mutually transforms the other. As one begins to comprehend how representations correlate with perceived reality as abstract simulations of its particular aspects (walls, floors, roofs, thicknesses, etc.), learning to think through these representations reinforces imaginary and conceptual design thinking with respect to other more symbolic aspects. Arnheim views representation and design as part of the same cognitive activity:

Primary abstraction cannot be said to presuppose an act of generalization. Instead, percepts are generalities from the outset, and it is by the gradual differentiation of those early perceptual concepts that thinking proceeds toward refinement. However, the mind is just as much in need of reverse operation. In active thinking, notably in that of the artist...wisdom progresses constantly by moving from the more particular to the more general. (Arnheim, 1997: 186)

Increasing abilities to use representation to augment imaginary visualization, correspondingly increases realization of manipulating the abstractions of design thinking. Realizing more than simulation within representation leads to use of representation to make connections with design issues from aspects of experience and concepts conjured in active thinking inclusive of such forms as symbolic or diagrammatic thought. This is the moment when design thinking begins. Use of representation merely as a mechanistic model of future building adds little to design thinking.

The pace of design and drawing mutually engendering one another differs for each learner. Each student's capacity for learning abstraction is influenced by both their own particular experiences in the world and by what learning researcher Howard Gardner terms their propensity for a particular manner, or intelligence, of learning. For each particular manner of learning, the degree of engagement between mind and the world differs, thus influencing the degree of disconcertment for abstraction's relation to the actual world. (Gardner, 2011) This, in turn, advances or delays the multivalent use of abstraction in design thinking.

Likewise, each student develops a differing relationship to the way digital modeling represents the world for design thinking. Digital applications, contrary to hand drawing, exist in the virtual world of the computer, which is a mechanism apart from its user that is indirect in its

operations. Digital modeling applications derive their origin in the methodologies of hand drawing and the manner in which drawing constructs representations of the physical surroundings. However, digital modeling applications are by degree more abstracted from the actual world than hand drawing techniques because they employ abstract computational symbolic languages embedded within software algorithms that are invisible to the user. (Spalter, 1999) Use of the hand in drawing does not engage this level of abstraction. As it is guided by mindful intentions and correlations with the geometries and proportions of the actual world, the hand moves analogously to that which is being drawn as a direct model of it. (Carpo, 2013, McCullough, 1996) In this way, comprehension of hand drawing develops in mutual relationship to the growth of design thinking in the young designer, while the digital working environment contains operations that are outside of design thinking. This is problematic for design students learning to think through representations.

Digital algorithms exist due to a pre-specified set of operations within computer programming. Full comprehension of these operations remains outside and beyond moment-to-moment design thinking. Additionally, the computer necessitates learning the referential notation of the keyboard, an indirect and symbolic form of mediation that has nothing to do with architectural design. Gregory J. E. Rawlins recognizes this difficulty as part of an entire system of substitution where, "the keyboard replaces our pen, the screen replaces our paper, and the chip replaces our brain." (Rawlins, 1997: 4) The keyboard's only reference is to its own history as keyboard commands, an analogous system of symbolic signs borrowed from language whose command structure must be learned through association and have no direct relationship to the representational tasks being asked of them. Screen menus, scroll bars, and palettes of symbol notations only seem less abstract because they are visual but keyboards still present the problem of learning through symbols and relationships that increase mediation between design thinking and the act of representation.

Learning design thinking through these highly mediated elements increases the abstract distancing from design ideas that are, in the end, meant to be carried out in actual materials and actual space, and with respect to actual experience, thus increasing the "wickedness" of the design experience. (Rittel, 1988) Increased mediation is a primary challenge to the path of beginning designers toward realization of more broad engagement with representation in design. The caveat here, as Zevi reminds, is that both representation and design processes are themselves abstract processes, and as such, have limitations on their respective capacities to address the living experience of architectural places (Zevi, 1974).

When constructed by hand, a representational architectural drawing presents elements of ratio, proportion, and depth, all brought into form as a function of both the physical process of drawing and the time is takes to perform the steps necessary to the drawing itself. Drawing by hand is a process of constructing step-by-step as an additive process, parallel to and concurrent with design thinking about what is being drawn. Digital modeling, by contrast, is "collapsed into a non-spatial world of encoded instruction," within a dimensionless virtual abstraction in which "concepts of space and time have been eroded." By its very nature, a digital model is constructed further from, or abstracted from, the interaction of the designer. In her book, The Computer and the Visual Arts, Anne Morgan Spalter evokes Paul Virilio's "reality effect of acceleration," a process in which digital processing speed and computational processing creates an abstract and dimensionless disjunction between an author and the work being produced. (Spalter, 1999: 440 - 410) Digital acceleration also has an effect of blurring the iterative flow of the creative processes within invisible algorithmic abstractions.

On the computer, the history of a work, and the evidence of an artist's hand and testimony to the process of creation (and also of exchange afterwards) are erased as soon as they are made. A digital work has no evident history. (Spalter, 1999: 441)

A digital representation does not retain connection or lineage to any origin – its only life is as an abstraction. This is why students like to engage it. The connection to an origin in the world that occurs in hand drawing is a function of the substantive consequences of the actual world and the immutable laws of its physical, material nature. In the representations of digital modeling, the laws of physical reality are suspended, as they are in the unreal world of cartoon animations. Digital modeling applications allow a designer freedom from issues like gravity, orientation, scale, time, and materiality while they enable other actions like immediate replication, mirroring, inversion, layering, and deletion of part or whole. A digital model appears to offer to the designer a picture of the whole and the illusion that one is working on the whole, as one toggles back and forth between a partial, closer view and an overall view from differing viewpoints. Conventional architectural drawings, on the other hand, offer only a single representational view at a time or they exist as differing single views that taken together can become whole only if connected within an observer's

imagination. The mental exercises required of this connecting frequently presents difficulties for a beginning designer who is also trying for the first time to build and hold together a conceptual idea, as well as fragmented representations abstracted from experience.

Representational media differ in other ways. Drawings constructed by hand with drafting tools require a duration of effort on the part of the designer, resulting in a sense of commitment to the process of drawing that must precede the act of drawing itself. Digital applications are, in a sense, always on, and do not require the engaged commitment of effort that completing a drawing requires. A digital model may be drawn and deleted, partially deleted, or partially saved (as a distinct digital file) at any moment in the process of constructing it, should the designer decide to do this. Drawings constructed by hand cannot accomplish this array of possible outcomes as easily or as quickly. The additional effort of tracing is required to make a partial version and it is not possible without much effort to produce various versions of a drawing.

Digital Lessons for Drawing Pedagogy

Students uninitiated to design thinking seem to prefer the more immediate volumetric visualization of digital modeling over conventional representational orthographic views resulting from the abstracted and un-real 'viewpoint' of the section-cut, a means drawn out of reality through a way of looking not natural to experience. Therefore, the primary difficulty in learning and subsequently using representational drawings is their abstraction from, rather than connection to actual buildings. Coming to terms with the abstraction of representation is thus experienced as a needless initiating ordeal that confuses rather than clarifies. Digital modeling, on the other hand, offers virtual three-dimensional images of reality that seem to students, not quite as abstracted from natural experience, albeit framed as it is by a seductive, non-physical, machine character.

If the more immediate volumetric visualization of digital modeling provides for beginning students a seemingly more tacit connectedness through experience than orthographic methodologies, then this engagement, if harnessed appropriately, can help alleviate student difficulties with the abstract formalization of drawings. Using three-dimensional modeling applications results in a visual display of volumetric solids, ostensibly arranged in a manner appearing more visually collateral with intentions toward the resulting shape. The displayed image is not a plan, elevation, or section drawing view but a three-dimensional view of the entire object at some distance. (Figure 1)

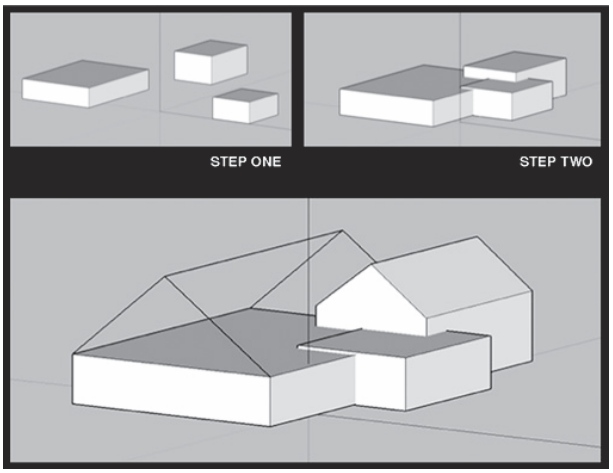

Figure 1. Three-dimensional cubic forms digitally transformed as a series of steps within Sketch-up software into a house-like form. (Sketch-up model by Stephen Temple)

Design judgment of what is being formed occurs with respect to a view of the object that can occur with variable points of view, including parallel projection and eye-level perspective views. The designer may choose to move closer to the object or inside the object for an interior point of view. The point of view may also be situated to a position that simulates eye-height scale, similarly to a physical model if raised to eye level and rotated along an imaginary flat plane. A physical model is limited, however, to the exterior view unless it is built to very large scale. One imagines Frank Gehry popping up inside the very large scale model of the interior of his design proposal for the Disney Theatre in California (as seen in the film, *Architecture in Motion*, which depicts Gehry's design process). (Sherrin and Gehry, 2003)

Early drawing exercises, if informed by digital modeling can make connections rather than distinctions that more seamlessly link abstract mechanisms to actual experience. A case study project demonstrates manipulation of three-dimensional forms to initiate drawing learning experiences that enable abstract operations of the drawing form to be more readily drawn out of experience and thus made more concrete for design thinking. This project was conducted within a beginning architectural drawing course with 18 students instructed by the author at the University of Texas at San Antonio. Pedagogical intentions of this project also establish ground for the use of digital tools in design thinking. Students were instructed to construct physical models from orthographic drawings that describe them. Physically constructed cubic solids were used to form primary interlocking volumes. (Figure 2) This physical

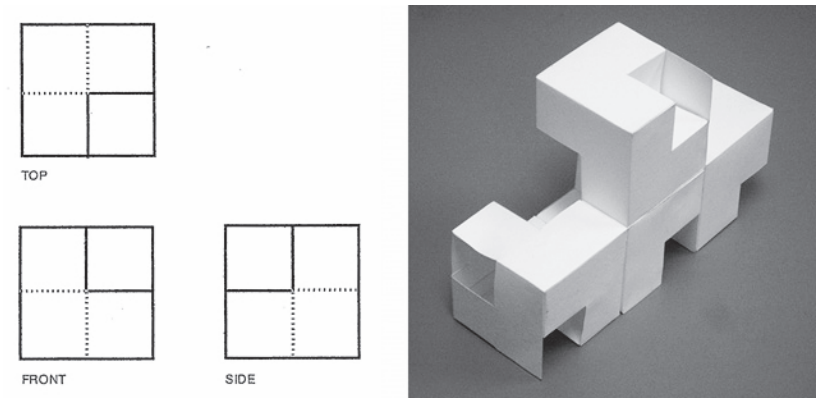

Figure 2. Four cubic paper models constructed from an orthographic drawing - placed in adjacent relation. (model constructed by Kevin Bates) Source: Stephen Temple

configuration of volumes was then used as a constant reference source from which drawings emerge, including cutting them in half with a band saw to demonstrate the section cut.

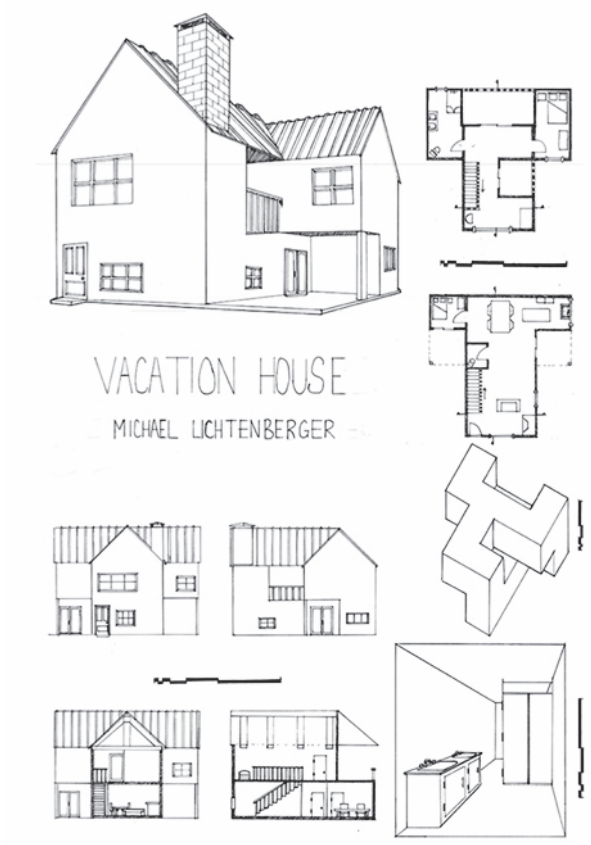

Figure 3. Complete composite drawing of a house designed block forms as its beginning (hand drawn by Michael Lichtenberger) Source: Stephen Temple

Abstractly developed two-dimensional drawing information informs visualization and construction of the three-dimensional forms built from this information. Four modulated cubic blocks with alternate corners removed to the half dimension are arranged into a whole side by side, stacked, or fitted together by interlocking missing corners, thus giving greater complexity to the whole. This model is then drawn in the orthographic drawing (front, top, side view) and as an axonometric drawing. (Figure 3) Students then design a vacation house using at least three cubes together as a starting point. Each cube measures 20' -0" on each side to cause visualization in scale. Section cuts of the cubic arrangement must be constructed to understand the arrangement of each floor plan and the vertical building section. Offsets in each cube cause complexity in floor plans and vertical sections and design challenges with the development of stair connections. A final composite drawing encompasses all the drawing lessons over an entire drawing course. (Figure 3)

Juxtapositions between learning to think through digital modeling and learning to think through drawing reveal that drawing pedagogies can be enhanced by digital modeling and also become a better precursor to it within the curriculum. By using three-dimensional models as a starting point to mimic the volumetric thinking that occurs in modeling, the learning of drawing and its abstractions is made more concretely connected to and ultimately drawn out of experience.

Ramifications

Because very tangible buildings are the result of architectural design activities, it is a near obligation of beginning design instruction to convey the idea of drawn representation in terms of conventional drawings that intend a one-to-one correspondence between represented architectural ideas and the actuality of the constructed building. Drawn representations are direct, scaled representations of a building in miniature purposefully for communicating a building's measured configuration. To become so, they are defined by certain mechanisms of abstraction that must be understood as such if the drawings are to enable their intended comprehension. But there is far more to the imagined reality and experience of architecture than these drawings are able to convey, especially when used by a designer to

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convey the conceptually imagined or to work out the effects of the actual architecture on the embodied experience of it's occupants.

Architectural drawings are not created as an end in themselves. They are produced to demonstrate architectural concepts…. Most importantly, they are the essential scaffold to form a transformative imagination since architecture begins not in thought (as other disciplines have often implied) but in the perceptual relationship between our bodies and the world. (Frascari, 2011: 58)

The dynamic and formative role played by media, whether by hand or digital means, in design thinking is itself reliant on the abstracting powers of representation in such transformative creative activities as 'visual thinking', diagraming, and modeling architectural designs that do not as yet exist. Media functions in design thinking as a form of thought apart from the actuality of things that can inform a designer's embodied engagement and, at the same time, it can limit design thinking to the specific form of media. Specificity caused by the abstracting operations of representation can allow focused thinking and the emergence of new thinking but such focused thinking can also abstractly reduce the issues addressed, often at the omission of important issues, or even obscuring the whole. This can be productive or detrimental or can result in a confused role for representation in design in which beliefs emerge that architecture should represent nothing but its own abstraction. (Vesely, 2004) Media will always manifest the power of abstraction in design transformations, and each different form of media presents itself distinctly as a mode of visualizing, as a way of seeing, and as such offers multiple directions for design thinking. Therefore, developing interplay between media, especially while it is being learned, can cause new thinking about the current media and the previous media, an interactive process that can give new context to design decisions at any iterative stage.

It has been the subject of this inquiry to consider a transformative role for digital media on both the pedagogy and learning of hand drawing techniques of conventional architectural drawing typologies. Although some correlations between student learning experience and offerings by media typologies have been shown to result in mutually beneficial pedagogies, this relationship lies largely unaddressed in architectural education. While derived from hand drawn conventions, digital tools for architectural representation that lead to building design are not equivalent to paper and pencil drawings because they rely on the mathematical projections of a machine. In this regard the potential of digital tools to aid in transforming architectural ideas is still undeveloped as its potential to transform design curricula (for better or worse).

As it is based on pre-engaged algorithms, the digital world, like drawing, conjures an abstract sense of operating outside design thinking. However, virtual representations are highly, and invisibly, mediated in ways that drawings are not and thus affect actions performed on design thinking in very different ways. In the book, Abstracting Craft, Malcolm McCullough argues that using digital imagery in designing the physical world can lead to diminishment of sentient, tacit relations to the world and the meanings that derive from it. (McCullough, 1996: 5) If Frascari's contention that drawing helps enable a greater connection for architecture in the perceptual realm between body and world is threatened by the abstract distancing of digital imagery, then drawing demands its place at the beginning of architectural education, prior to use of digital media.

Learning representation by hand drawing in correlation with design thinking exercises in beginning design experiences enables direct, mutual hand/mind connections, constructed relationships that may alleviate some of the abstraction of drawing conventions within a practiced continuity. Transformative iterations of design decisions occur with each additional drawing as a refinement of the previous by overlay tracing or by rebuilding the original drawing following renewed conceptual thinking. One does not erase (delete) a drawing and start over. Iterations in digital applications in beginning design experiences, to the contrary, tend to occur as a single digital construct or by way of complete deletion and reconstruction of a new digital model. Instead of an overlay of one way of thinking upon another, as happens in hand drawing, the original digital model – and the thinking that generated it – tends to be modified only by a new start on a blank screen. Differences of process within variations in media are fertile ground for additional investigation, especially as they affect early learning and pedagogies.

In pedagogies where learning drawing by hand precedes the learning of digital modeling, precursor experiences from digital modeling that inform hand drawing can help ground the abstractions of basic representational conventions. Such a shift in pedagogy can help alleviate the difficulties many beginning design students have in reconciling the abstraction of representation with their perceptual experiences and thus enable greater realization of the transformative impact of representational modes as instruments of architectural design thinking. Learning to

recognize a ground for abstraction early in design education can enable consideration of concepts by multivalent means and in ways that better enable meaningful connections of architecture to forms of human perception, and subsequent relationships, behaviors, and patterns of life. This more grounded connectivity is especially important as the computer and its inherent digitally encoded structures more and more become the normative device of transformation of architectural ideas into constituent representations.

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