Thinking it through: the importance of study sketches and the implications for design education

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Abstract Study sketches, the loose and open-ended drawings that designers use, have been essential to the design process since the time of Leonardo da Vinci. The extent to which they remain essential to the design process, though, is the extent to which they possess unique qualities that facilitate design thinking. To make this determination, I review research on the relation between sketching and design thinking in the light of findings in cognitive science.

After distinguishing between two types of design drawings, the analytic diagram and the study sketch, I outline findings in cognitive science that confirm the need for graphic media to support a designer's thought processes given certain cognitive limitations. Next, I summarize the research of Fish (1990, 2004), Goldschmidt (2003), and Herbert (1993) who have argued that, beyond a one-way recording of visual mental imagery, expert designers use study sketches interactively to augment their thought processes. Three unique and interrelated qualities of study sketches emerge that facilitate design thinking – *immediacy, ambiguity, and mutability*.

Following a description of each of these qualities and the way in which *expert* designers exploit each quality to further design development, I highlight ways in which design educators might assist *novice* designers in developing proficiency in the use of both study sketches and analytic diagrams. These include teaching the loose application of drawing conventions along with freehand graphic projection methods, the use of freehand analytic diagrams to transform concrete architectural precedents into abstract exemplars, and the use of context and exploration drawings in the graphic – cognitive cycle (Herbert, 1993, pp. 108-113).

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Design Drawing and the Design Student

In a previous study, McGlynn, Belanger, and Rolley (2012) posed the following question: How can design educators teach students the value of diagramming for design discovery, ideation, and communication? They believed it "*incumbent upon design educators to make explicit the roles of diagramming in the design process given the design student's relative lack of familiarity*" as compared to an experienced designer (p. 224). The working assumption was that "*actual engagement in analytical diagramming throughout the design process is key to developing students' capacities for critical thinking and argumentation*" (McGlynn et al., 2012, p. 226). Although the authors still believe this to be the case, recent experiences in design studio teaching have led to the realization that there is another type of design drawing that students must learn to use to foster design thinking that necessarily precedes the production of finished analytic diagrams, and that is the study sketch.[1]

In the early stages of the design process, designers use analytic diagrams to collect and analyze information of potential relevance to the design task. In later stages, diagramming serves a two-fold purpose: as an analytic tool to increase the designer's understanding of particular aspects of a design proposal and as a means of communicating the designer's intentions to others. However, study sketches are a much more effective means for designers to develop conceptual responses to design problems.

Unfortunately, an increasing focus on digital graphic media in architectural curricula has tended to crowd out freehand design drawing methods in the design studio. While digital applications are undeniably useful for drafting and certain aspects of design, they are as yet an insufficient substitute for study sketches, which possess unique qualities that serve to support and extend mental imagery. However remarkable, our cognitive abilities are limited and need the assistance of study sketching when confronted by the complex and ill-defined problems that are part and parcel of architectural design. To better inform decisions regarding graphic media, a clear understanding is needed of the relationship between our cognitive limitations and the qualities that make study sketches useful, if not indispensable, in design.

Furthermore, to the extent that study sketching still occurs within the design studio, it is largely taught by example and learned by imitation. This informal approach had been successful prior to the pervasive use of computers, but more explicit instruction is now called for if study sketching is not to be prematurely abandoned as a design method. The real and perceived need to incorporate more content into architectural curricula continues unabated, so it is at best unrealistic to assume that architectural programs would reintroduce traditional graphic media courses previously abandoned in order to address this need. However, opportunities exist for design educators to augment existing curricula to assist design students in developing proficiency in the use of both study sketches and analytic diagrams. After highlighting the differences between these two types of design drawings, I outline key findings in cognitive science and design research that confirm the need for study sketching to support a designer's thought processes. Next, I call attention to the three unique qualities of study sketches – immediacy, ambiguity, and mutability – that facilitate design thinking, and conclude by discussing the implications for teaching and learning in design education.

The Analytic Diagram and the Study Sketch

Although related, analytic diagrams and study sketches possess meaningful differences related to their intent. When the intent is to analyze and determine relationships between discrete entities, analytic diagrams reduce a subset of information within the design task to its essence to facilitate understanding (Fig. 1). However, when the intent is to foster development of a particular design proposal, study sketches compose the known information of the design task, while remaining

[1] To describe this particular type of design drawing, I adopted the term "study sketch" from Goldschmidt (2003).

open for discovery and revision (Fig. 2). "*To the extent that the drawing is inexplicit and ambiguous, it is open to multiple interpretation, and it is exactly these multiple interpretations that allow further development of the design*" (Herbert, 1993, p. 52).

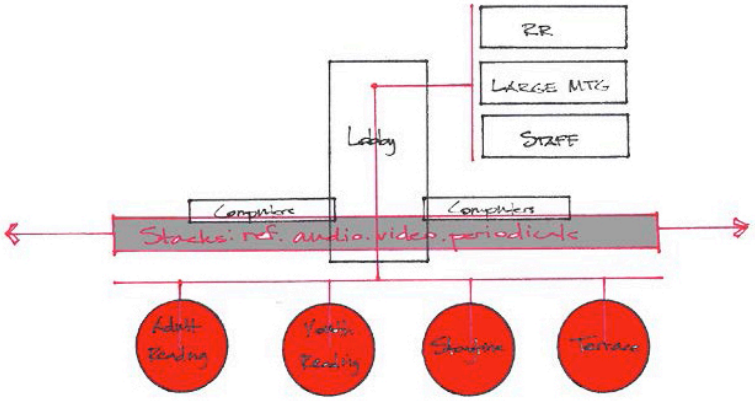

Fig. 1 Analytic Diagram (Kirk Chonis, 2010, with permission)

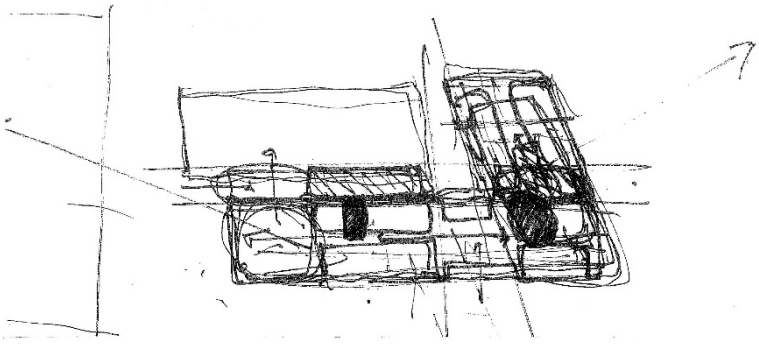

Fig. 2 Study Sketch (Author, 2013)

Herbert (1993) has pointed out that, while rough analytic diagrams resemble study sketches, they are in search of different ends - the analytic diagram "the appropriate form of the diagram" and the study sketch[2] "the appropriate form of a building" (p. 46). In other words, analytic diagrams, particularly in the early design stages, are non-representational and are intended to convey concepts of use to the design proposal (Fig. 1). Their non-representational character is precisely what makes these types of diagrams so useful in design as they, too, are "open to multiple interpretation". Rather than focusing on one particular design proposal, though, the concepts conveyed may result in the development of many design alternatives.

[2] Where I use the term "study sketch", Herbert (1993) used the term "design synthesis drawing". Design synthesis drawings are one type of what he called "architectural study drawings", which also include analytic diagrams.

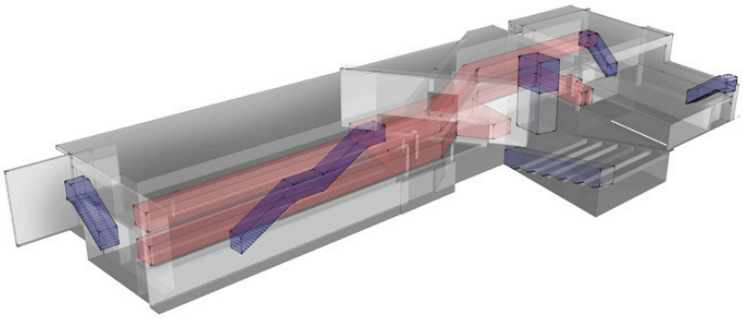

Fig. 3 Finished Analytic Diagram (Kirk Chonis, 2010, with permission)

Analytic diagrams occurring later in the design process often take on more of the formal characteristics of a particular design proposal as their role in the design process shifts from one of fostering design thinking to facilitating design communication (Fig. 3). In this role, analytic diagrams serve as a bridge between the designer's intentions and the understanding of others, and the easier it is for others to map the diagrams to the actual design proposal, the more likely it is that the designer's intentions will be conveyed. On the other hand, study sketches remain primarily "*private, investigative instruments. Any other use is incidental*" (Herbert, 1993, p. 17). When the design proposal reaches a sufficient level of development and external communication becomes necessary, the ambiguous and open-ended characteristics of study sketches are shed for the refinement and specificity of presentation or construction drawings, depending upon the audience.

While the theoretical basis for and practical application of these other drawing types is well developed, that is not the case for study sketches. This is problematic, as study sketches remain as essential to design thinking today as they have been since the Renaissance. The extent to which study sketches possess qualities that facilitate design thinking and are not duplicated by any other graphic medium, then, is the extent to which they remain essential to the design process. Prior to determining if there are such qualities, though, I first confirm the need for graphic media in design based upon findings in cognitive science.

Cognition and Study Sketches

Ultimately, the importance of graphic media to the design process is a product of our cognitive limitations. In order to understand these limitations, then, we need to understand the extent to which memory, language, and visual mental imagery contribute to our thought processes. The type of memory known as short-term memory is subject to significant storage capacity and duration limitations. First, we can only retain small amounts of information in short-term memory, about 5 to 9 items, while grouping related bits of information into about 4 "chunks". Second, we can only hold this information in short-term memory for upwards to about 30 seconds before this information is lost or transferred to long-term memory. It is also important to note that, while familiarity with particular bits of information makes it easier for us to "chunk" and thereby retain that information, it takes additional effort to retain complex information which reduces short-term memory storage capacity (as cited in Kosslyn & Rosenberg, 2011, p. 159). To make use of the information that we store in short-term memory, we use our working memory to transform and interpret both verbal and visual information "to plan, reason, or solve a problem". Working memory draws on the information from previous experience that is stored in long-term memory to guide thought processes and provide meaning (as cited in Kosslyn & Rosenberg, 2011, pp. 160-161).

Although not solely responsible for our thought processes, language and visual mental imagery are major contributors. We use language in working memory to break down more complex information, making it easier for us to hold on to this information in working memory for later recall and possible action. We also use language to describe and categorize objects, aiding in both the storage of information in working memory and the retrieval of related information stored in long-term memory (Kosslyn & Rosenberg, 2011, pp. 201-202).

Since visual mental images can represent actual and imagined objects, they "clearly play a role in thinking, allowing us to consider the results of possible arrangements and transformations of objects" (Kosslyn & Rosenberg, 2011, p. 204). Properties of visual mental imagery, such as spatial extent, limited field of view, and limited resolution, mirror those of visual perception because they share the same "topographically organized"[3] brain structures (as cited in Kosslyn & Rosenberg, 2011, p. 201-204). For this reason, visual mental imagery is subject to the same limitations as visual perception. Due to the limitations of short-term memory, designers cannot possibly hold enough information in working memory to resolve the complex, ill-defined design problems with which they are most often confronted. Designers use graphic media, then, to compensate for the incomplete and fleeting nature of their mental images.

Beyond a one-way recording of these mental images, though, designers use study sketches interactively to extend their limited cognitive abilities (Fish 2004, Goldschmidt 2003, Herbert 1993). Fish & Scrivener (1990) have argued that study sketches bridge between purely "abstract and categorical" descriptions (language) and purely "concrete and spatially specific" depictions (imagery) (Fig. 4). As such, study sketches are uniquely positioned as "*the percept*[4] *half of a hybrid percept – mental-image that amplifies the mind's capacity to make descriptive-to-depictive translations.*" (pp. 117-118)

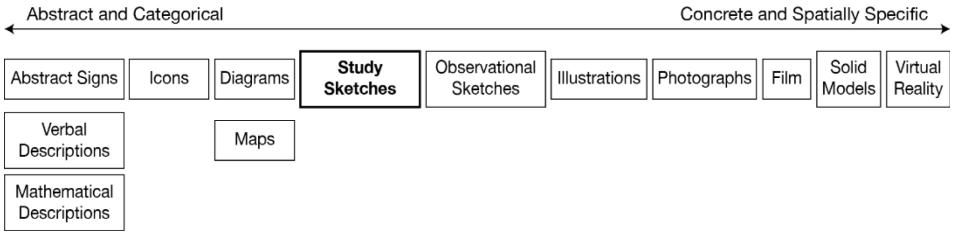

Fig. 4 A Continuum of Visual Representation (after Fish & Scrivener, 1990)

Similarly, Herbert (1993) has argued "*study drawings provide a means for cycles of graphic and cognitive processes to interact; their interaction is the source of information generated within the design task*" (p. 75). In describing this cycle, Herbert (1993) adopted a "functional model of cognitive processes" proposed by Charles Rusch (1970) (p. 76). Although slightly out of date, the model is in essential agreement with the cognitive processes described above. Therefore, Herbert's description of graphic and cognitive interactions requires only slight modification and is still of use in determining the unique qualities of study sketches that facilitate design thinking. In each cycle, the designer perceives and interprets a previous study sketch, retrieves relevant mental imagery from long-term memory to be combined with imagined imagery in working memory, adds a new mark to the previous study sketch, and perceives and interprets this new study sketch. Fish (2004) and Goldschmidt (2003) each described a virtually identical process. Herbert (1993) made clear that the two key interactions are drawing and interpreting. First, the designer must

[3] The brain structures responsible for visual processing "are organized so that the images projected onto the back of the eyes are laid out as patterns of activation on the surface of the brain" (as cited in Kosslyn and Rosenberg, 2011, p. 202).

[4] In this context, *percept* means "an object of perception; something that is perceived" (McKean, E. (Ed.). (2005). *The New Oxford American Dictionary* (2nd ed.). New York, NY: Oxford University Press).

make a deliberate addition to the study sketch, such as a new graphic mark, which is intentionally left open to interpretation. Second, the designer must regard the entire study sketch as mutable, allowing all marks to be read as ambiguous and, therefore, open to multiple interpretations (p. 83).

The Unique Qualities of Study Sketches

From the previous description of human cognition in relation to the designer's use of study sketches, three unique qualities of study sketches emerge that facilitate design thinking – *immediacy, ambiguity,* and *mutability*. The three are interrelated in that they are all an outgrowth of study sketch production methods, which include loose interpretation of drawing conventions, lack of detail, rough and unfinished character, and manageable size (Herbert, 1993, pp. 103-104). It is also important to note that, while these three qualities are inherent to the graphic medium, they require the skill of an *expert* designer to realize their potential in design. In other words, while the techniques can be learned relatively quickly, the conscious interpretation of study sketches is not automatic, but must be developed over time.

Immediacy, the quality of study sketches that allows for direct and rapid engagement with the task at hand, enables the graphic – cognitive cycle described above to occur unimpeded. Study sketches allow the designer to "*keep up the pace of change in the work, to capture as much as possible from the continuous reinterpretation of the cognitive image as it builds in new aspects of the design task*" (Herbert, 1993, p. 103). Goldschmidt (2003) noted that they are "cognitively economical", meaning precious cognitive resources need not be spent translating between multiple descriptive and depictive representational modes, such as from computational scripting to visual display to mental imagery (p. 87). Having internalized study sketch production methods, including a facility for graphic projection[5], expert designers can pay scant attention to drawing production, and instead can direct all of their attention to drawing interpretation.

Ambiguity is the quality of study sketches that allows for multiple interpretations and the generation of new information. The study sketch "*must be ambiguous enough to attract, admit, and hold new information from the designer's cognitive experience*" (Herbert, 1993, p. 116). The indeterminate nature of study sketches permits the designer to delay commitment to any one alternative and continue to develop the design. Ambiguity is essential to the graphic – cognitive cycle in that the quality encourages completion of the study sketch through mental imagery (Fish 2004). While using a study sketch to capture their intentions, expert designers are open to "*emerging relationships among its elements (i.e., lines, dots, etc.) some of which may be unintended*" (Goldschmidt, 2003, pp. 82-83). Whether intentional or accidental, these "emerging relationships" constitute new information, which expert designers recognize and exploit to move the design task forward.

Mutability is the quality that allows for study sketches to be subject to change. Like ambiguity, the mutability of study sketches is a consequence of their physical attributes and the way in which these attributes assist the human mind in manipulating and transforming study sketches through mental imagery. Fish and Scrivener's (1990) previously mentioned percept – image hybrid theory suggests that the rough and unfinished character of study sketches is not simply a product of the limited amount of time spent, but is actually quite deliberate and necessary (Fig. 2). In support of this claim, Fish and Scrivener (1990) cited research by Hayes (1973) in which some subjects reported that their ability to solve problems using mental imagery was hindered when the symbols that they needed to mentally manipulate were constrained in some way, for instance, by a bounding box. Also, some subjects indicated that they needed more space on the card displaying the problem in order to use mental imagery to solve the problem (pp. 123-124). Expert designers, then, will do such things as leave spaces between lines, allow lines to

[5] The five graphic projections as commonly understood are plan, section, elevation, axonometric, and perspective.

trail-off, and create open-ended shapes, while ensuring that the study sketch is of a manageable size with sufficient space for physical and mental manipulation.

The Implications for Design Education

Given the unique qualities of study sketches as a graphic medium and how *expert* designers exploit these qualities to facilitate their design thinking, how might design educators assist the *novice* designer in developing proficiency in their use? Traditionally, the design studio instructor models design thinking through study sketches, and then the student imitates. While traditionally highly effective and still the primary teaching method, increasing pressure to integrate digital applications into the design studio is leaving precious little time for instructors to teach and students to learn this critical skill. Despite this fact, there are opportunities both inside and outside of the design studio for design educators to teach the necessary techniques and emphasize the continuing importance of study sketches in design.

As noted earlier, designers must posses a facility for graphic projection, as it is key to the "cognitive economy" of study sketches. Herbert (1993) devoted an entire chapter to the subject, noting, "*Conventions allow economical cognitive schematization to begin by assuming one of a few possible armatures around which to organize the incoming visual stimuli*" (p. 91). However, graphic projection is primarily taught to students for the purpose of design communication, emphasizing strict rules of construction and hardline drawing. For design thinking, exercises allowing for loose application of drawing conventions coupled with freehand graphic projection methods should be emphasized (Fig. 5).

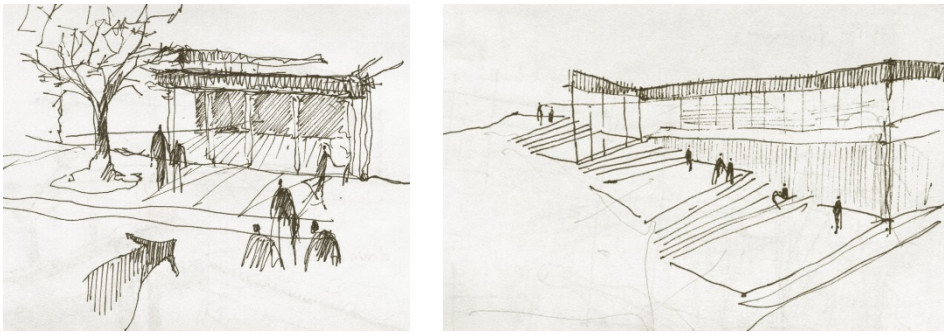

Fig. 5 Study Sketches Using Perspective (Annie Robinson, 2010, with permission)

Beyond technique, the one aspect more than any other that separates the expert from the novice designer is the depth of the expert designer's structural[6] long-term memory store due to experience. As previously discussed, working memory primarily draws on long-term memory for information which can be used to manipulate and transform mental imagery. Novice designers must compensate for this deficit in order to build-up a store of relevant information in dynamic[7] long-term memory for use in the design task. Analyzing architectural precedents, vicariously and directly, is an excellent means of doing so. Students should create analytic diagrams using freehand graphic projections to transform the "concrete and spatially-specific" design information of the precedent into an "abstract and categorical" exemplar capable of supporting many design alternatives.

[6] *Structural* long-term memory stores information "by connections among neurons" via a process called *consolidation*, which "converts information stored dynamically in LTM into a structural change in the brain". This process takes years to occur (as cited in Kosslyn & Rosenberg, 2011, p. 163).

[7] *Dynamic* long-term memory requires "continuing neural activity" to retain information (as cited in Kosslyn & Rosenberg, 2011, p. 163).

Of most importance to the novice designer, instructors must make evident the necessity of study sketches for design thinking. Instructors should teach design methods that emphasize "graphic manipulation" to generate information, and graphic media and production processes should be brought to the fore in the design studio for consideration alongside the design product. Perhaps Herbert's (1993) most important contribution, then, is his explication of the role of context and exploration drawings in the graphic – cognitive cycle based upon his empirical study of four expert designers. "The context drawing presents all that the designer knows about the work at that stage of the design task" and is used for "holding information in place and managing change" (Fig. 2). On the other hand, exploration drawings are abstracted from the context drawing "to explore possible changes" and "often appear as graphic asides at the edges of a context drawing" (pp. 112-113). Herbert's process is still valid, offers a level of specificity not found elsewhere, and could be used effectively to teach novice designers, who need to learn that they are not simply recording immediate experience or preconceived mental imagery, but instead are actively manipulating potential futures.

References

Fish, J. (2004). Cognitive Catalysis: Sketches for a Time-lagged Brain. In G. Goldschmidt & Wi. L. Porter (Eds.), *Design Representation* (151–167). London, UK: Springer-Verlag.

Fish, J., Scrivener, S. (1990). Amplifying the Mind's Eye: Sketching and Visual Cognition. *Leonardo*, *23*(1), 117–126.

Goldschmidt, G. (2003). The Backtalk of Self-generated Sketches. *Design Issues*, *19*(1), 72–88.

Herbert, D. M. (1993). *Architectural Study Drawings*. New York, NY: Van Nostrand Reinhold.

Kosslyn, S. M., Rosenberg, R. S. (2011). *Introducing Psychology: Brain, Person, Group* (4th ed.). Boston, MA: Allyn & Bacon.

McGlynn, M., Belanger, B., Rolley, S. (2012). Operationalizing Diagramming in Design Education for Design Thinking and Communication. In *Graphic Quest - The Search for Perfection in Design Communication* (224–232). Presented at the Design Communication Association Biannual Conference, Oklahoma State University, Stillwater, OK: School of Architecture, Oklahoma State University.