

Digital Environments for Early Design

Form-Making versus Form-Finding

Jerry Laiserin

The LaiserinLetter™ USA

jerry@laiserin.com

Abstract

Design ideas, like scientific theories, are falsifiable hypotheses subject to testing and experimentation and—if need be—replacement by newer ideas or theories. Design ideas also are known through distributed cognition, in which a mental construct and an external representation complement each other. Representations may be categorized along the axes 2D-3D and Analog-Digital, plus a proposed third axis from Form-Making to Form-Finding. In Form-Making, the mental construct component (of distributed cognition) arises before the representation. In Form-Finding, representation arises before the mental construct. All media of representation have different affordances. Certain media and representations afford Form-Making more so than Form-Finding; and vice versa. Design educators, students and practitioners will benefit from conscious, systematic choice of media and methods that afford an appropriate range of Form-Making and Form-Finding behavior when proposing and testing design ideas.

1. Design hypotheses and media

Austrian-British philosopher Karl Popper redefined thinking about science by casting scientific theories as “falsifiable hypotheses.”¹ In this view, the scientific method involves testing any theory via experiments to determine whether that theory is false. As theories survive the experimentation/falsification process, they gain greater acceptance and usefulness. By analogy, design ideas can be thought of as falsifiable hypotheses about possible solutions to design problems. Instead of the scientific method, design ideas are tested and experimented on in the design process. An architectural design idea, such as a *parti*, may be tested against the building program or brief; a massing model against the zoning envelope; or an enclosure design against the desired building energy performance. Design ideas that survive this process — are not falsified by the building requirements against which they are tested — gain acceptance and usefulness to the designer for subsequent phases of design.

Over the past two decades, numerous digital tools, both software and hardware, have emerged to help designers formulate, express, visualize and test design ideas. At the earliest stages of the design process, these digital tools complement, rather than displace, traditional analog tools and methods such as sketching on paper or building physical models by hand. However, this coexistence of electronic and paper-based tools tends to alter designers’ perception of both media.

Today’s designers are free to use a wide range of media and interfaces to represent their design ideas. In 1991, William Mitchell and Malcolm McCullough, both then at Harvard, laid out a framework for understanding these media in their ground-breaking book, *Digital Design Media*.² Grouping media according to what I call axes of representation, Mitchell and McCullough classified representations from 2D to 3D and from Analog to Digital. Thus, paper-based drawings are 2D Analog, while conventional CAD (or CADD) is 2D Digital, and so on. Furthermore, each of these modes of representation can be translated to the others. For example, paper drawings can be scanned to CAD files, and CAD can be plotted to paper; physical models can be 3D-scanned to 3D Digital models, and 3D Digital files can be

“printed” via rapid prototyping techniques; yet all these representations and media are different ways of expressing and viewing the same design ideas.

Architects and design professionals have enjoyed this analytic framework for design media and modes of representation for two decades. However, that framework does not explicitly accommodate classification of media by their suitability to support early design. I propose adding to Mitchell and McCullough’s two axes of representation a third axis from form-making to form-finding as in Figure 1. Form-making, loosely defined, is a process of inspiration and refinement (form precedes analysis of programmatic influences and design constraints) versus form-finding as (loosely) a process of discovery and editing (form emerges from analysis). Extreme form-making is not architecture but sculpture (perhaps, folly)—form without function. Extreme form-finding also is not architecture but applied engineering—form exclusively determined by function.

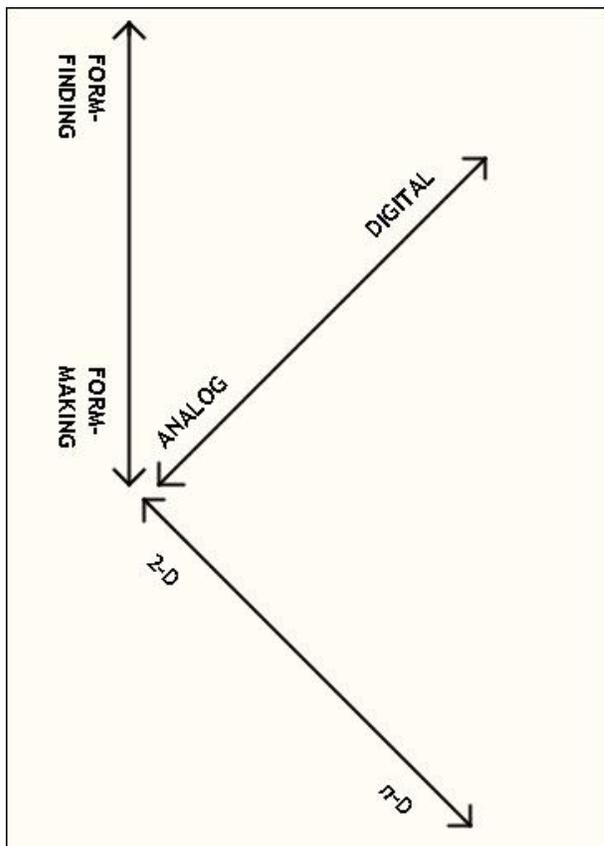


Figure 1 - Axes of representation

Known architectural design methodologies fall between these extremes. Although not intended for architectural criticism, it can be argued from this position that many canonical works result from design processes optimally balancing form-making and form-finding—e.g., the work of Louis Kahn.

2. Representation and cognition

Form-making and form-finding are more rigorously defined with respect to designers' ways of knowing. Distributed cognition posits that knowing occurs not solely as mental constructs, but is distributed in external representations as well. Such representations include maps, charts, graphs, diagrams, sketches, drawings, models and so on. Further, cognition of complex, social-behavioral phenomena such as operation of naval vessels may not reside with any individual but is distributed among crew members³—each of whom knows a portion of the whole as well as a mental model of which other portions are known by which crewmates.

Thus, representations are tools for knowing. As with all tools, these representations have affordances—the qualities of an object, or an environment, that allows an individual to perform action.⁴ This is a rigorous way of expressing the common-sense notion “to someone with a hammer, the whole world looks like a nail.” In other words, a fundamental property of the hammer is that it affords nail-driving.

If affordances determine or constrain the potential for action within or upon representations (in their role as tools), and if representations embody a necessary component of knowing (as constituents of distributed cognition), then knowing is determined or constrained by the choice of representation. Representations that seem well-suited to their subjects (i.e., their affordances are appropriate to desired actions with or on their subjects) are deemed to be “handy” (ready-to-hand, *zuhanden*⁵). Thus, maps are handy for wayfinding, graphs for mathematics and floor plans for building.

Representations that seem ill-suited to their subjects are not handy, but merely present-at-hand (*vorhanden*⁶). Such presence awareness disrupts knowing the tool-in-action and is experienced as “breakdown.”⁷ Designers seeking, e.g., a consistently handy representation for designing at campus scale may have difficulty choosing between GIS systems (handy at regional scale) and CAD systems (handy at building scale).

Distributed cognition and the affordances of design media thus correspond to our everyday understanding of “design”—designs are identified with their representations, which in turn are identified with the mental constructs of designers. A designer who “has a design” asserts the existence of both a mental construct and an external representation. To attain the condition *is_a_design*, then, there must exist both a mental construct and an external representation.

3. Time of design

Further, there must exist some “time of design,” T_d , at which both conditions (mental construct, external representation) obtain. For any $\Delta T > 0$ (i.e., after T_d) the condition *is_a_design* exists. For any $\Delta T < 0$ (i.e., before T_d) the condition *is_a_design* does not exist; which means absence of mental construct, representation or both.

Three possible sequences of action lead from a condition of “no design” to *is_a_design* as ΔT approaches 0 (time advances to T_d)—mental construct arises first, external representation arises first; or they arise simultaneously. Limits of human perception may imply that simultaneity is the more prevalent sequence; however, probability suggests simultaneity is a special case.

Cases or design methodologies in which mental constructs arise first can be labeled form-making: the designer has “an idea,” then sketches or otherwise represents the idea. Frank

Lloyd Wright's "shaking one out of [his] sleeve"⁸ also corresponds to form-making—mental construct precedes representation.

Cases or design methodologies in which representation arises first are labeled form-finding: designers doodle, pore over images or otherwise manipulate representations that are not yet "design"—but may represent programmatic influences and design constraints. Designers then "get the idea."⁹ *Objets trouvés*, algorithmic methods^{10,11} or aleatoric techniques of designers such as Peter Eisenman also are form-finding: representation precedes mental construct. However, it has been suggested that experienced designers, with greater knowledge of likely and/or possible designs, employ doodling strategies that inherently imply form.^{12,13}

Special cases in which mental construct and external representation arise simultaneously (or in such close temporal proximity as to be indistinguishable¹⁴) correspond to such scenarios as Merleau-Ponty's intentional arc¹⁵ or Schön's reflection-in-practice,¹⁶ plus practice examples as cited above re Louis Kahn.

Note that an alternative formulation collectively emerged from a 2004 workshop discussion on "The Designer as Tool Builder"¹⁷ in which the present author was a participant. Contrasts were drawn between "pre-rationalized form" (in which data precedes geometry) versus "post-rationalized form" (in which geometry precedes data) In the present argument, pre-rationalized form therefore corresponds to form-finding whilst post-rationalized form corresponds to form-making.

4. Form follows software?

Pierluigi Serraino, a Berkeley-based architect and theorist, has written extensively on the theme that "form follows software."¹⁸ In my view, Pierluigi's assessment is that different software tools afford different ways of design thinking and design expression.

What all of this means for practicing designers and design students is that no single tool can provide the best solution for representing any design idea. In fact, a disciplined process of exploring design ideas through multiple tools can help insulate designers from the subtle influences (and/or limitations) provided (and/or imposed) by the affordances of any single medium or tool. Many of the most proficient designers instinctively recognize this situation and consciously exploit it as part of their process for testing design ideas.

In his 2005 doctoral dissertation at Harvard, Athens-based architect Panagiotis "Panos" Parthenios examined many of these issues in considerable depth¹⁹ (full disclosure: I had the privilege of serving on Panos' dissertation committee). Panos' research included several elegant case studies of both skilled designers and design students at work. In one of these studies, an experienced project architect can be observed deliberately shifting her focus back and forth from sketches to CAD to study models and digital 3D to address emerging and evolving design issues as they came to hand.

This process is confirmed by a 2004 survey of 240 computer-using designers included as an appendix to Panos' thesis.²⁰ Regardless of age or years of experience, size of firm or types of projects, 60% of respondents identified pencil and paper as their favorite tool, with 80% starting their conceptual design process on paper—this despite the fact that all respondents identified themselves as computer-using designers.

The runners up to paper and pencil among tools/media for early design included Sketchup, 3D physical models, 3DStudio Viz/Max, AutoCAD, ArchiCAD, formZ, Revit and Photoshop.

Other favored conceptual design tools ranged from the expected, such as Maya, Rhino and Vectorworks, to surprises such as Microsoft Excel and Word (for conceptual design!). Adobe InDesign and Illustrator were not mentioned (perhaps because the Adobe Creative Suite was being revamped at the time of the survey) and Autodesk Impression had not yet been introduced to the market.

5. Choosing tools

By a 2:1 margin, survey respondents preferred to work with multiple software packages for conceptual design, despite expressed frustration with data exchange among the tools. Sixty-three percent believed computer tools allow them to design “better;” whereas 22% said faster, but not better; with 10% seeing no change; and only 3% perceiving the impact of software on conceptual design as negative. Among the aspects of their work that respondents saw as improved by digital tools were: visualization, communication, exploring more alternatives, exploring more complex geometry, improved perception, more organized thinking and “getting inspired.”²¹

Renée Cheng, Head of the School of Architecture in the College of Design at the University of Minnesota, says that students today “come in with great fluency in digital tools, so that schools of architecture no longer need to teach computer skills or specific software.” However, she also notes that “students don’t choose tools well and often stick with them too long — they get stuck, but don’t always know enough to know that they’re stuck.” The teacher’s job, then, is “to push students to use different tools and media... [in order] to ask different questions about the design.” In fact, according to Cheng, “any tool is more powerful if it is part of a cycle of digital and analog, going back and forth, rather than a linear progression from sketching first, then digital modeling, with no return.” She encourages her students to do the same with 3D models and digital tools, “3D printing the model, then sectioning it on the band saw, modifying and gluing it back together before remodeling it in the computer.”²²

6. Critical Implications

Design educators, students and practitioners will benefit from conscious, systematic choice of media and methods that afford an appropriate range or “space” of Form-Making versus Form-Finding and Analog versus Digital media, strategies and behaviors when proposing and testing design ideas—as shown in Figure 2.

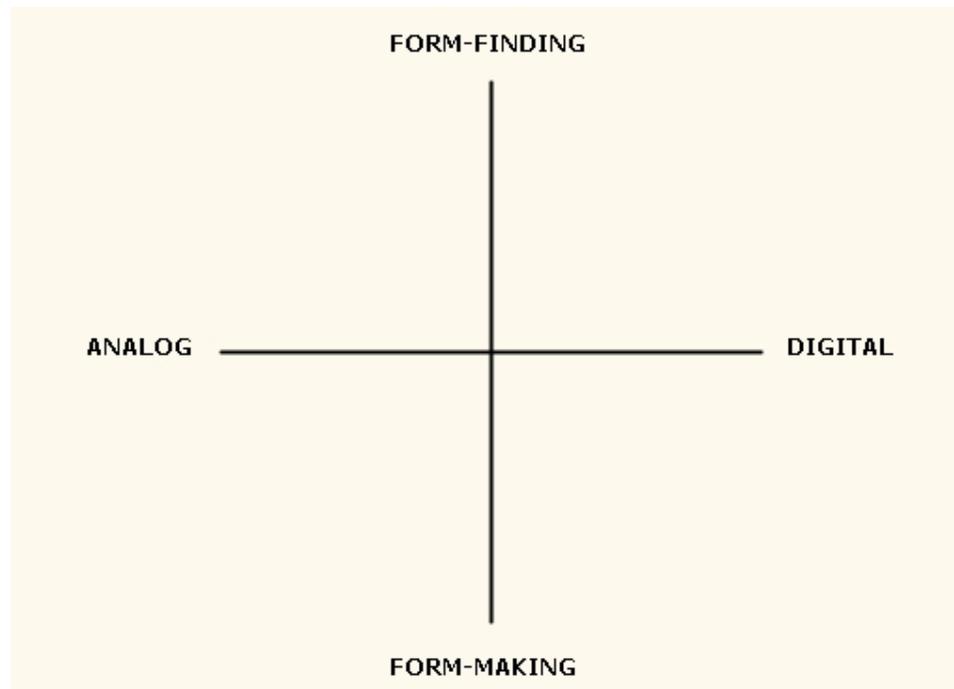


Figure 2 - Space of design media

These issues raise critical questions in the following areas, each of which warrants further study:

- *Software development*: Interfaces catering to different designers, different design methodologies and/or different aspects of design problem-solving.
- *Software selection*: Practitioners' choices among available software tools to support personal preferences of individual designers, design workflows across multiple designers or preferred methodologies within design firms.
- *Curriculum development*: Design schools' development and evaluation of curricula accommodating form-making and form-finding across n-dimensions of analog and digital media. Whither academic sequences, individual courses, problems and pedagogical methods? Must schools expose students to the full curricular space?
- *Pedagogy*: Design communication inherently is form-finding: recipients of design communication see (the sender's) design representation first, then develop mental constructs in response. Implications for teaching, the desk crit, pinup and so on?
- *Design Practice*: How do individual designers recognize and play to (or off) personal strengths (or weaknesses) relative to affordances of different media and demands of different design problems? How do design firms balance and/or blend inductive skills/processes of form-makers with design editing skills of form-finders.
- *Human-Computer Interaction (HCI)*: Many software developers seek machine-readable design data transfers via building information modeling (BIM), industry foundation classes (IFCs) and so on. However, media of representation best suited to machine-readability may lack affordances for human-accessibility. Must one be sacrificed for the other?
- *Mediated Collaboration*: Various media of design collaboration afford different qualities of human-to-human interaction. If one manifestation of distributed cognition is team

knowing, then to what extent should media of representation for collaborative technologies be chosen by their affordances (e.g., supporting emergence of shared context).

7. Conclusion

Design ideas, as scientifically falsifiable hypotheses, depend for their development and testing on the affordances of the media of representation chosen by their designers. The range or "space" of such media considered by designers must encompass all axes of representation: from 2D to 3D; Analog to Digital; and from Form-Making to Form-Finding. Exploration of all critical implications of this condition may lead to a future state in which designers embrace the capacity and opportunity to design their own tools with affordances appropriate to their intended design methods.²³

Endnotes

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⁷ Winograd, T., and Flores, F., *Understanding Computers and Cognition*, 1986

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⁹ Buxton, B., *Sketching User Experiences*, 2007

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¹⁵ Merleau-Ponty, M., *Basic Writings*, 2003

¹⁶ Schön, D., *The Reflective Practitioner*, 1983

¹⁷ Hesselgren, L., et al, *Discussion topic in DCC04 workshop: "The Designer As Tool Builder And The Limits To Parametrics,"* 2004

¹⁸ Serraino, P., *History of Form*Z*, 2002

¹⁹ Parthenios, P., *Conceptual Design Tools for Architects*, 2005

²⁰ Partnenios, P., *op.cit.*

²¹ Parthenios, P., *op.cit.*

²² Cheng, R., *Interviewed by the author for Cadalyst magazine*, 2007

²³ Kolarevic, B., *Private communication to the author at Innovation in AEC*, 2005

