Design Thinking: A Method or a Gateway into Design Cognition?

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The main claim launched in Lindgaard and Wesselius's paper[1] is that design thinking should be (re) considered in light of current developments in cognitive science, particularly theories of metaphor and embodied cognition. As the title of their article suggests, they conclude that design thinking must relate to feelings more than has been the case up to now. Here I will distinguish between different construals of design thinking, and address the term from a design point of view – albeit one divorced from the methodological meaning it has acquired in recent years. I will also consider the role of comparisons as carriers of meaning in design ideation, and comment on the significance of analogy alongside metaphor, with an emphasis on good fit. These musings I also relate to embodiment and visual thinking, especially sketching.

Quid est Design Thinking?

The term design thinking means different things to different communities. In the 1980s, the term was naively used within the design research community[2] in early attempts to study the natural behavior of designers during the design process, as opposed to the prescriptive nature of the design methods that had been in vogue earlier (see below). The idea was to try to penetrate the designer's mind and see what happens there while designing. It is in this simple sense of the term that design thinking is used, for example, in the appellation Design Thinking Research Symposia (DTRS), a series of successful international symposia that has held 11 meetings since its inauguration in 1991. Published research is, in part, empirical – researchers apply protocol analysis methods to real-life or laboratory design activities by individuals or teams. This research yielded descriptive models of the design process.

Roughly at the beginning of the 21st century, theoreticians and researches from the fields of business administration and management, who were under pressure to propose ways to augment innovation in industry, adopted the term design thinking as they became aware that design is an important factor in innovation – the enormous success of Apple products must have been persuasive. This led to the development of multiple versions of design thinking as a method[3] to be practiced in industries that strive to introduce innovative products or services. Design thinking has thus become associated with prescriptive models of design.

There are similarities and differences between the way the design and the business communities relate to design thinking. In a study comparing the attitudes of the two communities, Marina Herrmann[4] found that both communities emphasize iterative processes, collaboration, speed of concept modeling and testing through prototyping, and interaction with users. Designers see design thinking as a learning process; the business community sees it as a knowledge-based process. Design texts emphasize experience, exploration, experimentation, play, and even failure, when it leads to learning. Designers tend to search out validity, whereas the business community seeks reliability.[5] Business texts on design thinking stress innovation, while design texts center more on creativity. There is also a notable difference in the preferred mode of communication, which is mostly visual in design and verbal in business. Despite the common ground in the interpretation of design thinking by the two communities, the differences between them should not be overlooked. When referring to design thinking, it is important to specify the sense in which the term is used. In what follows, the viewpoint on design thinking concurs with the way designers understand and have understood this term before it became a method – and a buzzword – as this is the sense in which cognition matters most.

Design Methods

As pointed out by Lindgaard and Wesselius, the 1960s were characterized by a belief in the scientification of design, especially in architecture. Given wide dissatisfaction with a lot of what was built after World War II in Europe – where the unprecedented complexity and scale of projects appeared to be beyond the level of skill of designers – it was believed that adopting scientific methods, largely borrowed from or inspired by management methods, would lead to better results. This was also the time computation made its way into design, igniting hopes that it would help in

generating and selecting optimal design solutions. In retrospect, the methods that were suggested and the community that devised them were referred to as "the design methods movement."[6] A decade or two later, it became evident that the high hopes pertaining to design methods had not been met, and they were rejected in many design disciplines, possibly excluding engineering. Design researchers came to believe that before they could impact the way design is carried out, they must first understand in depth how designers actually think. At that point, the design process had stopped being mystified and, as Lindgaard and Wesselius observed, the then-new fields of cognitive psychology and cognitive science were looked at as facilitating paths into thinking in design. Another often overlooked force that kindled the interest in design thinking was the impact of the postmodern culture starting in the 1970s. Postmodernists were very interested in processes of creation – in literature, theater, cinema, art, and design. In architectural design, for example, this was reflected in unprecedented attention to preliminary sketches. Whereas such sketches used to be discarded after a design solution was solidified, and were never published or exhibited, they were henceforth archived and published in professional magazines and books. Cases in point are the thumbnail sketches made by James Stirling in the 1970s for three museums in Germany – of which only one was built – that were published in prestigious professional magazines.[7]

The failure of the design methods of the 1960s stemmed from the realization that such methods go against the grain of natural thinking in design. The recent incarnation of design methods in the form of design thinking was therefore somewhat risky to begin with, as it was not clear whether it resolves the incompatibilities between the way designers think and the use of prescribed methods. Design thinking methods differ from the methods of the 1960s, though. They are less specific and more general and flexible; they are more like guidelines than detailed operational steps. Therefore, they induce less resistance, but – as we know – opposition does exist all the same, and many predict that design thinking as a method will soon face the same fate as the design methods of the 1960s.

Analogy, Good Fit

The current surge of interest in metaphor should not obscure the difference between it and analogy. Both are instances of deriving meaning through comparison, but they have different connotations. If we do not include embodiment (see below), metaphor and analogy acquire a sharper specificity. Lindgaard and Wesselius treat metaphor at length; I would like to draw attention to the twin relationship of analogy, which is at least as prevalent, and most influential, in design processes in all design domains. I refer to inventive analogies used during design ideation and not to explanatory analogies. Metaphor may well be more feeling-based than analogy, which depends on abstraction more than metaphor. But analogy, too, may incorporate interpretations based on feelings.

A metaphor is a comparison in which the user implicitly transfers attributes from a source situation to a target situation. When we call a person a snake, or say a building is a boat, it is assumed that the words "snake" and "boat" have attributes whose meanings are shared between the speaker and his or her interlocutors. The set of attributes the speaker transfers are culture and context sensitive. In analogy, on the other hand, what is transferred is a relationship – the relations between features or components A and B of the source are similar to the relations between features or components C and D in the target (relationship of relations, A:B :: C:D). This is what Gentner calls structural analogy.[8] A structural analogy is deep, as opposed to a surface analogy, which involves similarity of features. In everyday language, analogy has often come to indicate any kind of similarity, but this designation should be avoided in scientific and professional discourse. Some researchers adopt an extended view that does regard the transfer of non-structural features – properties or relations – as analogy. However, in that case, structural features – those having causal implications – "have a greater impact than do surface features on a problem solver's ability to use an analogue once its relevance has been pointed out."[9] I subscribe to Gentner's structure mapping theory, and when referring to analogy I adopt the narrower meaning of analogy as the transfer of relations, not properties or surface features, as explained above.

Mapping involves the transfer of relations from source to target. The relations are abstracted such that in the target situation, the components to which the relation pertains do not resemble the corresponding components of the source, and they must be adapted to the target situation. Therefore, transfer is not enough, and transformation (of components) must also occur. Whereas transfer involves analogical reasoning, transformation requires the use of mental imagery. The two combine forces to arrive at a representation of new components/features in the designed entity that maintain the relationship that was derived

from the source situation.[10] In other words, a relationship between concrete components in the source situation is abstracted, so that when transferred to the target situation it can lead to a similar relationship between completely new and different concrete components. This combined transfer and transformation mechanism allows a wide use of domains as sources, which is why we distinguish between within-domain and between-domains in analogical reasoning. As stated, it is possible that because of the abstraction and de-abstraction mechanisms in analogy – which are missing from metaphor – analogical reasoning may encompass less feeling than does metaphor, where the choice of source is often motivated by feeling. However, in the transformational step in which components of the target situation are established, wherein imagery partakes, feeling may well play a role.

Good Fit

Abstraction and transformation help avoid fixation, which often occurs when shallow features are transferred from source to target, as when an analogy is of surface quality rather than structural.[11] In analogical reasoning, a problem solver abstracts relations between concrete components or features in the source, often in a gradual process. In the target situation, the direction of the process is reversed, from a high abstraction to relations among a new set of concrete components. A good fit should be attained between the chosen components and the rest of the target situation. "Good fit" is a term used by Christopher Alexander[12] to describe the agreement that must exist between every single response to a partial problem and the responses to the various other partial problems. This assertion was a consequence of Alexander's view that to be solved successfully, design problems must be decomposed into sub problems that should be solved separately before an integrated overall solution can be achieved. Therefore, the question of good fit among the components is of utmost importance. The iterative nature of design thinking – and the recommendation of design thinking as a method to engage in frequent prototyping – is in line with the notion of achieving good fit among components and features. Analogy and imagery go hand in hand here, and as I have stated elsewhere, "we can assume that over a sufficient number of cycles, enough transformations may take place to facilitate a good fit between the components of what is being created."[13] Sketching is helpful in this process, as I will discuss below. Iterative cycles in designing ensure that, at every step, what is being proposed is well matched with the rationale for that proposal.[14] No design decision can be validated without a justification and, therefore, proposal and rationale must always be aligned. This is another way of looking at the issue of good fit in design. The use of metaphor is an intuitive manner of seeking a good fit, and analogy solidifies the rationale because of the structural resemblance to a situation that is already known and trusted in the source situation.

Embodiment

Embodiment is a subject in its own right – bundling it together with metaphor does not do justice to either. Designers must imagine the user's interaction with the not-yet-existent object or space they are trying to create. Visual mental imagery is put to work to this end, but it does not always suffice. Images fade away quickly and reviving them is costly in terms of cognitive resources; the angle of vision in the mind's eye is limited, and the level of detailing quite poor. However, imagery is a powerful cognitive representational tool compared to verbal representation, which falls behind in its ability to represent concrete scenes or objects in a compact way that is easy to grasp. Kaufmann[15] related the utility of the mode of representation in problem solving[16] to the level of novelty of the task to be performed. He described three overlapping modes of representation: linguistic, visual imagery, and overt exploratory activity (Figure C1).[17]

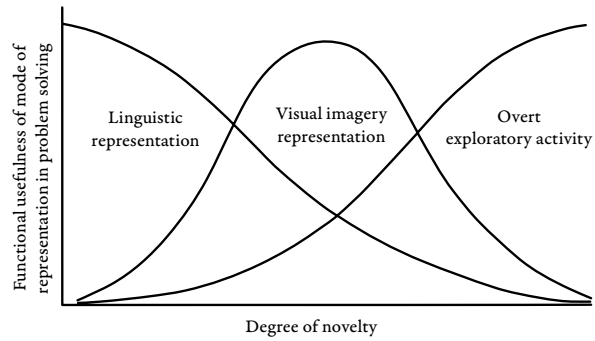

Figure C1 (Goldschmidt) Functional usefulness of different modes of representation in problem solving in relation to task-novelty. Copyright © 1980 by Geir Kaufmann.

Overt exploratory activity in the context of design could range from the building of scale models – such as prototypes and mockups – to embodying the experience of the user; for example, what one perceives and feels while walking through a building that is modeled through drawings. The term "felt-path" was used by Schön[18] to refer to the perceptions and experiences – including feelings – of a user as he or she

mentally wanders through a building when presented with its plans, sections, and elevations. Nowadays, this also applies to dynamic digital three-dimensional simulations. The user could be anyone, including the designer him- or herself; the description sounds like a guided tour of the building. Schön uses the term "spatial action language," – a term I prefer to the currently popular term embodiment. Felt-path is akin to "felt meaning" and "felt sense" as used by Lindgaard and Wesselius. It also relates to these authors' discourse pertaining to mental simulation when thinking or talking about activity, and the notion of shallow and deep processing, "suggest[ing] that the level of simulation may relate to degrees of ambiguity or uncertainty in a situation."[19] Mental simulation/overt exploratory activity hinges on the use of intuition, and is a basic building block in the construction of mental models that designers and design teams must construct on the fly to envision the design outcome they are working to achieve.[20]

The activity of sketching could also be considered as an overt exploratory activity, and it is also a kind of embodiment in which forms and shapes are first represented (see below). All three modes of representation, as described by Kaufmann, overlap each other – that is, most representations are composite and consist of at least two modes of representation that act in tandem. Shifting between representational modes facilitates flexibility, thus enhancing the creative potential of the design activity, by allowing alternating modes of reasoning such as ideation and evaluation, association and analysis, divergence and convergence.[21]

Embodiment, then, is a cognitive strategy that brings representations of the designed entity closer to home, and facilitates designers' construction of dynamic mental models of that entity, which is vitally important. In the design process, embodiment is hardly possible without visual images, and sketching enhances the visual thinking that generates such images.

Visual Thinking, Sketching

Design thinking entails small steps, or moves, that carry forward the designer's reasoning during the design process. The ultimate goal of the process is to create a representation of the designed entity at a specified level, and on the fly designers create a large number of interim representations, partial or whole. The design domains I am addressing here – including architecture, mechanical engineering, industrial design and graphic design – entail physical entities that have forms and shapes, and tangible properties like materials, color, texture, and so on. Therefore, representations in these domains are mostly visual or spatial. In the early, conceptual phases of the design process, it is vital for the designer to create quick representations that he or she can react to, and which match the pace of thought. The speediest, most convenient and cognitively least costly mode of representation is the rapid manual sketch. For experienced sketchers – who generate sketches without having to evoke rules of production – sketching has many benefits that support design thinking.[22] Designers produce various kinds of sketches – the thinking sketch, which the designer scribbles for him or herself as a thinking aid; the talking sketch, meant for communication with others; and the prescriptive sketch, meant as a record of properties of the designed entity, such as its dimensions.[23] Here I address only the thinking sketch, which is most relevant to the issue of design thinking from a cognitive point of view.

One of the prescribed recommendations of design thinking as a method is the frequent production of prototypes. In engineering and industrial design, this usually means creating a rough, three-dimensional model – a mockup – with the intention of facilitating feedback and evaluation. However, the phase in which the designer has a sufficiently worked out solution idea that can be physically modeled is a rather late in preliminary design. To get there, the designer conducts a search during which intense idea-generation takes place; many of these ideas concern partial problems and not necessarily the entire entity that is being targeted. This is the phase in which sketching excels as a yet-unbeatable mode of representation. Sketching serves the same purpose as prototypes later in the process – feedback and evaluation. Unbeatable, because no other mode of representation – including various digital modes – equals rapid manual sketching in speed, flexibility, tolerance to inaccuracy, lack of scale and incompletion, and capability for reversibility and transformation at any moment.[24] Because sketching is relatively free of rules, very fast, and not always pre-meditated, the emerging sketches can surprise the designer and offer opportunities for new interpretations – and, indeed, for unexpected discoveries.[25]

There is evidence that being able to interpret one's own scribbles is an innate human ability. Even very young children, aged three and younger, interpret portions of their own scribbles under certain circumstances, while they do not interpret others' scribbles.[26] When design students master the rules of orthogonal projections and the skill of producing

them, they acquire representational conventions that allow them to easily represent any object or space. Doing so in sketch form supports an experimental and exploratory approach, as experienced sketchers can apply the conventions very freely and flexibly. Research demonstrates that sketching interacts with visual imagery in a cyclic pattern[27] – a cognitive mechanism that Fish and Scrivener have described as "amplifying the mind's eye."[28]

A wider discussion of the role of sketching and its benefits for the process of designing is beyond the scope of this commentary, but suffice it to emphasize the critical importance of rough, rapid sketching to design thinking, including the ability to allow feelings to affect the process. The way one sketches certainly hinges on one's feelings – results are not pre-determined and the practice is not standardized or rule-based. Indeed, I would risk proposing that design thinking at the early front edge of the design process is not possible without representations in the form of rapid sketches.

In Conclusion

The excitement surrounding design thinking as an innovation-spurring method may be temporary, but design thinking as a field of study that centers on design cognition is here to stay. The alliance between cognitive psychology, cognitive science, and research into the behavior designers exhibit in the process of designing – now a few decades old – is well established. It is currently expanding further into collaboration with what is called embodied cognition, which is more sensitive to issues regarding feeling, as well as with neurocognition, which strives to combine the study of mind and brain. These are sensible and promising directions of development that will hopefully shed further light on the processes that occur while designers – be they individuals or teams – generate and shape design ideas. The paper by Lindgaard and Wesselius is a nice introduction to some of the difficult questions that face us in making the next steps in these lines of research. The authors' recommendation to conduct interdisciplinary research is one that I embrace wholeheartedly; the seeds have already been sown, and if this paper will give a further push in this direction, it will deserve the attention bestowed upon it.

1 Karin Lindgaard and Heico Wesselius, "Once More with Feeling: Design Thinking and Embodied Cognition," *She Ji: The Journal of Design, Economics, and Innovation* 3, no. 2 (2017): 83–92, DOI: https://doi.org/10.1016/j.sheji.2017.05.004.

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3 For example, see Vijay Kumar, "A Process for Practicing Design Innovation," *Journal of Business Strategy* 30, no. 2/3 (2009): 91–100, DOI: https://doi.org/10.1108/02756660910942517.

4 Marnina Herrmann and Gabriela Goldschmidt, "Thinking about Design Thinking: A Comparative Study of Design and Business Texts," in *ICoRD'13: Global Product Development, Part 1*, ed. Amaresh Chakrabarti and Raghu V. Prakash (New Delhi: Springer India, 2013), 29–40, DOI: https://doi.org/10.1007/978-81-322-1050-4.

5 Roger Martin, "Design and Business: Why Can't We Be Friends?," *Journal of Business Strategy* 28, no. 4 (2007): 6–12, DOI: https://doi.org/10.1108/02756660710760890.

6 John Z. Langrish, "The Design Methods Movement: From Optimism to Darwinism," in Proceedings of *DRS2016: Design + Research + Society: Future-Focused Thinking* vol. 8, ed. Peter Lloyd and Erik Bohemia (London: Design Research Society, 2016), 51–64, available at http://www.drs2016.org/222/.

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10 Gabriela Goldschmidt, "Avoiding Design Fixation: Transformation and Abstraction in Mapping from Source to Target," *The Journal of Creative Behavior* 45, no. 2 (2011): 92–100, DOI: https://doi.org/10.1002/j.2162-6057.2011.tb01088.x.

11 Holyoak and Koh, "Surface and Structural Similarity," 332–40.

12 Christopher Alexander, *Notes on the Synthesis of Form* (Cambridge, MA: Harvard University Press, 1964).

13 Gabriela Goldschmidt, "The Dialectics of Sketching," *Creativity Research Journal* 4, no. 2 (1991): 139, DOI: http://dx.doi.org/10.1080/10400419109534381.

14 Gabriela Goldschmidt, "A Micro View of Design Reasoning: Two-Way Shifts between Embodiment and Rationale," in *Creativity and Rationale*, ed. John M. Caroll (London: Springer-Verlag, 2013), 41–55.

15 Geir Kaufmann, *Imagery, Language and Cognition: Toward a Theory of Symbolic Activity in Human Problem-Solving* (Bergen: Universitetsforlaget AS, 1980).

16 Designing is seen as problem solving, in a wide sense of the term.

17 Kaufmann, *Imagery, Language and Cognition*, 167.

18 The term "felt-path" was coined by Donald Schön and Jeanne Bamberger in 1978. See Donald A. Schön, *The Reflective Practitioner: How Professionals Think in Action* (New York: Basic Books, 1983), 360, note 4.

19 Lindgaard and Wesselius, "Once More with Feeling," 86.

20 Petra Badke-Schaub, Andre Neumann, Kristina Lauche, and Susan Mohammed, "Mental Models in Design Teams: A Valid Approach to Performance in Design Collaboration?," *CoDesign* 3, no. 1 (2007): 5–20, DOI: https://doi.org/10.1080/15710880601170768.

21 For example, see Min Basadur, "Optimal Ideation-Evaluation Ratios," *Creativity Research Journal* 8, no. 1 (1995): 63–75, DOI:

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22 For example, see Gabriela Goldschmidt, "Modeling the Role of Sketching in Design Idea Generation," in *An Anthology of Theories and Models of Design: Philosophy, Approaches and Empirical Explorations*, ed. Amaresh Chakrabarti and Lucienne T. M. Blessing (London: Springer-Verlag, 2014), 433–50.

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24 Goldschmidt, "Modeling the Role of Sketching," 433–50.

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26 Esther Adi-Japha, Iris Levin, and Sorin Solomon, "Emergence of Representation in Drawing: The Relation between Kinematic and Referential Aspects," *Cognitive Development* 13, no. 1 (1998): 25–51, DOI: https://doi.org/10.1016/S0885-2014(98)90019-3.

27 Goldschmidt, "The Dialectics of Sketching," 123–43.

28 Jonathan Fish and Stephen Scrivener, "Amplifying the Mind's Eye: Sketching and Visual Cognition," *Leonardo* (1990): 117–26, DOI: https://doi.org/10.2307/1578475.

Author's Response

Developing Whole New Perspectives: Change, Creativity, and Process Philosophy

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Receiving commentary on this paper was not at all what my colleague, Heico Wesselius, and I expected when we wrote it. As early career researchers, we consider it a privilege that a group of accomplished scholars agreed to respond directly to our article. We also appreciate the opportunity to reply in a less formal tone than is usual in scholarly work.

I admit the process was somewhat daunting, as I was aware of the limitations of the sections of the article where we discussed design processes. As I suspected might happen, some of the commentators noticed these. Therefore, to clarify, I am not a designer – I have only a limited background in design theory. My background is philosophy and cultural studies. In practice, I am an interdisciplinary theorist. I engage with theories from multiple fields with a perspective informed by process philosophy. I have applied this to understanding consciousness from an evolutionary and developmental perspective.[1]

Some of the commentaries suggest that we did not clearly convey the overall purpose of the article, although at the end of the introduction we state our intention to be exploratory and suggestive as we outline some developments in cognitive science. To offer some background, my initial research into design thinking – in 2009, when publications were at their high point – left me quite confused and wondering why it had not followed developments in cognitive science more closely. Later, when developing my understanding of the burgeoning field of embodied cognition, it occurred to me that some people who were familiar with the term design thinking – or had simply heard of it – might be interested to know more about the developments in cognitive science. Thus, the paper was intended as an introduction to some key ideas, in a sequence that would be accessible for an audience not familiar with them. I am pleased that some commentators – Gabriela Goldschmidt, Alissa Antle, and Kees Dorst – have acknowledged the article as an introduction, even if they do not necessarily agree with all of the content.

With this rather broad audience in mind, I decided not to introduce a definition of design thinking, but to point to papers where it has already been thoroughly and schematically discussed and to position the article in relation to these discussions. Considering Bo Christensen's response that it was not clear which theories in design or design thinking we were targeting,[2] this is a shortcoming of the article. Those who know very little about design thinking may not have a strong enough foothold, while specialists in design theory would, like Christensen, prefer more specific criticisms. However, I felt that choosing a position – rather than a definition – within an already complicated discussion would allow for a more constructive paper. My sense was also that many versions of design thinking, particularly those in the business arena, were very influenced by the wicked problems narrative of design thinking as complex problem