

Understanding Innovation

Christoph Meinel
Larry Leifer *Editors*

Design Thinking Research

Looking Further:
Design Thinking Beyond
Solution-Fixation

 Springer

Christoph Meinel • Larry Leifer
Editors

Design Thinking Research

Looking Further: Design Thinking Beyond
Solution-Fixation



Editors

Christoph Meinel
Hasso Plattner Institute for Digital
Engineering
University of Potsdam
Potsdam, Germany

Larry Leifer
Stanford University
Stanford, CA, USA

ISSN 2197-5752

ISSN 2197-5760 (electronic)

Understanding Innovation

ISBN 978-3-319-97081-3

ISBN 978-3-319-97082-0 (eBook)

<https://doi.org/10.1007/978-3-319-97082-0>

Library of Congress Control Number: 2018957128

© Springer Nature Switzerland AG 2019

This work is subject to copyright. All rights are reserved by the Publisher, whether the whole or part of the material is concerned, specifically the rights of translation, reprinting, reuse of illustrations, recitation, broadcasting, reproduction on microfilms or in any other physical way, and transmission or information storage and retrieval, electronic adaptation, computer software, or by similar or dissimilar methodology now known or hereafter developed.

The use of general descriptive names, registered names, trademarks, service marks, etc. in this publication does not imply, even in the absence of a specific statement, that such names are exempt from the relevant protective laws and regulations and therefore free for general use.

The publisher, the authors and the editors are safe to assume that the advice and information in this book are believed to be true and accurate at the date of publication. Neither the publisher nor the authors or the editors give a warranty, express or implied, with respect to the material contained herein or for any errors or omissions that may have been made. The publisher remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

This Springer imprint is published by the registered company Springer Nature Switzerland AG
The registered company address is: Gewerbestrasse 11, 6330 Cham, Switzerland

Theoretical Foundations of Design Thinking



Part II: Robert H. McKim's Need-Based Design Theory

Julia P. A. von Thienen, William J. Clancey, and Christoph Meinel

Abstract Although design thinking is often understood as a practical approach to creativity and innovation in design, it builds on highly refined theories. Many influential ideas were gathered and advanced at the Mechanical Engineering department of Stanford University from the 1950s onwards, as explored in this history series. In *part I* we introduced the “creative engineering” theory of Stanford educator John E. Arnold. This chapter—*part II*—is dedicated to the need-based design theory propounded by one of his successors at the department, Robert H. McKim. His theory, first published in 1959, advanced human-centred design conceptions by providing an elaborate account of human needs, by clarifying the role of designs and designers in the process of culture development, and by providing guidelines to assess, or actively increase, design value. According to McKim, the ultimate purpose of design is to promote the well-being of people by helping to gratify their basic needs. As his overall design framework is broadly scoped, it can also serve as frame of reference to analyse and compare different present-day approaches to design, such as innovation-focused design thinking and usability-focused studies in Human-Computer Interaction.

1 Introduction

As early as 1959, Stanford educator Robert H. McKim championed a design theory based on human needs that strived to go beyond the physical concerns of ergonomics to embrace a broader range of the human intellectual and emotional nature. McKim's theory is a precious resource for design thinking studies. First, he singles out and unites two subjects in John E. Arnold's varied teachings on creativity, which obtained a key role in design thinking many decades thereafter: design and human

J. P. A. von Thienen (✉) · C. Meinel

Hasso Plattner Institute for Digital Engineering, University of Potsdam, Potsdam, Germany

e-mail: Julia.vonThienen@hpi.de

W. J. Clancey

Florida Institute for Human and Machine Cognition, Pensacola, USA

© Springer Nature Switzerland AG 2019

C. Meinel, L. Leifer (eds.), *Design Thinking Research*, Understanding Innovation,

https://doi.org/10.1007/978-3-319-97082-0_2

needs. McKim's theory presents the two concepts so intricately connected as though they could not possibly be thought of independently.

Apart from the relevance of the topics, McKim's theory is also of historical relevance, as it set the course for notable subsequent developments. John Arnold had brought to Stanford a rich framework of creativity theories. It included the overall aim that designers satisfy human needs and the notion of a comprehensive designer, inspired especially by Buckminster Fuller's work. All along the way, John Arnold emphasized the importance of tangible results. In his framework, the creative process does not end with an abstract creative idea or insight, but with a tangible design. McKim elaborates on these thoughts and carries them further into practice. His articulation and teaching of product design and "rapid visualization" facilitated the move from design theory to design doing, and even today furthers a fruitful exchange between them. Thus, McKim establishes a knowledgeable and reflective culture of designers as "makers," emphasizing experience and prototyping, which has been a hallmark of design thinking up to the present.

While in many respects McKim's design theory elaborates ideas and ideals he shares with John Arnold, such as the key importance of human needs and self-knowledge, he also opens up novel perspectives on the subject that soon proved fruitful. Drawing on art theory and related fields of expertise, McKim proposed a conceptual framework with seeds of thought that he and his future colleagues subsequently developed into the rich notions of *Visual Thinking* and *Ambidextrous Thinking* (McKim 1972; Faste 1994).

Historically, it is also worth noting what elaborate design theories were already developed in the 1950s, which viewed design as a process of accommodating human needs. McKim presented a theory in scholarly style on this behalf. Arnold had integrated such ideas intricately in his creative thinking theories. And, of course, other protagonists like Fuller (1963) and Dreyfuss (1955) also advanced need-based design practices at the time. McKim's treatment of the subject comes particularly close to presenting a formal need-based design model—which, according to Hugh Dubberly's (2004) historically organized compendium, emerged in explicit form only a decade later. So, McKim's account can be particularly valuable to further elucidate the historical development of need-based design conceptions.

Yet another promising aspect of the theory reviewed in this chapter is the scope, which is very large, similar to Arnold's creativity theories. In Arnold's framework outstanding creative achievements can be treated as a special case, but the framework covers creativity in general, from minor to major achievements. Analogously, McKim presents a theory covering all instances of design, in which radical innovation can be treated as a special case. In this regard, his theory of design differs from present-day design thinking, which is often discussed specifically as an approach to design innovation (Brown and Katz 2009; Plattner et al. 2009; Meinel and Leifer 2011). The breadth of McKim's account supports using it as a more general framework, in which the relation of innovation-focused design thinking practices to other design approaches, such as usability studies in the field of Human-Computer Interaction, can be explored systematically.

This chapter figures as *part II* in the series *Theoretical Foundations of Design Thinking*. As in *part I*, in which we discussed John Arnold’s creativity theories, we again endeavour to present the historical original in a systematic format, organizing the material in definitions (D), basic assumptions (A) and meta-theoretical remarks (M), to emphasize theoretical ideas that are particularly relevant for design thinking studies. The approach pursued here is clearly interpretative, notwithstanding many quotes from McKim’s original text, especially because our summary is formulated from the perspective of design thinking research. We highly recommend reading McKim’s (2016/1959) original essay, “Designing for the Whole Man,” in addition to our analysis. It is available online in Clancey’s (2016) *Creative Engineering* edition.

We will begin with a brief review of historical developments, tracing how McKim came to write the essay here discussed (section #2). The chapter then introduces McKim’s definition of design (#3), his theory of human needs (#4), theory of culture development (#5), and theory of good design (#6). In the final section, we relate McKim’s design framework to present-day design approaches, where we consider design thinking on the one hand and usability assessments, particularly in the field of Human-Computer Interaction, on the other (#7).

This chapter is specifically devoted to McKim’s need-based design theory. His complete works go far beyond this subject. We expect to discuss further contributions he made in *part III* of the series *Theoretical Foundations of Design Thinking*, which will be dedicated to the concept of *Visual Thinking*.

2 The Emergence of Robert H. McKim’s Essay on Design Theory

Robert H. McKim, born September 24 in 1926, moved to the Pratt Institute in Brooklyn to pursue Industrial Design after having earned a Mechanical Engineering degree at Stanford University. He came to work for Henry Dreyfuss in Manhattan as an industrial designer. Here, “human factors” were a prominently invoked concept. At the same time, McKim felt inspired to advance the human-centric perspective in design beyond what he witnessed in New York.¹

The Dreyfuss studio in Manhattan in the late 1950s was a large room with a desk for every designer, fewer than a dozen altogether. Dreyfuss would personally tell every designer what human needs to consider; need-finding was thus a privilege of the design lead. Furthermore, core design ideas were often in place before human factors were considered, so these could only inform the style and packaging of a product, whereas the core design idea was developed independently. Finally, there was only one prototyper in the New York studio, working in the back of the room; none of the other designers would build prototypes.

¹The following recollection was kindly shared by Bob McKim in personal conversation with William J. Clancey (12 Jan 2016, 16 Sept 2016, 19 October 2016, 31 Jan 2018).

McKim pondered a number of ways for advancing the human-centric perspective. He determined that, following Arnold's guideline "to understand man," core design ideas should emerge from a deep understanding of human needs. Furthermore, endorsing the notion of the "comprehensive designer," he envisioned the design process as less partitioned. Designers should be able to enact the whole process, including need-finding and building prototypes. Design for McKim is design doing, which in turn is a comprehensive process.

When McKim moved back to California, forming his own design firm in Palo Alto, he became aware of Arnold's work and planned to attend his *Creative Engineering* seminar in 1958/59 as a student.² They met ahead of the seminar, discovering an array of shared interests and visions. Both of them wanted to do "industrial design right," by which they meant focusing on human needs, designing "for the whole person" and educating students to become comprehensive designers instead of limited domain experts. In their first meeting Arnold suggested that McKim should attend the *Creative Engineering* seminar as a guest-lecturer, not as a student, which entailed writing an essay for the course manuscript. McKim agreed, and in his essay he formulated the need-based design theory reviewed in this chapter. Given the context of its emergence, unsurprisingly McKim's essay elaborates trains of thought that were of common concern to him and Arnold. Both of their accounts are included in the *Creative Engineering* manuscript dated 1958/59, which we will abbreviate as CE henceforth.

Besides McKim, Arnold invited other guest lectures to the course, who also contributed essays for the CE manuscript. The other guest authors were well-known then and now: the psychologists Joy Paul Guilford and Abraham Maslow as well as the philosopher Robert Hartman. This was the context and stage where McKim, at age 32 in 1958, developed and presented his design theory.

3 The Definition of Design

McKim straightforwardly presents a definition of the core concept of his need-based design theory.

(D1) "Design is the unique capacity of the human species to manipulate materials and energy in a reasoned or a felt response to human physical, intellectual, and emotional needs—human needs which are partially formed and modified by the natural and cultural environment" (McKim, CE, p. 200).

This definition indicates what phenomena McKim's theory sets out to clarify. In particular, he speaks not only about designed products, but takes specific interest in the process of their generation.

²Robert McKim, personal communication with William J. Clancey, 16 September 2016.



Fig. 1 Reconstruction of an early Neolithic Japanese pit house. (Image reprinted with permission from Aileen Kawagoe, originally published in *Heritage of Japan* (2018))

According to McKim, reasoned and felt responses to needs are approaches by which humans produce designs. This account parallels a key distinction in Arnold's framework, who speaks of two basic approaches for promoting creative problem solutions: *organized* and *inspired*. Relating Arnold's and McKim's conceptions helps to elucidate central ideas advanced from different angles by them and their fruitful interplay.

As Arnold explains: "The group of *organized approaches* is so named because they usually exhibit a logical, orderly, step-by-step type of problem solving technique" (Arnold, CE, p. 73, our emphasis). This group includes empirical trial-and-error procedures, as well as processes of careful reasoning and rationally deducing solutions. *Organized creativity approaches* re-appear in McKim's definition as *reasoned design responses*.

(D2) A reasoned design response is a non-instinctual way of addressing human needs, guided by a step-by-step rationale.

Interested in the origins of human design capacities, McKim gives an example from early hominin designs, indicating how these past creators were already capable of reasoned, that is, rationally planned design processes.

This early Neolithic Japanese pit house (Fig. 1) looks very much like a nest which has been built on the ground by an enormous bird. A closer examination of the house and its contents would reveal, however, that its occupant has a very unusual talent for making a great variety of non-instinctual design responses. A reasoned design response, for example, makes possible the combination of a sharpened rock fastened to the end of a stick to make a hatchet with which to build the house. (McKim, CE, p. 198)

Here, McKim highlights the importance of rational planning to achieve the tools with which housing could then be built.

Inspired approaches form the second group of creative processes distinguished in Arnold's framework. He gives two examples. In what he calls the *Big Dream* approach (Arnold, CE, p. 67) people ask "big questions" or "dream the biggest dream they possibly can" and then spend ample efforts on answering the question or making the big dream come true. As another example of inspired procedures, Arnold describes the *Flash-of-Genius* approach. Here, the originator works tirelessly on a problem until an insight just pops into his or her mind in the form of a "eureka" experience, seemingly out of nowhere.

As the CE manuscript does not provide a straightforward definition, we tentatively defined inspired creativity approaches in our reconstruction of Arnold's framework as building "on intuition, fantasy or other loosely controlled psychological processes; they are characterized by relaxed ties to that which is considered possible, advisable or state of the art in the domain of creative work" (von Thienen et al. 2017, p. 29). What Arnold, in any case, makes very clear is the role and importance he attributes to inspired approaches.

Inspired [...] approaches [...] are those closely associated with the art of creativity rather than the science. Big leaps in knowledge are apt to occur using these approaches, as compared with the slow but steady step-by step advancement made using organized techniques. (Arnold, CE, p. 73)

In McKim's theory, inspired creativity approaches re-surface as "felt design responses." He turns to art theory to further elucidate the process of creating designs by means of feeling, that is, how to enact an inspired creativity approach. In subsequent years McKim drew extensively on art theory and exercises from art education in the curricula he developed at Stanford.³ In his CE essay he points out how discussions of artistic processes often make reference to emotions. By contrast, when people follow the orderly step-by-step approach of *reasoned design*, they are not necessarily relating to their feelings and experiences. Moreover, no reference to feelings seems necessary to evaluate a reasoned design. McKim invokes this observation to establish a defining contrast between reasoned/organized versus felt/intuitive design approaches. He suggests that feelings, or genuine experiences, play a key role in "felt design" processes, which he even names after this characteristic. The basic idea underlying this description McKim imports from art theory.

As Clive Bell writes in his book, *Art* [1914, p. 50]:

"[...]To make the spectator feel, it seems that the creator must feel, too. What is this that imitated forms lack and created forms possess? [...] What is it that distinguishes the creator from the copyist? What can it be but emotion? Is it not because the artist's forms express a particular kind of emotion that they are significant?—because they fit and envelop it, that they are coherent?—because they communicate it, that they exalt us to ecstasy?["] (McKim, CE, p. 216)

³McKim epically advances a *Visual Thinking* curriculum, beginning with a course on Rapid Visualization in 1961, which is later re-named into *Rapid Prototyping*. An overview of courses offered by McKim is included in CE (Clancey 2016, p. 219f.).

Although in the CE manuscript from 1958/59 McKim seems to highlight the role of emotion, in line with Bell's original formulation, he will later on expand this perspective to experiences in general. The title of McKim's 1972 book states its objective: to help students have *Experiences in Visual Thinking*. This later curriculum covers much more than working with emotions. In particular, students are trained to use sensory experiences and imagery productively for creative purposes. To render the definition of felt design responses open towards these later developments, we suggest the following refinement:

(D3) A felt design response is a non-instinctual way of addressing human needs, guided by experiences.

In creative processes, experiences can play a guiding role in at least two ways. The first is in the form of emotional impulses such that some course of action may feel right, appropriate, exciting, promising, etc., while another can feel improper, unsatisfying, etc. To say that the person allows herself to be guided by what feels right, or to follow her urges and impulses, seems tantamount to John Arnold's description of people following intuitions in "inspired" creativity.

Yet, there is another sense in which experience can obtain a guiding role, and that is in the active seeking out of situations where the person has a chance to make and explore new ways of seeing, manipulating, feeling and thinking, ideally in ways that crystallize intuitions. This second sense of letting experiences guide the process will remain an important topic in McKim's work. In *Visual Thinking* (1972) he emphasizes how it helps to engage the senses, or the full body, in creative work. He explains how people could generally use different "thinking vehicles" (p. 3) to develop ideas. At school and the universities people were often trained to use verbal languages or mathematics. However, other thinking vehicles would also be highly valuable, and in this regard he especially points to "sensory imagery, and feelings" (p. 3), whose usage he trains in the classes he offers. *Part III* of this history series, dedicated to McKim's concept of *Visual Thinking*, will discuss these ideas and practices in further detail.

In his CE essay McKim already notes how reasoned and felt design responses need not come in pure form. Like Arnold, he also discusses combined cases.

(A1) Design responses can be both rational and felt.

Again, McKim provides an example from humanity's prehistory. He points to cave paintings, which obviously constitute artistic achievements (harnessing means of feeling), while requiring technical skill and preparation (drawing on means of reason) as well (Fig. 2).

These cave paintings are a response, partly a reasoned response and partly a felt response, to this artist's intellectual and emotional needs to understand the mysteries of nature and to record his feelings about the world in which he finds himself. These drawings reveal that man is a good deal more than a reasoning creature with a unique ability for satisfying his own physical needs. He is, as well, a feeling creature with the ability to respond, by design, to emotional needs of a very high order. (McKim, CE, p. 199)

In this passage, McKim already refers to different kinds of needs, which shall now be discussed in more detail.



Fig. 2 Cave paintings as partly reasoned and partly felt design responses. (Image reprinted from KnowledgeNuts (2018); no image-copyright indicated)

4 A Theory of Human Needs

Although McKim sometimes invokes additional terms such as “visual needs” (CE, p. 214) or “instinctual [appetites],” (p. 213) his design theory specifically differentiates three groups of needs: physical, emotional and intellectual.

(A2) Physical needs include bodily well-being and the bodily aptitude to achieve desired ends.

As physical needs McKim explicitly mentions staying “alive, fed, and sheltered” (CE, p. 198) as well as “physical comfort and sensory well-being” (p. 217). In the latter case, typical design objectives are to avoid sensory unease or pain and to create circumstances where people can use and trust their senses. For instance, it is important that designs provide “illumination levels high enough and sound levels low enough” (p. 203).

Furthermore, people need to be physically capable of performing the actions and achieving the ends to which they aspire. This objective McKim discusses with an array of examples in which people’s physical needs are not met. For instance, kitchen machinery may be noisy and a sofa uncomfortable. Another example would be a garage door that closes automatically at such a rapid pace that some people fail to pass through quickly enough. Such designs do not accommodate people’s physical needs.

(A3) Emotional needs include experiencing positive or appropriate emotions and living out personal motives.

An arguably basic need is to experience positive emotions. McKim emphasises how designers can satisfy this need in straightforward ways. Designers should bear

in mind “the delight which sensory stimuli such as color, shapes, rhythmic patterns, and textures can bring to the emotions” (p. 212).

Apart from the need to experience positive emotions, humans also need to have emotions that are appropriate to the situation. A fire alarm that strikes people as so charming that they want to linger and enjoy the sound would obviously be misconceived. Most of all, designs should “evoke emotions which are appropriate to the product” (p. 215).

Beyond basic or situation-specific needs, people also pursue personal motives, such as reinforcing preferred self-images. McKim quotes Vance Packard’s motivational consumer research: “A major appeal of buying a shiny new and more powerful car every couple of years is that it gives him (the buyer) a renewed sense of power and reassures him of his own masculinity, an emotional need which his old car fails to deliver” (p. 212).

Importantly, emotional needs or motives are different from emotions. Emotions convey needs of all categories.

(A4) All needs—including physical and intellectual—can be present to the person in the form of an emotional inclination, where she feels attracted or repelled by something.

Although some needs may be understood predominantly in terms of emotional motives, such as reinforcing a preferred self-image, feelings have an altogether mediating role in McKim’s framework. All needs can be—and usually are—present to the person emotionally. The narrow airplane seating that offends physical needs of moving the legs freely is experienced as unpleasant and the person wants to leave the inconvenient situation. Here feelings convey physical needs. Similarly, intellectual needs are experienced emotionally. “Purely intellectual appetites do not exist. To desire or to have an appetite for the ‘joys of the intellect’ implies an urge which is motivated by emotion” (p. 210).

(A5) Intellectual needs include understanding things and according with abstract ideals.

Understanding the purpose of tools or understanding messages quickly, operating tools with minimal intellectual effort, having designs accord to abstract ideals, and understanding nature are all examples of intellectual needs.

Generally, McKim notes, humans exhibit strong intellectual desires for knowledge; they even design theories about the world. It seems that already in humanity’s prehistory people experienced “intellectual [...] needs to understand the mysteries of nature” (p. 199).

Furthermore, intellectual needs inform the arts. Mondrian’s *Composition with Red, Black, Yellow, Blue, and Gray*, for example, “satisfies the intellectual appetites for unity, balance, and proportion” (p. 210).

In the domain of product design, McKim suggests two strategies to address intellectual needs: “(1) Minimizing needless intellectual effort required in the use of a product. (2) Satisfying the intellectual appetite for knowledge and order” (p. 204). Examples for achievements of the first kind can be found in jet aircraft

designs, where it would be very dangerous if pilots puzzled over the meaning and function of cockpit knobs. “Human engineers have made extensive contributions to [...] design clarification, especially in the cockpit controls of jet aircraft where the minimizing of intellectual effort is essential to pilot safety.” Indeed, these designs could have safety implications much beyond the airplane crew. One does not want to imagine an army pilot who mistakenly releases an atom bomb while simply intending to switch on a reading light, all in confusion because his cockpit buttons were designed as look-alikes. The second objective is to satisfy intellectual appetites for knowledge and order. Examples for achievements in this regard obtain “when a design *looks* like it does what it does. [For instance:] A pleasing visual quality of some of our current automobiles is the fact they look like they are capable of going in a forward direction at a rapid rate of speed [which is exactly what they do]” (p. 205).

Notably, the three need categories provide heuristics for design; however needs by themselves can be ambiguous and sometimes include aspects of more than one kind.

(A6) The categories of physical, emotional and intellectual needs are not fully disjunctive.

Rhythm is one example for multifaceted needs, which McKim discusses drawing on Dewey’s elaborate treatment of the subject (cf. Dewey 1934). In McKim’s words: “Rhythm [...] is an aspect of design which is capable of satisfying a larger appetite, partly instinctual, partly physical, intellectual, and emotional.” Here, the “larger appetite” does not sort neatly into any singular category. Speaking of a “need for rhythm” or a “need for structure and repetition” could be rough approximations to capture this multi-faceted need.

5 A Theory of Culture Development

In his discussion of human needs and design McKim assumes an extremely broad historical perspective. Besides analyzing present-day conditions, he considers the evolution of needs and design in the course of human history.

Needs are described by McKim as highly dynamic. They continuously evolve in a co-evolution of needs and culture, where the latter includes designs. By tendency, the development of needs precedes and entails further advancements in human design, though the relationship is generally reciprocal. Developments on one side enable and entail further developments on the other, and vice versa.

(A7) Human culture, needs, and designs co-evolve.

As McKim lays out, in early forms of human life, ...

needs are most often caused by some condition in the natural environment. The sun, rain, wind, the sea, the forest, animals in the forest—all had an enormous formative effect upon man’s early needs for design.

But as man began to develop into the communal sort of life, into tribes and kingdoms, he soon found that he had to respond, by design, to an unnatural environment, which I shall call the cultural environment. (McKim, CE, p. 200)

(A8) Cultural developments bring about novel needs, which in turn bring about novel cultural developments, including designs.

To illustrate the effect of the cultural environment upon human needs, and upon design, we may take as an example a recent design experience among many of the [...] tribes of Africa. For centuries, the warm natural environment of these tribes made the design response of clothing seem highly unnecessary. Their cultural environment was also quite untouched by the civilized values of the United States which require that men wear tight shirt collars, ties, and suits on a sweltering hot business day. But when Christian missionaries came upon the scene in Africa, a change in the cultural environment of many [...] tribes took place. The need for a design response—clothes—was experienced in very short order. Today, the native women are wearing calico dresses and the men are wearing dungarees, despite the hot weather. (McKim, CE, p. 200)

All in all, culture plays an ambiguous role in McKim's conception of human need and design evolution. On the one hand, culture is a driver of progress. Without cultural developments, human needs and designs might stagnate, or be simply reactive to happenstances in the natural environment. On the other hand, culturally induced concerns can be given priority over basic needs, engendering bad designs, unhealthy and unhappy people.

In a modern society such as our own, the cultural environment probably has a more decisive effect upon human needs than does the natural environment. It often causes seemingly irrational needs for design which appear absurd to the people of other cultures. It causes fashions and styles in design. It sometimes frustrates the satisfaction of important human needs. But the design and art forms which constitute a good part of the cultural environment are the essential backbone of civilized values. It is a very stiff backbone, to be sure, but designers have, in the past, had remarkable success in bending it to their will. A cultural environment which frustrates the healthy satisfaction of human needs is, in my opinion, a culture which is in for a change. (McKim, CE, p. 200)

Here McKim describes culture-specific or culture-dependent needs that emerge, dynamically interrelating with physical, emotional and intellectual needs of mankind.

In more recent analysis, the developmental pattern McKim lays out can be reconstructed as a dependent hierarchy (cf. Wilden 1987; Clancey 2016). A level is called dependent on another, if it would disappear were the more fundamental level abolished. In McKim's framework, the physical level is the most fundamental one. Without physiological processes there would be no human emotions. As emotional creatures, humans also develop intellectual motivations and desires. Based on their intellectual capacities (including abilities of making reasoned design responses) mankind engenders a richly complex culture (Fig. 3).

All hierarchy levels are intricately interrelated, and causation can work bi-directionally. When a person becomes physically ill, her emotions, intellectual capacities and opportunities to produce or enjoy culture may be affected. Conversely,

The Dependent Hierarchy of Needs

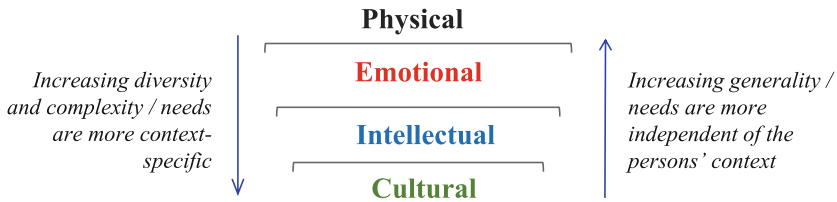


Fig. 3 McKim’s discussion of needs that unfold on the levels of physical, emotional, intellectual and cultural requirements, or motives, can be analyzed in the form of a dependent hierarchy

an unjust cultural environment can affect the intellectual processes of community members; it may elicit emotional upset and thus even physiological impairments.

McKim describes the evolution of needs and culture in the course of human history as a process, in which the impact of culture increased over time. Thus, increased rates of activity and downward influence would be expected on the cultural level if the evolving dependent hierarchy were to be modelled chronologically.⁴

Notably, in his essay McKim elaborates on three groups of basic needs—the physical, emotional and intellectual—while not refining what “basic” means. Based on his theory we suggest the following tentative definition.

(D4) Basic human needs have already existed in humanity’s pre-history; they hold cross-culturally and must be gratified regularly in order to ensure long-term health and happiness.

While the basic needs are taken to be particularly important for human designs and the objective of human well-being, people are taken to actively determine the gratification priority they assign to needs. It can happen that a culturally-induced, non-basic need obtains a higher gratification priority than a basic need. This is not only a matter of individual choice; society or one’s reference group can prioritize some needs over others.

(A9) Both individuals and larger groups can develop distinctive preference patterns were gratification priority is assigned to some needs rather than others.

⁴Reconstructing McKim’s ideas in the form of a dependent hierarchy explores their potential to be understood in terms of a single, unified and complete hierarchy of human needs. In his CE essay, McKim suggests no particular ordering among the physical, emotional and intellectual need categories. The term “need hierarchy” subsequently used also does not presuppose any such order. It refers to the possibility of needs being ordered from more basic/general to more concrete/context-specific/culture-dependent. Resulting need hierarchy branches can remain within a single need category. E.g., in the physical need spectrum a person may need. . . “to stay healthy. . . to endorse physically healthy postures. . . to have more head-room in her automobile”.



Fig. 4 Culture evolves as novel needs promote the development of novel designs. These become part of culture, so that the cultural environment of people changes. Finding themselves in novel situations, people develop novel needs. They also change their need hierarchies, re-evaluating the gratification priority they assign to needs

On these grounds, McKim describes an endless, iterative process of culture development. Novel designs bring the community into novel situations. This may lead to an updating of the need hierarchies, with gratification priorities differently assigned. In addition, novel needs may emerge, which in turn prompt designers to develop new artefacts. So the cultural environment changes etc. Figure 4 visualises the process of culture development McKim suggests.

Against this background of culture development, McKim discusses the role of designers. He highlights how they are important contributors in the process of culture formation. Indeed, they have the power to change patterns of need-gratification.

(A10) Designers shape culture for good or bad. It is the designer’s responsibility to understand and, if necessary, influence the cultural environment, to satisfy the basic needs—to design for the whole person.

We provide a tentative definition of the term “designer” to underpin the framework. McKim did not spell out an explicit definition himself, but he clearly does not reserve the term “designer” for people living in recent times. Pre-historical humans who built Neolithic pit houses and engendered cave paintings are addressed by McKim as designers. In his framework they even exemplify what it means to be a “human designer” (p. 200).

We suggest a twofold refinement to explicate McKim’s outlook on designers: a more liberal and a stricter definition. The more liberal account is intended to capture pre-historical cases, in which little is known of people’s reflective abilities. The stricter definition adds one criterion in brackets, requiring of designers increased self-awareness and anticipation.

(D5) A designer is an individual who—by means of reason and/or feeling—develops a new tangible or non-tangible product to address needs (and who anticipates a reproduction of the product to address needs of the same kind repeatedly in the future).

McKim discusses the activities of present-day designers in terms of the stricter definition. He adds that designers should not only anticipate the reproduction of their designs, but ought to envisage also the ensuing effects. The automobile industry provides critical examples.

Jagged door openings, insufficient head, leg, and knee room, and uncomfortable sitting positions are but a few of the unpleasant physical features of the latest “advances” in automobile styling. Of course, automobile manufacturers know full well that they are offending the human anatomy with their design. They claim, and they have reams of market research statistics to back them up, that the public prefers the long, low, fast look to being comfortable. Comfort, in other words, is an insignificant need in comparison to the emotional needs which are satisfied by current modes in styling. (CE, p. 202)

In this example it is not only an individual, but “the public” who endorses a non-holistic design. Priority is not placed on the satisfaction of all the basic needs, including the adoption of physically healthy postures, but on gratifying emotional needs of driving fashionable, long, low cars. Designers in the 1950s supported unfavourable patterns of need-gratification in society by providing ever more emotionally-attractive, uncomfortable cars.

(A11) Culturally induced needs can obtain a high gratification-priority both in human desires and designs, leading to the harmful neglect of some basic human needs, causing unhappiness and illness over time.

Reconsidering these objectives in McKim’s design treatise from the present-day perspective of design thinking research, the relationship between design(ers) and culture can be identified as a topic of enduring interest. Recently Jonathan Edelman pondered how “designers create culture” (2017a, p. 8). Barry Katz (1990) added another perspective by exploring also the other way around, how culture impacts the persons who develop novel artefacts. He observed how some cultures promote innovation while others prefer and generate more tradition-bound designs.

M1: Design thinkers continue to research the relationship between design, designers and culture.

Based on his model of cultural evolution—where developments can generally occur for the good or bad of humanity—and in light of the important role he attributes to designers, McKim spells out an explicit theory of good design.

6 A Theory of Good Design

Unlike natural occurrences that simply happen one way or other, humans develop their designs purposefully. McKim emphasises how “design is ultimately for the well-being and happiness of man” (CE, p. 198). Generalising this formulation just a little to avoid misinterpretations, such as an exclusion of women, the purpose of design might be defined as follows.

(D6) The ultimate purpose of design is the well-being and happiness of creatures, humans in particular.

In order to achieve that, McKim emphasises how designs must address human needs *comprehensively*. “As in a well-balanced life, good design must balance the requirements of physical, intellectual and emotional needs” (CE, p. 211).

Addressing needs comprehensively also means that in each need category a great bandwidth of different concerns must be accommodated. For instance, concentrating on only one need in the physical realm—that of amplifying human powers—is unlikely to spawn good designs.

The human values in design which are the chief concern of modern technology are physical values. The engineer and scientist are primarily concerned with extending man’s physical power over his environment. Utopia, to the engineer, would be a world in which the most strenuous physical task would be the pushing of a button. This Utopian vision, which presumably has the majority of the world’s population sitting at home contemplating its navel, is perhaps not too far off. (CE, p. 200)

Such a utopian vision could be realised with machinery that is physically offensive to the senses and designs that induce unhealthy postures as well as too little physical activity. To achieve a good design, in each need category the full spectrum of basic needs must be accommodated.

Furthermore, it is important that each design covers needs from all three categories—physical, emotional and intellectual—instead of focussing selectively on needs of just one kind. In this regard, McKim especially criticises an “overemphasis, in modern design, upon intellectual needs” (p. 210).

In my opinion, “good design” and the slogan “Form Follows Function” has come to mean an almost exclusive emphasis on the intellectual values of visual clarity of function, structure, and materials plus the visual application of the intellectual principles of unity, balance, and proportion.

It is certainly all to the good for design to satisfy the thinking man. But what of the function of design, in terms of other human values? Man also has emotional needs. Man has shown an irrational appetite for decoration, for example, since his earliest utilitarian art—can modern design revolutionize this human need for decoration out of existence? Man has also a great irrational need for being enclosed, cozy, secure [...]—can modern design with its goldfish-bowl expanses of glass, liquidate this human need for security? (McKim, CE, p. 211)

As a final requirement for good design, McKim invokes a moral evaluation of the needs that designers set out to gratify. The designer’s goal cannot be to satisfy as many needs as possibly in each category, for some human desires are actually immoral.

Not all emotional needs are good ones. The bloody history of the weapons of war is but one example of man fulfilling the wrong emotional needs through design. When we consider designing for the emotional needs of man, therefore, we come quickly to the question of morality in design. (McKim, CE, p. 211f.)

In this regard, McKim is especially concerned that “motivational researchers have spurred designers on to satisfy emotional needs that would perhaps be better left unsatisfied” (CE, p. 216). Building and selling ever faster cars that appeal to the

buyers by means of conveying power and masculinity are cited as one example in place.

With 33,000 dead and 5,000,000 injured as a result of last year's automobile accidents, this design response to emotional needs for "power" and "masculinity" seems to me to be decidedly immoral. Our morality of behaviour certainly does not sanction everyone to go around carrying a loaded gun so that they can be "reassured of their masculinity." It seems to me that designers should have similar standards for design morality, standards which would be applied at the inception of every new design. (McKim, CE, p. 212)

(D7) A good design accommodates (1) basic needs in all three categories: physical, emotional and intellectual, (2) comprehensively addressing relevant needs in each category, while (3) satisfying civilized needs only.

These are necessary but not sufficient conditions; a design must of course also satisfy context-specific requirements, such as situation- or culture-specific needs.

As one technique to elucidate the moral value of a design, McKim suggests to imagine the use of the designed product and analyse the ensuing behaviour.

Today it is considered immoral (and illegal) to use a switchblade knife; but you may design one without restraint. It is moral to design a thermonuclear weapon; fortunately, it is currently considered immoral to use one. The emotional values of many of our most popular products, if translated to human behaviour patterns, would certainly seem, if not immoral, at least overbearingly arrogant and power-happy. (CE, p. 212)

(D8) A designed product satisfies civilised needs when typical forms of product usage entail morally acceptable behaviour.

From a meta-perspective, McKim's move to weave normative questions of design value and even ethics right into his theory of design is a noteworthy one. In design thinking research quite disjunctive work traditions have been identified that either focus on descriptive objectives or address normative questions as well (Lindberg et al. 2009). The meaning that is associated with the term "design thinking" differs considerably up to the present across these different work traditions (Lindberg 2013). Notably, openness to normative concerns has been highlighted as a special characteristic of the design thinking approach pioneered at Stanford.

Advanced mainly by research from Brian Lawson and Nigel Cross, 'Design Thinking' was initially communicated as an open concept to describe cognitive problem solving strategies in design processes [studying descriptively what design experts actually do]. Subsequently, in the 1990s, a normative-pragmatic conception of design thinking became increasingly known, which was developed at the Stanford School of Engineering. It was used both in business practice (e.g., IDEO, frog design) as well as in the form of didactic concepts developed at the schools of Design Thinking (d.schools). (Lindberg et al. 2009, p. 47, our translation)

This concern for normative questions that Lindberg et al. highlight to be a special characteristic of Stanford's design thinking approach as advanced from the 1990s onwards, can now be seen to have much longer historical roots. To McKim,

normative questions inform the heart of design. He naturally treats these questions in his design theory and encourages the readers to reflect on them.

(M2) McKim's need-based design theory is both descriptive and normative.

(M3) On normative grounds, McKim addresses what designers should do, such as gratifying basic needs, and what makes a good design.

With this discussion we end the introduction of McKim's need-based design theory and now explore its relations to present-day design approaches, especially in the realm of design thinking and Human-Computer Interaction (HCI).

7 Relations of McKim's Framework to Design Thinking and HCI Usability Research

As McKim's need-based design theory was formulated in the 1950s, a considerably long time ago, a likely reflective question to conclude this chapter addresses relations to present-day design approaches, in particular design thinking. To what extent did McKim's ideas anticipate or go beyond recent-day practices? What concerns have endured or changed? As will soon become evident, strong continuities can be observed from his theory to present-day design thinking. Yet, in some regards the need-based design theory also goes beyond recent design thinking concerns. Some of McKim's ideas rather seem continued in usability studies, as advanced in the field of Human Computer Interaction.

On behalf of design thinking, a first thing to note is the enduring concern for basic human needs. They shall inform core design concepts, instead of being merely invoked as styling rationales. Products developed by design thinkers are directly tailored towards the careful and intentional gratification of important human needs. That is why design thinkers learn to empathize with users prior to thinking up designs. When interviewing a user, design thinking students are told,

we want to understand a person's thoughts, emotions, and motivations, so that we can determine how to innovate for him or her. By understanding the choices that person makes [...], we can identify their needs and design for those needs. (d.school 2010, p. 10)

As design thinkers are well aware, users often report context- or person-specific concerns when asked straightforwardly about their needs. *Why-How-Laddering* is invoked as a technique in present-day design thinking projects to make sense of user needs in a more systematic fashion (d.school 2010). Here, needs are analysed in the form of need hierarchies. They are sorted from more concrete, context- or person-specific to more basic, context-independent and common-human.

When considering the needs of your user, start with a meaningful one. [...] Ask why your user would have that need, and phrase the answer as a need. For example [looking at the handling of food], "Why would she 'need to see a link between a product and the natural process that created it'? Because she 'needs to have confidence that something will not harm her health by understanding where it came from'." [...] At a certain point you will reach a very abstract need, common to just about everyone, such as the 'need to be healthy'. This is the top of that need hierarchy branch. (d.school 2010, p. 20)

This understanding of needs resembles McKim's in that needs can be elaborated in a dependent hierarchy from basic/common-human to concrete/context-specific. In McKim's framework, similar need hierarchy branches are hinted at, for instance, in the emotional need category. Men who cherish powerful sports cars may be described as needing "...to feel socially respected ...to feel masculine and powerful ...to show off with a powerful car".

Clearly, merited designs in terms of human values emerge when the more basic needs are addressed. Needs or desires that are relatively more concrete, context- or person-specific can be immoral or power-happy, such as wanting to drive venturously with a powerful car; a socially responsible designer would not want to support these kinds of needs.

On behalf of need-terminology, a minor refinement has been developed after McKim formulated his theory. Today students learn: "Needs are *verbs* (activities and desires with which your user could use help), not *nouns* (solutions)" (d.school 2010, p. 15). McKim does not yet invoke this refinement. He speaks of a need for clothing (even in particular styles), decoration, comfort, delight, power etc., thus phrasing needs in terms of nouns. Just as regularly, he uses verbs, describing people as needing to stay alive, fed and sheltered, needing to know or understand something, needing to be cosy or needing to record their feelings.

Yet, behind superficial differences in the articulation of needs lies an important continuity. The term "need" is used in a permissive way. Essentially all culture-, situation- or person-specific requirements and desires can be rendered as needs, just like the common-human concerns to stay alive, to have something to eat or to be socially accepted. Only due to this permissive term usage does it make sense to evaluate needs morally, as McKim does. The same holds for the designer's self-selected task to differentiate between needs that shall be addressed by design and those that remain unattended—a selection task clearly articulated in McKim's theory and accepted as a matter of course by design thinkers at present. If, by contrast, the term "need" was used in a stricter sense, reserved only for common-human objectives such as staying alive, no moral evaluation would be possible and designers should better attend to every human need.

M4: The term "need" is used permissively by McKim and present-day design thinkers. By implication it refers to all human concerns, from common-human objectives such as staying alive ("basic needs") to culture-, situation- or person-specific objectives.

M5: The designers' task to organise needs in hierarchies, sorting them from "more basic" to "more concrete", and the task to evaluate which needs shall be gratified by design, derive from permissive talk about "needs".

M6: Design thinking continues McKim's human-centred approach of establishing good designs by envisioning relatively more basic needs behind concrete, context- or person-specific objectives.

Next to these strong lines of continuity, some relevant changes can also be observed from McKim's theory to present-day design thinking. Notably, McKim does not refer to "innovation" even once in his essay, while present-day design

thinking is typically understood as an approach to engender design innovation. Meinel and Leifer articulate this objective clearly in their description of the “first two schools of Design Thinking” at Stanford and Potsdam University.

“We believe great *innovators* and leaders need to be great design thinkers. We believe design thinking is a catalyst for *innovation* and bringing new things into the world. We believe high impact teams work at the intersection of technology, business, and human values. [...]” These are the visions of the first two schools of Design Thinking [...]. With overwhelming success these schools educate young *innovators* from different disciplines [...] to work together to solve big problems in a human centered way. (Meinel and Leifer 2011, p. xiii, our emphasis)

M7: McKim’s design theory has a broader scope than present-day design thinking in the sense that it covers all instances of design, while design thinking is specifically concerned with innovative design.

However, to avoid misconceptions, it should be recalled how Arnold’s creativity theories were concerned with innovation (Arnold 1959/2016; von Thienen et al. 2017); and Arnold clearly interpreted McKim’s need-based evaluation as contributing to the creative engineering curriculum. So this objective of present-day design thinking has long historical roots as well, arguably including McKim’s need-based design theory.

Also, with regard to the design process McKim’s theory can be said to have a broader scope than present-day design thinking. McKim’s theory discusses design processes comprehensively. Human values are assigned a key role throughout, from the inception phase, where he suggests that human factors ought to inform the core design concept, up to final design decisions, where he prompts designers to be aware of the impact that colours, texture and knob positions have on the user. Crucially, the theory underscores a multiplicity of needs that each design must ultimately address on all levels of analysis, the physical, emotional and intellectual. These are objectives that come into play when designs undergo finalization.

By contrast, according to present-day design thinking such details do not yet matter in the inception phase. It is instead considered helpful to concentrate on one single basic need to develop the core design idea.

In design thinking methodology, the search for basic design ideas is directed by a *How-Might-We* question, which is structured as [user] + [need] + [insight]. In the “need field” one does not state an array of physical, emotional and intellectual needs, but concentrates on a single objective (Figure 5 provides an example).

Based on the *How-Might-We* question, design thinkers gather multiple potential solutions. One core design idea is then selected, prototyped and tested. Again, in the prototyping phase design thinkers often do not work with highly refined artefacts that would address the full range of physical, emotional and intellectual needs with carefully chosen knob positions, textures and colours or broader considerations of safety, comfort, and usability. Design thinking research has pointed out the benefits of working with rough prototypes (cf. Fig. 6), which promote open discussions about core design ideas and allow different concepts to arise. By contrast, highly refined

USER	+	NEED	+	INSIGHT
An overworked husband	(needs)	to feel good about recycling		When things pile up he feels behind. And ultimately the big pile on the curb feels more like generating waste than doing good

Fig. 5 Design thinkers learn to concentrate on one need to be addressed by design. It is specified in the *How-Might-We* question, which directs the search for solutions (Creative Commons image reprinted from the bootcamp bootleg, d.school 2010)

prototypes with many design details already in place seem to stimulate conversations about solution details, not discussions of basic solution approaches (Edelman and Currano 2011).

Building on such research insights, design thinking teams are encouraged and schooled in the production of rough prototypes. Teams can use them as a tool to learn whether or not they are on a good track with their focus on a particular user need, and with their general idea of how to gratify the need with a novel design. By contrast, clarifications of precise design details are usually thought to come after a design thinking project, for example, when the core design idea is handed over to the production department in a big company. Present-day design thinking models concentrate on initial phases in a design process, whereas later phases—getting all the details right, moving on to production, promoting an innovation despite of potential resistance and criticism—do not lie at the focus at present (von Thienen and Meinel 2014, 2015).

M8: McKim’s design theory has a broader scope than present-day design thinking in the sense that it covers the overall design process, from the inception of a core design idea to the finalization of all design details, while present-day design thinking focuses on the inception of a highly valuable and innovative core design idea.

In accord with its broader scope, McKim’s design theory also submitted ideas for the finalisation of designs that historically came to be advanced in other design approaches, apart from design thinking. In this regard it is especially noteworthy how his theory anticipated concerns and methods that would later be elaborated under the rubric of *usability* in the field of Human-Computer Interaction (HCI).

The HCI approach to design bears some resemblance to design thinking insofar as a human-centred perspective is endorsed and ample tests are launched to ensure good designs. There is furthermore a joint focus on technology. HCI explicitly refers to computers, while design thinkers are recognized for working at the intersection of “*technology, business, and human values*” (Meinel and Leifer 2011, p. xiii, our emphasis). None the less, relations of the two approaches are seldom clarified. Given

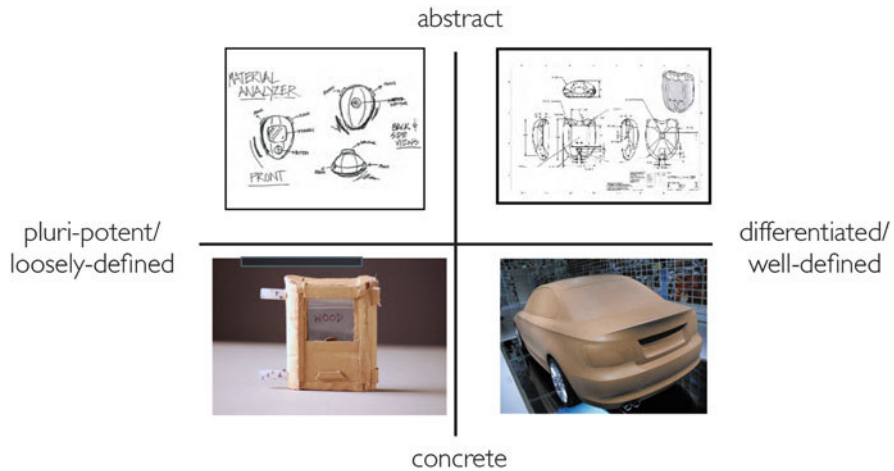


Fig. 6 The media model framework (Edelman and Currano 2011), developed in design thinking research, sorts prototypes according to their level of refinement and abstraction. Design thinkers often, intentionally, work with unrefined prototypes (left side of the matrix). These help to communicate about core design ideas. By contrast, refined prototypes (right side of the matrix) are suggestive of almost finalized solutions; they rather stimulate conversations about fine-grained design details (Image adapted with permission from Edelman 2017b; including the depiction of a clay car model by Bigge, CC BY 3.0)

that design thinking is innovation oriented, while HCI is neutral in this regard, one could imagine merging the approaches by incorporating a design thinking perspective during HCI's inception phase and using unrefined prototypes.

This chapter shall close with an exploration of ideas in McKim's theory that seem to continue in usability (more than in design thinking) studies at present. Here, McKim's theory can serve as a systemising framework, in which the relation of design thinking and HCI can be further clarified. Moreover, the discussion brings us back to McKim's original formulations, with seeds of thought that design thinkers might wish to pick up (again) in the future. The potential of the need-based design theory to underpin design thinking practices might not be fully realised as of yet; further ideas could be re-integrated and elaborated.

In the field of *Human-Computer Interaction* (HCI), Dix et al. (2004) provide a dense introduction to the subject of usability. They name three objectives that designers ought to bear in mind to achieve high levels of usability. Designers should attend to the objectives of...

Learnability—the ease with which new users can begin effective interaction and achieve maximal performance.

Flexibility—the multiplicity of ways in which the user and system exchange information.

Robustness—the level of support provided to the user in determining successful achievement and assessment of goals. (Dix et al. 2004, p. 260)

McKim's design treatise was clearly concerned with related objectives. He can be said to have anticipated *learnability* maxims as he thought about the time and effort people had to invest when trying to handle some product for the first time. "We have all had the frustrating experience of not being able to understand how to turn a simple product on or off. Clairvoyance is certainly required to divine that the rotating knob on several popular appliances must be *pulled out* to turn the appliance on" (McKim, CE, p. 204, emphasis in original). He also offers advice that could just as well appear in a present-day usability textbook:

Many puzzlers could be solved with greater ease if less reliance were placed on instruction manuals and more thought given to "building in" the instruction by means of design clarification. Modern kitchen stoves, for example, are often partially inoperable without complex instructions from a manual. Many of these instructions could be built into the design in the form of the logical arrangement of the controls into flow patterns which visually indicate operating procedure. (McKim, CE, p. 205)

In a similar vein, he advocates for hierarchies in operating controls to make the product easily usable—what in present-day terminology we would address as an aspect of *learnability*. Dominant design elements such as big, colourful buttons, should be reserved for important functionality.

A "functional hierarchy" for a low-priced TV set might be established, in terms of a broad "human use factor," as: 1. Picture tube [i.e. screen in present-day TVs]. 2. Channel selector. [...] 6. Speaker. [...] To arbitrarily reverse this hierarchy in the visual ordering of these components would normally be quite undesirable. For example, to satisfy an "aesthetic impulse," the designer might make the volume control overly prominent in terms of its color, size or position—thereby distracting the eye from No. 1 of the functional hierarchy—the picture tube. (McKim, CE, p. 208)

Issues of *flexibility* are also addressed straightforwardly in McKim's framework. He especially criticises designs of his time that forced users to rigidly use one specific interaction mode, relying on a single sense-channel.

Every evening thousands of Americans climb into their automobiles, reach for the headlight knob, turn instead its identical twin, the windshield wiper knob, or perhaps its triplet, the cigarette lighter. It is not difficult to find examples of "Chinese puzzles" in our everyday design world. Unfortunately these puzzles are not fun; they are frustrating. (McKim, CE, p. 204)

He underscores how there should be multiple ways of interacting with a device. In addition to visual clues, there could be tactile ones.

The headlight—windshield wiper—puzler [...] could easily be minimized in several ways.

(1) *Coding* the knobs by shape or texture so that their differences would be tactually clear—day or night. The confusion that arises with these controls usually takes place when it is dark.

(2) *Positioning* the knobs according to their respective functions—the windshield wiper knob near the wipers, the headlight knob near the ignition key for handy use when starting up at night. (p. 204f.)

All in all, designers are prompted to consider differing usage scenarios, such as driving at day versus at night. Designers should offer multiple ways for users to operate a device, people should be flexible in how they interact with a machine.

The issue of *robustness*, in turn, is not to be found in a single quote in McKim's essay, though it is arguably a central concern throughout. Nevertheless, McKim's focus is somewhat different from present-day usability research about computer systems that engage people in prolonged, sequential or recurrent interactions.

In HCI a quick recognition of, and recovery from, errors has become of notable concern (e.g., Nielsen 1994). Questions strictly similar to those raised in many HCI studies—such as what happens after a mistaken mouse click, how long it takes to find the undo button or another way around—are not prominently discussed in McKim's design theory. However, it is clear that not being able to recover quickly from a mistake is frustrating, and user frustration to McKim is an unambiguous indicator that the device needs to be redesigned.

The aspect of robustness that is indeed centrally discussed in McKim's theory (as well as in Arnold's framework) amounts to finding out what goals the users *really* pursue, what needs people *really* have. Designers who develop technology are warned of the perils of automation and modernisation for their own sake. In one typical example McKim reviews a “modern” house and its kitchen machinery.

The house itself, a collection of all the geometrical clichés of modernism, was the essence of cold impersonality. The automatic kitchen was a nightmare of whining motors and flashing lights. (McKim, CE, p. 198)

On behalf of present-day usability research Dix et al. (2004) explain: “In a work or task domain, a user is engaged with a [...] [product] in order to achieve some set of goals. The robustness of that interaction covers features that support the successful achievement and assessment of the goals” (p. 270). McKim would highlight how designers need to understand “the user's true goals”, that is, their basic needs, in order to design suitable products for them. From McKim's point of view, greatest robustness hurdles might not stem from clumsy recovery processes, but from mismatches between the goals a product is designed to support and the goals users actually pursue.

M9: McKim's theory anticipates design maxims that are advanced under the headline of usability in the field of Human-Computer Interaction; they bear on the *learnability*, *flexibility* and *robustness* of user-product interactions.

What HCI usability research and McKim's design theory also share is their sensitivity to a huge array of final design details. To assess a product's usability from an HCI perspective, a large number of functional design issues must be settled first. Only then can typical human factors questions be answered: whether all operating procedures are internally consistent, whether the use of colour and sound is not distracting, whether the chosen language labels are understandable etc. Similarly, McKim requires of a good design that it satisfies multiple physical, emotional and intellectual needs. How well a design figures in this regard depends not only on the core design idea. Rather, McKim emphasises, it is highly important what forms, materials, colours, textures, etc. the designer selects.

M10: McKim's design theory and usability studies include assessment strategies of design value that work for refined artefacts only; they require that final design details are already in place.

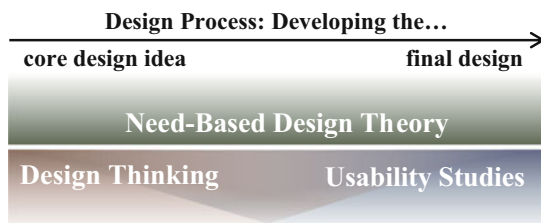


Fig. 7 Design thinking focuses mostly on the development of a valuable and innovative core design idea, while fewer resources are devoted to the clarification of final design details. Usability studies are specialized on the clarification of final design details, while the process of developing a core design idea is less elaborated. McKim's need-based design theory spans the overall process

M11: Given its broad scope, including also accounts of design value, McKim's theory can serve as an overarching framework, in which different present-day design approaches with varying objectives (focusing on design inception versus finalization, on innovation vs. general usability etc.) can be systematically compared.

All in all, a broad-scope design theory is offered by McKim, which covers the design process from early to late stages, consistently from the point of view of human needs (Fig. 7). Even in late design stages—where details are attended, such as colours, texture, sound-levels, the size and positioning of knobs etc.—McKim's design theory consistently analyses designs and human-product interactions from the perspective of user needs.

The passage that closes McKim's CE essay shall also close this review of his theory. It reflects a great continuity of concern for truly valuable designs, to be achieved by working in a human-centred way, by addressing human needs comprehensively. McKim states the objective in obvious synergy with Arnold's visions and clearly anticipating present-day design thinking practices. While many of the submitted ideas have already been picked up and are fruitfully elaborated in present-day design thinking culture, McKim's overall framework offers a cornucopia of suggestions that can continue to provide inspiration.

Clearly we badly need the designer who understands and is capable of responding to the needs of the whole man. This designer should be capable of reasoned as well as felt design responses. He must understand man's physical needs, needs not only for power over his environment but needs for physical comfort and sensory well-being. He must understand man's intellectual needs, needs for minimizing needless problem solving in design as well as visual needs for knowledge and order. The designer who designs for the whole man will also understand man's emotional needs for designs which satisfy civilized motivations and which delight the emotions through the senses. This designer must have the fortitude to exert his influence on the current cultural environment which is depriving us all of basic human needs. (McKim, CE, p. 217)

Acknowledgements We thank Robert H. McKim for his interest and support in the reconsideration of his need-based design theory. We thank Anja Perlich and Jonathan Edelman for helpful discussions and are grateful to Aileen Kawagoe as well as Jonathan Edelman for the permission to re-print their images.

References

- Arnold, J. E. (2016). Creative engineering. In W. J. Clancey (Ed.), *Creative engineering: Promoting innovation by thinking differently* (pp. 59–150). Stanford Digital Repository. Available from <http://purl.stanford.edu/jb100vs5745> (Original manuscript 1959).
- Bell, C. (1914). *Art*. London: Chatto and Windus.
- Brown, T., & Katz, B. (2009). *Change by design: How design thinking transforms organizations and inspires innovation*. New York: Harper Collins.
- Clancey, W. J. (Ed.). (2016). *Creative engineering: Promoting innovation by thinking differently, by John E. Arnold. Edited with an introduction and biographical essay by William J. Clancey*. Accessed February 2018, <http://purl.stanford.edu/jb100vs5745>
- d.school. (2010). *Bootcamp bootleg*. Accessed February 2018, from <http://longevity3.stanford.edu/designchallenge2015/files/2013/09/Bootleg.pdf>
- Dewey, J. (1934). *Art as experience*. New York: Perigee.
- Dix, A., Finlay, J., Abowd, G. D., & Beale, R. (2004). *Human–computer interaction*. Harlow: Pearson, Prentice Hall.
- Dreyfuss, H. (1955). *Designing for people*. New York: Simon and Schuster.
- Dubberly, H. (2004). *How do you design? A compendium of models*. San Francisco: Dubberly Design Office.
- Edelman, J. A. (2017a). *Dimensions of engagement*. HPI Brown Bag Series, December, 2017.
- Edelman, J. A. (2017b). *Bridging the research/practice gap: Towards innovation algorithms and qualitative functions in domain specific design scenarios*. HPI D-Flect, December 2017.
- Edelman, J. A., & Currano, R. (2011). Re-representation: Affordances of shared models in team-based design. In H. Plattner, C. Meinel, & L. Leifer (Eds.), *Design thinking. Understand – improve – apply* (pp. 61–79). Heidelberg: Springer.
- Faste, R. (1994). Ambidextrous thinking. In *Innovations in mechanical engineering curricula for the 1990s*. New York: American Society of Mechanical Engineers. Accessed February 2018, from http://www.fastefoundation.org/publications/ambidextrous_thinking.pdf
- Fuller, B. (1963). *Ideas and integrities: A spontaneous autobiographical disclosure*. Englewood Cliffs: Prentice-Hall.
- Katz, B. (1990). *Technology and culture: A historical romance*. Stanford: Stanford Alumni Association.
- Kawagoe, A. (2018). *Heritage of Japan* [website]. Accessed February 2018, from <https://heritageofjapan.wordpress.com/just-what-was-so-amazing-about-jomon-japan/ways-of-the-jomon-world-2/jomon-architecture/>
- KnowledgeNuts. (2018). *The strange truth about the people who painted cave art* [website]. Accessed February 2018, from <http://knowledgenuts.com/2014/04/04/the-strange-truth-about-the-people-who-painted-cave-art>. Article published April 4, 2014.
- Lindberg, T. S. (2013). *Design-thinking-Diskurse: Bestimmung, Themen, Entwicklungen*. Doctoral dissertation, University of Potsdam, Germany. Accessed February 2018, from <https://publishup.uni-potsdam.de/opus4-ubp/frontdoor/index/index/docId/6733>
- Lindberg, T. S., Noweski, C., & Meinel, C. (2009). Design Thinking – Zur Entwicklung eines explorativen Forschungsansatzes zu einem überprofessionellen Modell. *Neuwerk, Zeitschrift für Designwissenschaft*, 1, 47–61.
- McKim, R. H. (1972). *Experiences in visual thinking*. Belmont, CA: Wadsworth Publishing.
- McKim, R. H. (2016). Designing for the whole man. In W. J. Clancey (Ed.), *Creative engineering: Promoting innovation by thinking differently* (pp. 198–217). Stanford Digital Repository. Available from <http://purl.stanford.edu/jb100vs5745> (Original manuscript 1959).
- Meinel, C., & Leifer, L. (2011). Design thinking research. In H. Plattner, C. Meinel, & L. Leifer (Eds.), *Design thinking. Understand – improve – apply* (pp. xiii–xxxi). Heidelberg: Springer.
- Nielsen, J. (1994). Enhancing the explanatory power of usability heuristics. *Proceedings of the ACM CHI 94 human factors in computing systems conference* (pp. 152–158).
- Plattner, H., Meinel, C., & Weinberg, U. (2009). *Design thinking*. München: MI Wirtschaftsbuch.

- von Thienen, J. P. A., & Meinel, C. (2014). *Let's bring home even more benefits from design thinking: Ideas for an iterated design thinking process model*. Electronic colloquium on design thinking research. <http://ecdtr.hpi-web.de/report/2014/001>
- von Thienen, J. P. A., & Meinel, C. (2015). *Building on a Stages of Change Model to bring home more big design thinking ideas*. Electronic colloquium on design thinking research. <http://ecdtr.hpi-web.de/report/2015/001>
- von Thienen, J. P. A., Clancey, W. J., Corazza, G. E., & Meinel, C. (2017). Theoretical foundations of design thinking. Part I: John E. Arnold's creative thinking theories. In H. Plattner, C. Meinel, & L. Leifer (Eds.), *Design thinking research. Making distinctions: Collaboration versus cooperation* (pp. 13–40). Cham: Springer.
- Wilden, A. (1987). *The rules are no game: The strategy of communication*. London: Routledge and Kegan Paul.