

Understanding the [design] problem in addressing human-building interfaces

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Abstract

As society shifts towards an increasingly sustainable future, high-performance buildings can provide a means to meet sustainability and energy efficiency goals. Occupants in high-performance buildings are often expected to interact with building systems to maintain individual levels of comfort and productivity. However, the critical role of the human-building interface is often ignored (Day & Hescong, 2016). Too often, building controls are not intuitive and poorly understood by typical users. Conversely, some buildings rely on entirely automated building systems (e.g. lighting, shading, HVAC systems), which take control away from occupants. This approach is largely unpopular with building occupants. The literature suggests people desire and prefer control of their interior environments (e.g., Escuyer & Fontoynt, 2001). Designing a high-performance building that effectively engages users presents a more complex problem than most designers are prepared to handle.

Design teams require an ability to see the whole situation—from how the parts of the system work to how users will engage and adapt the system. This ability relies on systematic efforts to understand broad swaths of human behavior and design research, which go beyond computation or modeling (e.g., Huppertz, 2015; Rittel & Webber, 1973). In this context, design and design research supports third order (activities and processes) and fourth order (environments, organizations, and systems) design problems (Buchanan, 1999). Creating design teams, who can comprehend a whole situation, requires reframing how clients and designers understand design problems. This draft paper links theory about design problems with practical processes for using design research to improve the human-building interface.

Keywords: interior environment, human-building interface, design research, design theory

As society shifts towards an increasingly sustainable future, high-performance buildings can provide a means to meet sustainability, energy efficiency goals, and more. Many sustainable buildings exist, and may target goals such as water use reduction or energy efficiency; these goals are important. However, a high-performance building is designed to go beyond building performance metrics, and as such, it is intentionally designed to maintain sustainability goals while also enhancing occupant productivity and overall well-being. Specifically, a high-performance building “integrates and optimizes all major high-performance building attributes, including energy efficiency, durability, life-cycle performance, and occupant productivity” (EPA, 2005).

This paper presents a literature review of relevant design thinking concepts and research, which provide a theoretical framework for understanding the complexity of human-building interfaces and corresponding occupant interactions with the built environment. Key elements from the design thinking literature are explored and supported by human-building interface examples.

better understand how designers can encourage occupant interactions with the built environment while also supporting sustainability goals and occupant productivity and comfort.

Human-building interface: Context

In high-performance buildings, occupants are often expected to interact with building systems to maintain individual levels of comfort (visual and thermal) and productivity. For example, an individual in a passively ventilated office building may be expected to add or remove layers of clothing, close or open windows or window blinds, or interface with HVAC building controls to maintain thermal comfort. However, in some buildings, the critical role of the human-building interface is often ignored and these actions may not be possible (Day & Heschong, 2016); these types of adaptive actions may be poorly understood or the human-building interface may not be intuitive for the majority of users. In other buildings, controls for adaptive comfort opportunities may be completely removed and may rely entirely on automated building systems (e.g. lighting, shading, HVAC systems), which take control away from occupants. This approach is largely unpopular with building occupants. In some cases, occupants may unsuccessfully attempt to override a human-building interface, leading to discomfort, frustration, and / or misuse of systems (Day & Heschong, 2016).

The literature suggests people desire and prefer control of their interior environments (e.g., Escuyer & Fontoynt, 2001). Research has shown that occupants may even accept a wider range of temperatures as comfortable if provided with local control of their environment, which may support energy use goals. On the other hand, if controls are not used properly or misunderstood, the use of windows, window treatments, lighting, and other building systems may impede energy goals. It is important that occupants understand their environment and how to control it effectively (Day & Gunderson, 2015; Janda, 2011). Designing a sustainable building that provides comfort and maximizes productivity for occupants can become a difficult task quickly. The challenge is not just about energy, building form, or technical systems; the challenge engages how people understand and will regularly use the spaces and systems. Teams of designers—including engineers, architects, interior designers, and other experts—work together to solve these problems, but still fail to develop solutions that operate and meet user experience expectations. Designing a high-performance building that *effectively* engages users presents a more complex problem than most designers are prepared to handle.

Literature Review

Design teams require an ability to see the whole situation—from how the parts of the system work to how users will engage and adapt the system. This ability relies on systematic efforts to understand broad swaths of human behavior and design research, which go beyond

computation or modeling (e.g., Huppatz, 2015; Kimbell, 2011; Rittel & Webber, 1973). Design teams also require a clear understanding about the implications of their work. While some design problems will be addressed by physical solutions, design is now communication more than product (Buchanan, 1985). In this context, design research supports third order (activities and processes) and fourth order (environments, organizations, and systems) design problems (Buchanan, 1999). The third and fourth orders of design can be leveraged to understand interactions with the environment and how to design for those interactions.

Design problems

The framework for this argument rests on Rittel and Webber's definition of the wicked problem (1973), as extended by Coyne (2005). Rittel and Webber's explanation presents certain problems as indeterminate and impossible to frame and safely solve without unknowable consequences.

Specifically, wicked problems (1) have no set definition, (2) have no identifiable stopping point, (3) only offer variably good-to-bad solutions, (4) have untestable solutions, (5) cannot be solved by trial and error, (6) are not bound by a "set of permissible operations," (7) are unique, (8), are linked to other wicked problems, (9) offer multiple explanations of conditions, and (10) do not permit the solver to be wrong. Most wicked problems have social components. The wicked problem defies singular human recognition.

Rittel and Webber were reacting to earlier framing of complex problems through systems theory. Systems theory presented the possibility for a scientific truth, which could be determined through coming to know the interrelated character of related parts. The wicked problem approach denied that such a truth could exist. Coyne (2005) noted that both assumptions were outdated in a postmodern world that struggled with questions about *who* over *what*. Today, the question of *who* has been replaced with the multitudinous acceptance of unquestioned, asserted *whys*. Assertions of ethical value now trump identity.

Knowing how or what to do is insufficient when the questions become about why, values, and goals (e.g., Meadows, 1999). Goal-finding still turns out "to be an extraordinarily obstinate task" (Rittel and Webber, 1973, p. 157). Our perception of acceptable and desirable outcomes has shifted from assertions of efficiency and economics, to questions of moral and ethical choices.

For the professional tasked with addressing a problem in the twenty-first century, passive or dispassionate resolution is inadequate. Designed solutions have social, cultural, and intellectual purpose far beyond their tangible manifestations. Design must communicate to convince others to act.

Design as action

Design is now an action. As such, design is framed as "integrative thinking" (Buchanan, 1992, 6). Design should now be considered two types of actions: thinking and communicating.

Buchanan (1992, 1999) emphasizes design as a way of thinking by modeling four orders of design: symbolic and visual communication, material things (or processes for making), activities and organized services, and complex systems for living. The orders can be simplified as *signs*, *things*, *actions*, and *thoughts*. He explains that these orders, "properly

understood and used, ...are also places of intervention shared by all designers, places where one discovers the dimensions of design thinking by a reconsideration of problems and solutions” (Buchanan, 1992, 10). This framework provides the basis for innovation in considering wicked problems by drawing together professionals who “share a mutual interest in...the conception and planning of [what Herbert Simon calls] the artificial” (Buchanan, 1992, 14).

At the same time, design outcomes are communications. The design of signs, things, actions, and thoughts is only partially about manipulating material, space, or tangible characteristics. Instead, the designer’s goal is to communicate an argument that will shape others’ thoughts and actions. Buchanan (1985, 2017) presents this as design rhetoric focused on *logos* (or a technical structure

for thinking about an issue), *pathos* (or emotion and appropriateness to a given situation and user), and *ethos* (or character and identity). A design (communication) based only on one or two of these characteristics is incomplete. The most convincing design will embrace all three; the designer (or design team) cannot hope to resolve a wicked problem without convincing others that a solution is best or most. The ways they do so will demonstrate technical resolutions, the inherent nature of the problem, and the humanity for solving the challenge.

Considering our premise requires one further step. The separation of words and things “has proven nearly disastrous...for [designers’] ability to understand, let alone discuss or shape, new technologies...that support practical life” (Buchanan, 2001, 186). If designers have exclusionary and narrow foci, they miss too much. Designers must create “whole products” that include not only the expression of ideas in language or visual media, but also integrate recognition that the design is situated in the converging paradigms of designer, individual user, and humanistic society (Buchanan, 2001). The multiple people on a design team, who are thinking about a problem from different directions, become crucial to integrating interdisciplinary knowledge, the shifting paradigms, and recognizing novel, effective, and powerful solutions.

Design thinking

A core premise of design thinking upends the linear notion of problem definition preceding problem solutions. Instead, design thinking’s integrative approach relies on the co-evolution of understanding--of both problem and solution--through the process of developing both (Dorst & Cross, 2001; Michlewski, 2008). Cross (2010) stated it as the designer’s ability to resolve “ill-defined problems by adopting a solution-focused cognitive strategy and productive or appositional styles of thinking...[using] sketching, drawing and modelling” (19). When designers address indeterminate problems, they cannot know the topical areas to be considered, the range of possible solutions, or the scope of a project because the problem is inherently outside those boundaries. As a result, design is a way of thinking and acting separate from pre-set boundaries. “Design has no special subject matter of its own apart from what a designer conceives it to be” (Buchanan, 1992, 16). It is the designer’s role to focus and make tangible the characteristics of the problem being faced. This does not change the problem’s determinacy, but provide ways into explore and respond.

Design is socially oriented. Design addresses wicked problems, which are inherently social, by proposing human-based solutions. These solutions are social because they are about ethics, values, and communication rather than material, location, or technical processes. The only way designers can explore solutions is by considering how humans interact and act in context. An understanding of both human behaviors and social context becomes critical.

Design is socially oriented in a second aspect. Recent literature has highlighted ways that team-based design is crucial to successful problem solving (Eris, Martelaro, & Badke-Schaub, 2014; Røise et al., 2014; Ingebrethsen, 2013; Jonson, 2005, Oxman 1997). The communication between design teams is critical to how the team members understand and address a problem (Purcell & Gero, 1998). Just as sketching is important to all individual designers to “handle different levels of abstraction simultaneously” (Cross, 1999, p.35), communication between team members using graphics and oral exchanges is essential to the team shaping understanding of ideas (Orthel & Day, 2016). How teams communicate and think is fundamental to their potential success in addressing any wicked problem, like human-building interfaces.

Because these problems are so complex, and inherently “wicked,” it is important that they are approached from an interdisciplinary team-based design perspective. “When designers do not have mastery of a subject, they have become adept in collaboration with engineers, computer scientists, or content experts” (Buchanan, 2011, 195). To solve the problem of human-building interface interactions, designers cannot rely on their own understanding in isolation from engagement with other experts and real users. The *team* becomes more than a group of like designers. This approach to design teams must be interdisciplinary. Creating design teams, who can comprehend a whole situation and understand the scope of design’s problems, requires reframing how clients and designers understand design problems.

Encouraging interactions through design

Design teams must bridge the technical and the human. These characteristics are not oppositional. But it is too easy (and too frequently a problem) that designers only consider one or the other. A design solution’s technical wizardry rapidly and effectively acts, but too few people understand how to use the design. Or, a design is aesthetically desirable, but ineffective in solving a problem. Neither proposed solution can be considered a successful design. We see this challenge emerge specifically in the realm of building energy systems.

According to Buchanan (1985, 2017), every successful design embodies: *ethos*, *logos*, and *pathos*.

logos – reason – is there a technological reason for the product’s existence?

pathos – affordances and accessibility – is the product usable?

ethos – character or voice – is the product desirable?

A strong design is a balance of all three elements. Oftentimes designers are able to achieve logos and the pathos, but fail to integrate ethos. So many interesting technological ideas may fail because they do not have usefulness or desirability (Buchanan, 2017). Each of the three characteristics—logos, pathos and ethos—are important, but in the context of human-building interfaces, an additional factor may be important to consider.

We propose a fourth dimension: *kairos*. A design must have a reason, usability, and desirability, but in an environment designed for interaction, a design or building interface will only be successful if the occupant or the *actor in the environment* understands how to use or operate the building interface. The greek word *kairos* is defined as a *propitious moment for decision or action*, or an opportune moment. In an interior environment, one that depends upon human-building interfaces, the success of the design may rely upon signaling or identifying opportune moments for the occupant to act or interact within the interior environment. The solution must communicate with and educate a user about how to act. The solution is only successful when it is put into the action of time and use. Just as time offers a fourth dimension in relation to geometric position, *kairos* activates a design through use. More, the designer cannot leave *kairos* to fate. The design must be considered for how it will communicate with users in an ongoing and productive way. In a human-building interface, this success requires that the design do more than save energy, mechanically work, or be aesthetically appealing. The design solution must extend itself forward.

Human-building interface: an applied example

For example, in a naturally ventilated space, where occupants are encouraged to open and close windows for ventilation and thermal comfort, a successful design might include a natural ventilation system that signals opportune moments or actions to occupants. In this simple example, the logos, or rationale for the system is the potential for fresh air, comfort, and energy savings. The pathos may be the accessibility of the window (e.g., can occupants reach the window and open or close it?). Ethos may be more difficult to illustrate, but desirability of the product would certainly relate to the desire for thermal comfort. The *kairos* could be embodied by a red/green light system that indicates favorable outdoor conditions. When it is too humid, too hot, or air quality is poor, the light near the window is red (signaling to occupants: “do not open”); and when outdoor conditions are conducive to occupant health and building efficiency, the light turns green (signaling to occupants, that they may interact with the building interface if desired). This example is oversimplified; opening and closing a window should not be difficult and certainly seems less-than “wicked.” However, in a high-performance building, shared by many users,, occupants can quickly undermine design intent and function (e.g. energy efficiency). Clearly communicating these intentions and beneficial behaviors is part of the design’s (and designer’s) responsibility. Additionally, the *kairos*, as discussed in the above example, will fail if the goals and objectives of the system are unclear, or if the interface is designed in a way that it not intuitive or easily understood by the occupant.

Discussion

In the case of human-building interfaces, designing to encourage occupant interactions with building systems for energy efficiency and comfort can become exponentially more complex when occupants are in a shared environment (e.g. an open office or public space). Occupants may also be influenced by others’ actions, perceived norms, cultural expectations, or social cues (Jain et al., 2013). In these cases, the design should support social interactions and encourage desired actions, through both careful interface design and behavior change

strategies (Day & Gunderson, 2015). In fact, many behavior-based energy efficiency utility programs encourage behavioral energy savings to mitigate some of these social factors through direct and indirect feedback, motivations, prizes, competition, etc. “However, such social interventions will only work to the extent that the building interface allows occupants to take an action” (Day & Heschong, 2016, p. 8-1). These behavior-changing strategies are likely to fail if occupants are unable to interact, or do not understand how to act.

Therefore, a successful design certainly requires the balance between logos, pathos, and ethos, as defined by Buchanan. But to truly thrive in an interactive environment, where occupants are expected to engage with building interfaces, people must be armed with the knowledge for how and why to take action, such as education or outreach (Janda, 2011; Day & Gunderson, 2015).

Kairos, a design characteristic that brings the design solution forward into users’ understanding and everyday consciousness, become essential parts of the design’s success. Whether through the design of the actual interface, or through other means, *kairos* activates the design into a self-fulfilling and perpetual solution to a problem. Designers must match design solutions with the user(s), which requires understanding humans in their social context. In addition, the designer must effectively present the design in a way that brings the user into the opportune moment to understand, use, and implement the design into regular practice. Designers recognize the importance of thoughtful solutions that seek a balance between building efficiency and healthy, functional and productive environments for occupants. How to meet this goal is often less clear. Interdisciplinary design teams committed to dynamic intra-team communication and integrative consideration of broad issues provide one step forward. Success also requires reconsidering the design problem to recognize design as action and communication. The desired solution will engage technical and physical expressions, but must also act across time to match *kairos* with logos, ethos, and pathos. The complexities of human-building interfaces are just one example of the wicked problems design teams will face. Design, used in this way, can be applied to even more complex, consequential problems currently facing our society. As such, designers are uniquely suited to further address wicked problems in ways that bridge the gap between the human and the environment.

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