Methods to Obtain the Occupant Perspective

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4 Methods to Obtain the Occupant Perspective

Clinton Andrews, Julia Day, Philip Agee, Rich Wener, Quan Jin and Jennifer Senick

Summary

In this chapter, we will critically examine methods for learning about the occupant's perspective regarding the design of buildings. We will discuss the nature of occupant data; the strengths and weaknesses of self-report, observational, and simulation methods; and the need to represent occupants prudently during the design process. These methods help make an occupant-centric approach to building design feasible.

4.1 Introduction

Building designers necessarily make significant assumptions about occupant needs and comfort because during the design process, the occupants are usually not yet present. Thus, the project developer's or the client's priorities, governmental regulations, industry norms and standards, and the designer's prior experience serve as proxies for the occupants' interests. This is a satisfactory situation when the developer or client will occupy the building, regulations and standards are well-crafted and current, and the designer has substantial and relevant prior experience. Unfortunately, this is not always the case. For example, clients that develop buildings on a speculative basis may prioritize short-term financial returns, or large institutional owners may mandate regulatory minimums due to capital constraints. Such circumstances can lead occupants to experience uncomfortable and even unusable buildings.

The previous chapter, Chapter 3, provided a valuable perspective on occupant needs from the designer's point of view. It highlighted the designer's information needs at different points in the design process and the importance of client and design team interactions, while also identifying formal and informal constraints on design possibilities. Chapter 3 closed with a proposal for occupant-centric design patterns that link typical problems and solutions to guide design practice. In this chapter, we offer a counterpoint to Chapter 3 by highlighting the potential direct roles of occupants

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in the design process. There is a visionary aspect to this proposal because today, non-client occupants rarely play a direct role in the design process. Enhancing their role would require overcoming practical barriers. For example, occupants are diverse and have varied needs, and some occupants may have difficulty articulating their needs if they have limited literacy in building systems and construction. In this chapter, we consider practical ways to bring in the occupant to inform the design of new buildings.

Our proposal is significant. Buildings are meant to provide shelter to people and the things they care about, and so designers should inherently be concerned about occupants. Traditionally, design practitioners have done their work *on behalf of* occupants, applying their expertise to achieve outcomes that satisfy what designers assume to be the occupants' needs and wants. To guide these decisions, designers have developed standard models of occupants' functional requirements and behaviors (as discussed in Chapters 2 and 3). Unfortunately, some models ignore the variability of occupants' needs, capabilities, and perceptions, or fail to consider the occupant as an active participant in building performance outcomes. This traditional design approach can result in buildings that perform poorly and do not satisfy their occupants. Adverse examples include divergence between intended and actual building operational schedules, air temperature and illuminance levels, or usability of control interfaces by different types of occupants (Stazi *et al.*, 2017).

The emerging paradigm of occupant-centric design reframes the design process by stipulating that practitioners do more of their work *with* occupants. At every stage in the building life cycle, design practitioners should seek to interact directly with occupants to hear what they like and dislike, what creative ideas they may have, and what is working or not. This democratization of the design process is philosophically satisfying, but how is it done?

In this chapter, we argue that there are multiple opportunities to integrate occupant-centric elements into traditional design processes. Traditional building design processes are conceptually relatively linear, progressing from the owner's abstract program to a final refined design that gets built and occupied. In contrast, occupant-centered design processes involve much iteration, invoking what Lindblom (1959) called *mutual incremental adjustment*. For example, if the user is known, a pre-intervention study to identify their needs can augment the linear design process. Likewise, a circular design process considers building design, construction, operation, and adaptive renovation to be ongoing and iterative activities (Cobaleda Cordero *et al.*, 2017). As we move through this chapter, we consider designers' and operators' need for information about occupants, the nature of occupant data, methods for acquiring occupant data, how to manage the occupant–practitioner relationship, and how to engage occupants throughout the building life cycle.

4.2 Designers' and Operators' Informational Needs throughout the Building Life Cycle

Practitioners need to know and understand different things about occupants as a project advances through the building life cycle. Professional specialties and the associated toolkits lead programmers, architects, engineers, constructors, and operators to seek distinct types of data.

In the pre-design stage, architectural and engineering programs need basic information, such as the number of people who will use the building and for what general purposes. Residential building programs necessarily focus on households or other social units, and they allow occupants to perform a relatively standard set of activities, including sleeping, hygiene, nourishment, and recreation. Commercial building programs allow groups of many sizes to enact myriad production or consumption activities. Chapters 2 and 3 provide relevant details on occupant needs and the relevant design decisions.

An integrated design process proceeds through stages of increasing detail, from schematics to shop drawings, where at each stage there is a need for information about—and ideally from—occupants. The process begins with identifying occupants' functional needs and translating those to design requirements. For example, questions of how many people doing what and where dictate the sizes and adjacencies of spaces. Questions of occupant capability, responsibility, and motivation translate to levels of building automation. Questions of occupancy levels and schedules guide equipment specification and estimates of building performance. Occupants' desired levels of thermal comfort, indoor air quality, lighting, and noise guide design targets. The range of expected occupant behaviors anticipates risk management and usability strategies. Designers and their clients may start with assumed answers to all these questions, but the outcome likely will be better if occupants or their proxies weigh in because occupants exhibit much variability (Belazi *et al.*, 2018).

Except in cases where the design project is a renovation, or the client is also the occupant, methods for acquiring occupant data draw on evidence from existing buildings to inform a new building's design. This practice raises important questions about the transferability of insights from one building to another and the limits of extrapolation from collected evidence to hypothetical future circumstances. The reproducibility, validity, and representativeness of data collected using the methods discussed below become important dimensions for assessing the data's value. These dimensions extend beyond the data to include the models that use the data. To illustrate, is the transferable item a "typical" value, such as the average floor area per person needed in an office environment; an inferential statistical relationship, such as a multivariate regression model linking observed indoor air temperature to subjective thermal comfort sensations; or a rule-based dynamic relationship, such as a parameterized agent-based model of occupants' adaptive

responses to changing lighting conditions? Each type of transfer bundles different assumptions with the transferred data (Andrews *et al.*, 2016).

Once a building is constructed, occupant behavior moves from hypothetical to observable. Post-occupancy evaluation of the building and its operations allows assessment of its as-built performance, identifies issues that need resolution, and extracts lessons for future building designs. Seeking ongoing feedback from occupants allows operators to respond in real time to changing building conditions and allows occupants to participate in improving the building's performance. The nature of these interactions differs between commercial buildings, which may have building automation systems that operate without occupant involvement, and residential buildings, which may have a consumer-grade digital assistant that interacts frequently with occupants.

4.3 The Nature of Occupant Data

Occupants can be counted, tracked, timed, observed, and queried to yield useful data for designing and operating buildings. These many types of occupant data have properties that vary widely and may limit what can be done with the data.

Some occupant data is objective, meaning that it is directly observable by reliable instruments or people. Two observers should be able to agree on the number of people occupying a room, for example, and on the occupancy schedule, these people follow. Instruments such as infrared-beam-breaker people counters placed in doorways, or more advanced overhead counters that rely on computer vision algorithms to interpret video feeds, will vary in their level of accuracy and reliability, but they all seek to measure something objectively quantifiable.

Other occupant data is subjective, meaning that it is not directly observable in the same way by all instruments and people. For instance, two reasonable observers may perceive things differently because of personal beliefs or feelings that color their observation. An occupant's thoughts are inherently subjective because outside observers cannot see them; hence, the observers must ask the subject what they are thinking. Although professional observers use standardized surveys and interview instruments that have been previously tested and shown to perform reliably, the subjective element remains.

Psychological models of behavior attempt to explain and predict behavioral outcomes based on models that include both objective and subjective input data. This spectrum spans values, beliefs, attitudes, preferences, perceptions, norms, intentions, habitual behaviors, reactive behaviors, reasoned behaviors, social behaviors, and more. For example, Ajzen's (1985) Theory of Planned Behavior attempts to predict behavior based in part on expressed intentions, which are in turn based on subjectively measured attitudes and driven by subjectively measured beliefs. Wide-ranging empirical

tests of this model have found that subjective data on beliefs and attitudes can be reasonably good predictors of subjectively measured intentions, but intentions accurately predict objectively measured behavior only about one-third of the time (Armitage and Conner, 2001).

Underlying the occupant behavior modeling challenge is a serious epistemological problem in the social and behavioral sciences. Recall that *epistemology* refers to theories of knowledge, or the study of how we know what we claim to know. When studying phenomena in physics and chemistry, for example, scientists develop theories and evidence to understand better how the natural world works. The roles of the subject (actor) and object (recipient of action) are clear: scientists are studying nature, although sometimes (such as in quantum mechanics) there is an observer effect that affects measurements. When studying human behavior, action goes in both directions: while social scientists study the behavior of other humans, those humans are reacting to being studied. Worse, both sets of humans share social circumstances that add subjectivity to their interpretations of the data collected. Hence, the social and behavioral sciences are afflicted by what Giddens (1987) calls the *double hermeneutic*, which acknowledges the interactions between subject and object, the inherent subjectivity of research in this domain, and the possibility that everything we claim to know depends on who is doing the interpretation.

There are two ways out of this intellectual dilemma: first, practice intellectual humility regarding what experts assume they know about people (Andrews, 2002); and second, acknowledge some objective agreement on the material facts of the physical world (Sayer, 1992/1984). Thus, a key practice of good occupant behavior research is to let people speak for themselves, i.e., ask people directly what they perceive. A second key practice of good occupant behavior research is to study people in their physical context, i.e., study occupants as part of a coupled building-occupant system.

4.4 Methods for Acquiring Occupant Data

Traditionally, the information used to make spatial design decisions has been based on standards, building codes, the personal experience and training of designers, and input from clients—all documented with an eye on considerations of legal liability, as discussed in Chapter 3. Often left out of this process are the end users, i.e., those who live, work, shop, or otherwise regularly use a space, even though they are the most affected and often the most knowledgeable about space needs. This oversight is especially relevant in buildings meant to be energy efficient, since user behaviors can play a significant role in energy use (Sonderegger, 1977; Guerra-Santin and Itard, 2010; Majcen *et al.*, 2016). Design-behavior research has begun to address this gap by providing empirical, user-based information about user behavior, perception, and needs for spatial design (Zeisel, 2006; Wener, 2008; Horayangkura, 2012).

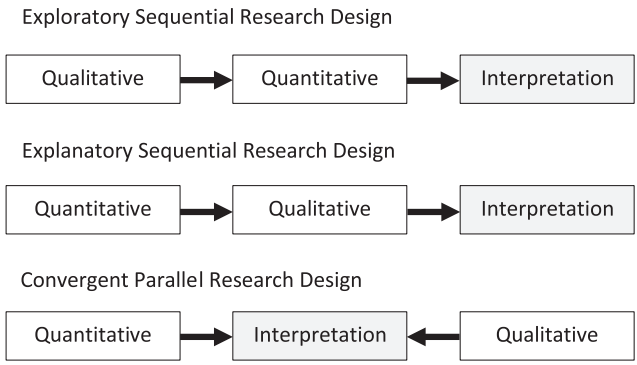


Figure 4.1 Mixed methods data collection designs.

There are various social science methods for collecting data on user spatial behavior, needs, and perceptions. Since each method has strengths and sources of bias, whenever possible it helps to use multiple data sources to enable triangulation of findings. Multiple data sources pointing to similar results increases confidence in the validity of the outcomes. A mixed methods approach that uses both quantitative and qualitative measures—for instance, a combination of questionnaires, interviews, diaries, and virtual reality-based exercises—may provide more data and deeper insights (Jin *et al*., 2019). Mixed methods designs differ depending on whether the data collection is exploratory (early stage), explanatory (later-stage), or convergent (for robust design guidance). As shown in Figure 4.1, an exploratory design uses quantitative methods to confirm qualitative insights, an explanatory design uses qualitative methods to clarify quantitative results, and a convergent design compares qualitative and quantitative results to triangulate across methods (Bergman, 2008).

In the following sections, we expand on two types of qualitative and quantitative data collection methods for building design researchers to better understand occupant needs: (1) participatory, self-reported or self-engaged measures collected through methods such as questionnaires, interviews, focus groups, and diaries; and (2) less participatory and often unobtrusive observational methods such as behavior tracking, mapping, instrument-based data collection, photography, and videography (Wener, 2008). A third type of method, simulation, creates synthetic data based on patterns detected in primary data.

Self-report measures allow researchers and designers to understand how users perceive a space and their own needs. Information can include, for instance, what users consider the key characteristics of a space that helps them engage in better and more productive work, or how they feel about adjusting thermostats or lighting (as per the example shown in Figure 4.2).

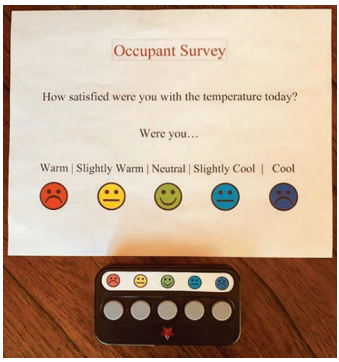


Figure 4.2 Example of collecting self-reported information from occupants via wireless voting devices (Berquist *et al.*, 2019).

As stated previously, the simplest way to get information on how people behave in a space and what they want and need is to ask them. At the same time, informants may not always be fully aware of what they do, where they do it, or how these behaviors fit into broader patterns of spatial behavior. They may forget, misremember, or give biased answers reflecting, for example, socially desirable responses (Fowler Jr, 2013; Hine *et al.*, 2016; Moy and Murphy, 2016). Triangulation using mixed methods can help overcome self-reporting bias.

Self-report techniques can include open-ended questions (questions that allow free-form responses from the subject) and closed-ended questions (those with a discrete number of fixed-choice response items). Careful sampling and survey design can reduce potential biases. In the best cases, researchers will make use of survey scales that have been developed and tested in previous studies, providing obvious advantages in terms of reliability, validity, and comparability of data.

Participatory techniques are especially important for occupant-centric design practice. There are many such techniques, ranging from design charrettes to crowd-sourced data collection. As part of design, these techniques can be simple and direct, as illustrated by the temporary display inviting occupant participation shown in Figure 4.3. They can also be quite elaborate and involve a substantial information infrastructure, as shown in Figure 4.4.

Behavior observation offers another approach to gathering occupant data and has the potential to show broader patterns of group behavior that go beyond individual activity. This approach provides an objective view of placement, patterns, and flow of behavior in a space, often directly linking these to physical features. The choice of which observational methods to use and how to use them depends on the kinds of data needed and the time and resources that are available. Formal observations, such as behavioral maps

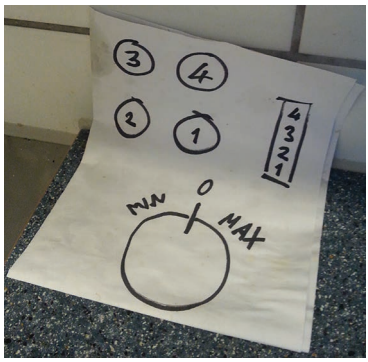


Figure 4.3 Example of folk labeling, which can be used as an indicator for opportunities to improve design.

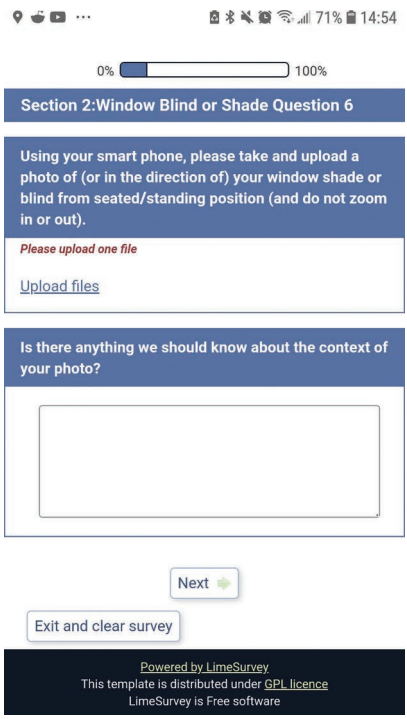


Figure 4.4 Example of smartphone-based survey that asks participants to upload photos of building features from a seated position at their workplace.

(i.e., time-sampled snapshots of who is where and doing what) or behavior tracking (i.e., following the movement of one person at a time through a space; Ittelson *et al.*, 1967), can be used to obtain a more complete and less biased picture of how and where users spend their time than self-reports provide. Mapping and tracking can be time consuming, but their use has been much aided by the development of portable telecommunication devices (Dalton *et al.*, 2012, 2013). Sensor-equipped buildings can greatly facilitate such data collection, as shown in the example in Figure 4.5.

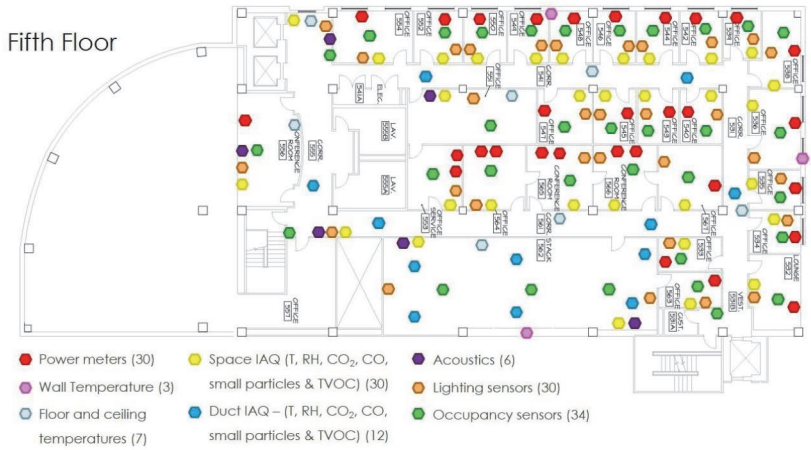
Still and time-lapse photography and videography are other useful sources of observational data on space use, though these methods must consider the ethical bounds of consideration of the privacy of the occupant. White (1980) used a time-lapse film of people using public plazas in New York City and elsewhere to demonstrate the impact of design on activity, which led to critical changes in the city's zoning laws governing the design of such spaces. More than a half-century after White's pioneering work, photography and videography are mainstream techniques, now supplemented with computer vision tools for extracting occupant behavior patterns (Tomé *et al.*, 2015).

Crowd-sourced photographic evidence using tools such as smartphone apps (see example in Figure 4.4) is gaining popularity in occupant behavior research (Day *et al.*, 2020). Crowd-sourced observational evidence combines the strengths and weaknesses of self-reported and observational data and illustrates how methods continue to evolve.

An emerging method synthesizes new data from simulation models based on primary occupant behavior data. It allows model-based interpolation and extrapolation from a limited number of direct observations or self-reports. The validity of this approach is enhanced by its ability to adjust for behavioral context but is constrained by the model's limitations.

Interface design for building systems, such as light switches and thermostats, is an important special category in the study of occupant behavior. It is iterative by nature, and its success depends on the input of reliable data about occupants' perceptions of the interface's user-friendliness in a specific application context. There are numerous methods that provide relevant data, such as qualitative affinity diagramming and cognitive walk-throughs, and quantitative ergonomic analysis and eye-tracking studies (Agee *et al.*, 2021). These specialized methods will not be discussed further in this chapter. For reasons explained in Chapter 9, it is sensible to view each method as providing only part of the information desired, and the contingency of the social and behavioral sciences suggests that triangulation and mixed methods approaches can help build confidence in the insights such evidence can provide to the design process.

The methods discussed in this chapter can generate vast quantities of qualitative and quantitative time-series data. Examples include individual occupant beliefs, attitudes, intentions, and perceptions; observed occupant presence and actions, local indoor environmental conditions, building system status, and other variables; and system measures such as building-wide



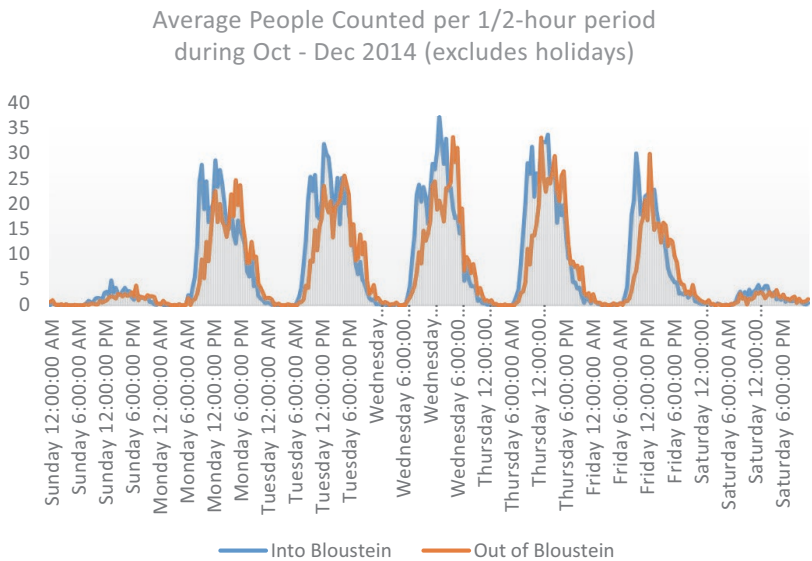


Figure 4.5 Example of a building suite equipped with sensors for monitoring indoor conditions and resulting data on occupant presence.

energy consumption. Some methods track change by the millisecond and others by the year. Wrangling these heterogeneous data is a significant challenge.

Table 4.1 summarizes the characteristics, strengths, and weaknesses of methods for occupant behavior data collection methods and provides pointers to published examples of their use. Regardless of method, most

Table 4.1 Methods, applications, strengths, weaknesses, and examples

Method	*Applications*	*Strengths*	*Weaknesses*	*Example(s)*
Self-reported and self-engaged (participatory)				
Interviews	Concept, schematic, and design development, post occupancy	Inexpensive, not overly-taxing for designer/researcher or participants, typically targeted by respondent position (e.g., facility manager, tenant administrator)	Not representative of "rank-and-file," might miss important data	Agee *et al.* (2021) and Day *et al.* (2020)
Focus groups	Design phases and possibly contract administration	Inexpensive and not overly taxing, allows for deeper dive into specific topics	Some participants may try to dominate the discussion, scope is necessarily limited	Jin *et al.* (2019)
Charrettes	Concept and schematic design	Hands-on co-creative approach, newer tech such as VR for added interest and range suits some participants	May not be representative (self-selection participant bias), relatively larger effort required	Andrews (2008)
Virtual reality (visualization, auralization, etc.)	Through the design process	Allow occupants to understand/experience space/design/layout without needing to interpret drawings and other technical documents	Requires effort to build 3D model	Jin *et al.* (2019)
Questionnaires	Concept design, post-occupancy	Sample size not limited (typically a population sample), careful sampling strategies can help to reduce bias, open-ended questions can motivate new considerations	Development and deployment are time-consuming and therefore more expensive, requires building owner/tenant approvals), potential participant bias, may be difficult to encourage participation	Day *et al.* (2020), Zhao *et al.* (2017), Zagreus *et al.* (2004), and Tsoulou *et al.* (2020)

Diaries (traditional)	Post-occupancy	Opportunity to obtain quasi-systematic chronological activity data. Smart-phone voice-enabled and other technologies may help to automate and relieve burden on participant	Recall bias is a known limitation. Not well-suited to address behavioral change and lacks context, can be taxing for the participant, may be difficult to sustain interest (even with incentives)	Jin *et al.* (2019)
Ecological Momentary Assessments	Post-occupancy	Samples/records participants real-time behaviors with preservation of context, minimizes recall bias, encompasses a wide range of technological (low-high) options, and may include individual sensing. Particularly good for interventional study	More complex administration—e.g., random time sampling is common as is a multi-method approach (telephone + electronic diary + physiological sensor)	Roa *et al.* (2020)
Social Media Posts, Individual Sensing (posts)	Post-occupancy	Opportunity to gain "uncensored" data and to learn about building occupant triggers to report, capture of "citizen scientist" data	Data needs to be carefully quality controlled, participant bias and bias toward the more sensational	Lu *et al.* (2021)

(*Continued*)

Table 4.1 Continued

Method	*Applications*	*Strengths*	*Weaknesses*	*Example(s)*
Observational				
Direct	Post-occupancy	Creates a record of contextual markers for understanding activity use data, works well in combination with archival data (e.g., charting direct observations on interior floor plan)	Researcher and participant subjectivity	Zimring and Rosenheck (2001)
Photography: still and time lapse, video	Post-occupancy	Creates a record of contextual markers for understanding activity use data, may be dynamic in nature	Researcher and participant subjectivity, ethical boundaries not always clear	Day *et al.* (2020)
Occupancy and flow counters	Post-occupancy	Objective measure with spatial coordinates, some contextual data preserved. Increasingly important given the prevalence of flexible work hours (partial load conditions) and management of airborne disease	Counter errors occur, occupants may "trick" the counters, limited activity use data, high variability in how different devices store and send data, format incompatibilities	Trivedi and Badarla (2020)
CO2 and IAQ (building) sensors	Post-occupancy	Objective measure with spatial coordinates, heightened importance/focus per COVID-19 pandemic	Limited context or activity use data	Tsoulou *et al.* (2020)

Building Management System logs	Post-occupancy	Archival measure potentially with a large and varied sample, likely to include both objective (e.g., temperature, humidity, CO2) and subjective (e.g., occupant reports) data	Quality and quantity of BMS logs vary widely. Underlying bias of occupant reports based on willingness to report	Schweiker *et al.* (2019)
Simulated Occupant Behavior Models	Design phases through post-occupancy	Allows "what-if" simulations to inform design; clarifies the role of occupant behavior in building performance	Requires much data, time, and expertise	Senick *et al.* (2018) Andrews *et al.* (2016) Chandra Putra *et al.* (2017) Andrews *et al.* (2011)
Digital Twins	Design phases through post-occupancy	Facilitates greater (pre-design/build) experimentation and specific assessments (e.g., on organizational compatibility, detailed use cases)	Requires significant investment in data, time, and expertise; masks uncertainties	Onile *et al.* (2021)
Affinity Diagram	Concept, schematic, and design development, post occupancy	Extracts insights from qualitative data, supports group discussions	Subjective results can be influenced by user's skills, biases, and chosen interaction process	Ortiz *et al.* (2020)

researchers who seek to publish work based on these methods will be required by their employer or sponsor to submit their research protocols for approval by an institutional review board (IRB) that works to protect human subjects from harm during the research process (Chen *et al.*, 2018). Practitioners using these methods may face fewer such requirements but should still acknowledge their responsibility to respect occupant privacy.

4.5 Managing the Occupant-Practitioner Relationship

Many different relationships between occupants and building practitioners are possible, and understanding how they differ is important for successful design and operational outcomes. Arnstein (1969) proposes a power-based ladder of lay engagement with practitioners that ascends from expert-dominated non-participation by lay people, to tokenism and mere consultation, all the way to delegation of decision-making power to lay people. Renn, Webler, and Wiedemann (1995) suggest that it is beneficial to acknowledge tensions between the competing objectives of fairness (to lay participants) and competence (of lay participants) when choosing how to structure this relationship. In other words, practitioners should only relinquish decision-making authority in areas where occupants are likely to be equipped to make good decisions. This stance provides an aspirational, occupant-centric contrast with the assumed power asymmetry that is baked into many owner–tenant and client–contractor relationships.

Whereas occupants are likely to have some knowledge of their own needs and desires in terms of building design, building practitioners generally have substantial knowledge about both typical occupant needs and how building systems work (as discussed in Chapter 2). Ensuring fairness might mean that all voices—that is, both occupants' and building practitioners'—are heard, and ensuring competence might mean appropriately matching tasks to roles. However, the challenges of successfully managing the occupant- practitioner relationship are many, including (at least) the following:

- *Philosophy of control*: Do designers and their building owner clients trust occupants enough to give them local control of key features? If occupants know their own comfort preferences best, it makes sense to build in local controllability of systems that provide occupant comfort, such as incorporating many small thermal zones and associated thermostats into the HVAC system design. Designers who do not trust occupants, or clients who prioritize other considerations, may create large zones and no means of local control.
- *Usability*: Are the interfaces occupants use to control building systems comprehensible, efficient, and effective? However well designed the rest of the system is, if the interface is flawed then occupants will struggle to perform with competence. See the interface discussion in Chapter 9.

- *Transferability:* Designers do their work before the building is constructed, and so the actual occupants are not yet in place to be asked about their preferences and perceptions. Instead, designers seeking occupant input will need to ask occupants about existing buildings that are similar to the new building in terms of occupant characteristics, activity types, climate, and physical details. Alternatively, the designer will need to rely on the client developer or building owner, or a behavioral consultant to speak for the future occupants, or they can turn to established design guides and standards.
- *Data ownership:* Building operations have been traditionally guided by data collected by building management systems or consultants hired by the client owner. However, it is increasingly common for occupants to install devices to monitor indoor environmental quality independently. These consumer-grade devices provide evidence that occupants can use to challenge factual claims made by owners about the building's performance (He *et al.*, 2020). Some regulations and leases specify performance requirements for tenanted spaces, making this a financially relevant development. Like the citizen science movement, data streams provided by occupants can disrupt traditional authority relationships and provide new insights about problems (Kim *et al.*, 2019). A constructive role for practitioners is to help citizen-scientist occupants ensure quality control and to incentivize continued occupant engagement (Andrews, 2016).

The above challenges highlight that the occupant–practitioner relationship is multi-faceted and varies by building and occupant type. An occupant-centric design philosophy emphasizes local control, usability, direct communication with occupants, and openness to consideration of occupant-provided data.

4.6 Engaging Occupants along the Building Life Cycle

The relationship between occupants and practitioners will necessarily vary throughout the building life cycle. Broadly, in the earlier stages, from conceptual design through completion of construction, occupants can be engaged in *formative* evaluation activities designed to specify directional targets, monitor progress, and provide ongoing feedback to the design and construction processes. After the building is occupied, it becomes possible to conduct *summative* evaluations by occupants to determine how well the building works.

At the outset, the client developer or owner needs to decide where and when they are comfortable placing occupants within the design process, from no participation to putting occupants in charge of specific decisions. An occupant-centric design process seeks to be closer to the empowerment end of the spectrum. A common example is allowing tenants to choose the

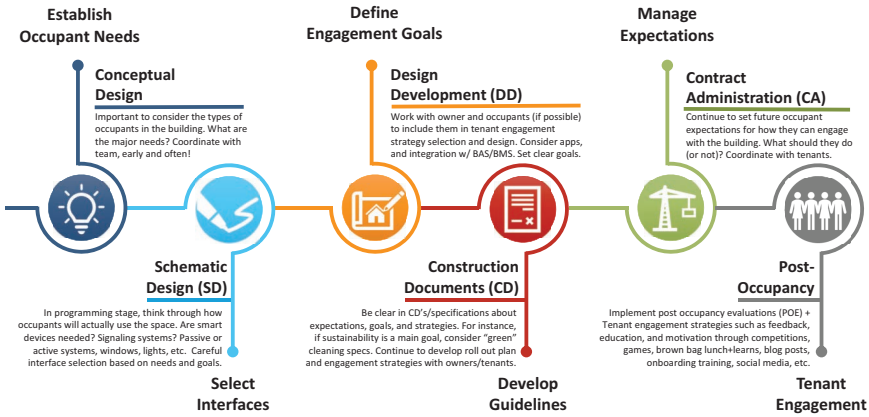


Figure 4.6 Diagram demonstrates ways in which to engage occupants throughout the design process.

color of interior paint. A more inspiring example is the redevelopment of public housing by the Charlottesville Redevelopment and Housing Authority (CRHA), where residents were directly involved in the initial needs assessment and conceptual design as well as throughout the remainder of the design and acceptance process (CRHA, 2021). The Budapest housing co-design case study in Chapter 11 is another encouraging example.

Traditionally, each stage of the building life cycle requires different data from occupants. In Figure 4.6, we illustrate the life cycle using stages defined by U.S. practitioners (AIA, 2019), recognizing that these may differ in other countries. As shown in Figure 4.6, occupant engagement at the conceptual design stage is focused on establishing occupant needs; at the schematic design stage, the focus shifts to selecting interfaces; during design development, it is on defining engagement goals; during preparation of construction documents, it is on developing guidelines; during contract administration, it moves to managing expectations; and, finally, in post-occupancy, the focus is on occupant engagement.

Agha-Hussein (2018) offers prescriptive guidance for engaging occupants in the design process, including core principles such as sharing risk and responsibility, involving the end users and operators, using feedback to improve design, and communicating and informing.

4.7 Using *Personas* to Integrate Occupants into the Design Process

Occupant data can become overwhelming in its detail, with ubiquitous sensors collecting observations every few seconds, over many months, about

perhaps hundreds of occupants in dozens of rooms in a medium-sized building. Such data can only provide insights if it is aggregated. Standard aggregation approaches focus primarily on characterizing the central tendency of the probability distribution—i.e., the "average" occupant—or the dispersion around the mean, such as the predicted mean vote/predicted percent dissatisfied construct used in thermal comfort surveys (Andrews *et al.*, 2016). A different approach that fits well with the occupant-centric design perspective is to work with clusters of relatively homogeneous occupants that can be represented as archetypes or personas, as discussed below. Personas belong to a spectrum of approaches that use increasingly sophisticated models to process occupant data, as discussed in Chapter 6.

Figure 4.7 summarizes the process of creating personas from a set of occupant data collected through a mixed methods approach. Data are applied toward the development of user personas in four discrete steps. First, the researcher collects energy use data and develops descriptive statistics. Second, they deploy a behavioral survey. The survey might ask participants demographic questions as well as questions about preferred thermostat set points, adaptive comfort behaviors, dishwasher use, shower length, and other indoor environmental quality factors. Survey responses are initially categorized by demographics (e.g., age). The researcher then generates descriptive statistics of the survey responses. Third, the researcher interviews a small subset of users (e.g., 5–10) to add richness and additional context to the persona. The interview script probes user attitudes, beliefs, and preferences for human-building interaction (e.g., acceptance of automation). Fourth, the researcher codes the interview transcripts and develops affinity diagrams for

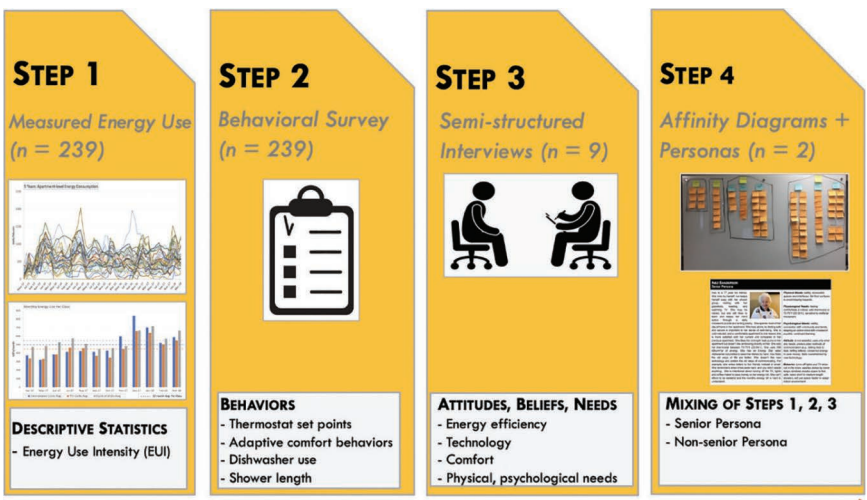


Figure 4.7 Multi-step, mixed methods approach to develop a persona for an energy use study.

categorizing themes in the data. Employing the persona(s) during the design process provides a basis for occupant-centric problem-solving. For example, when faced with a decision regarding building systems or interfaces, the designer would ask what would [Persona name] want or need in this system.

Personas also have particular value for constructing occupant indoor environmental quality (IEQ) comfort profiles. Such profiles can help designers and building developers to better appreciate individual differences and needs in the early design phase. Some recent examples in which personas provided analytical and design insights include the following:

- Hong *et al.* (2020) defined six human-building interactions behavior profiles: average, reserved, environmentally friendly, role model, self-centered, and mechanist.
- Kim and Bluyssen (2020) clustered office workers into the following categories: healthy and satisfied, moderately healthy, and noise-bothered, and unhealthy and air and temperature bothered.
- Despenic *et al.* (2017) identified four lighting preference profiles: activeness, tolerance, dominance, preference.
- Eijkelenboom and Bluyssen (2020) established IEQ clusters for outpatient staff: uncomfortable with air and preference for control of ventilation, moderately comfortable and preference for fresh air, moderately thermally uncomfortable and preference for control of temperature, comfortable and preference for good acoustics, and uncomfortable and preference for not too cold or hot temperature.

There are several advantages of personas, including that teams often perform their work with no or limited knowledge of building occupants. Personas can help project teams have a more complete understanding of the system they are designing through the integration of human factors. Generalizing user needs, particularly behavior and attitudes, is helpful for resisting technology-centered solutions (Hannington and Martin, 2012). For example, with the proliferation of building management systems (BMS), personas can assist simulators in making decisions regarding the likelihood of a user accepting the BMS. Further, personas can be used as a communication tool to communicate user needs across stakeholders as well as inform simulation inputs, as shown in Chapter 8. Personas can serve as a guideline at various stages of design and construction; for instance, they can be applied for spatial design, building simulation, and automation. A significant advantage of personas is that designers can use them to evaluate what-if scenarios with diverse occupant behaviors.

At the same time, it is important to acknowledge the limitations of personas. First, some building uses may limit the efficacy of trying to develop a generalized user. Building uses also change, particularly commercial buildings. Some building simulators lack the skills needed to collect and analyze the mixed quantitative and qualitative data required to develop a

rich persona. Further, building simulation is often developed to understand compliance with energy standards, and so, while the integration of personas in the design and simulation workflow of a project may add value from an occupant-centric design perspective, it may not be valued by compliance-focused clients. Personas may be most realistic for retrofitting, as data can be collected from current occupants, but it may pose a challenge for new buildings when the users are unknown. Conducting surveys to create personas for different projects is also time-consuming and expensive for industry practitioners. A final—and significant—limitation is the lack of systematic processes and/or set rules for integrating personas into simulation.

4.8 Closing Remarks

In this chapter, we presented three key arguments. First, building designers and operators can learn much from occupants, and the occupant-practitioner relationship will vary according to the stages of the building's life cycle. Second, the methods needed to engage occupants successfully draw upon traditional social and behavioral sciences methods, and new methods are emerging as sensing and computing technologies advance. Finally, occupant-centric design approaches that employ these methods can improve both the depth of insights generated during the design process and the likelihood of successful building and occupant outcomes. Metrics, discussed next in Chapter 5, provide an occupant-centric perspective on how to link occupant data to building performance.

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