Interactive Building-User Systems for Positive Behavioral Change by Enhancing E-Participation of Building Occupants

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ABSTRACT

The main deficiency with the Post-Occupancy Evaluation (POE) method discussed in this paper is that feedbacks collected are delayed and exert limited influence on the building being surveyed. Another drawback with this approach is that it fails to take the technological updates, such as ICTs, Web 2.0, big data, etc. into account due to the fact that the POE system is rooted from the 1980s but methods to carry out POE surveys remains almost same recently. Therefore, it is necessary to look beyond POEs and to promote direct e-participation of building users with regard to advanced ICT technologies.

Previous studies have figured out that user-led innovations with the purpose to deepen the level of user controllability of indoor environments are able to improve user perception of comfort and increase the quality of their daily life. The study presents a literature survey on how different factors influence human comfort in indoor environments with respect to user controllability. An app running on iOS and Android is introduced as a platform to display information, to make suggestions about actions can be taken, to collect feedback from users. The concept, the gap, challenges and determining factors of interactive building systems will be discussed.

Keywords: *Human-oriented Buildings, Real-time buildings, Interactive building-user system, Behavioral change*

1. INTRODUCTION

Post-Occupancy Evaluation (POE) has been applied as a systematic framework to evaluate the built environment according to responses of occupants in the buildings (Brand 1994), which indicated that POE surveys aimed to collect user responses at the operation stage and provide evidence-based design knowledges for the next generation of buildings. The main deficiency with this method is that feedbacks collected are delayed, sometimes simply ignored and exert limited influence on the building being surveyed. Another drawback with this approach is that it fails to take the technological updates, such as ICTs, Web 2.0, big data, etc. into account. The POE system is rooted from the 1980s and methods to carry out POE surveys are normally questionnaires, interviews, observations, recording, etc. (Preiser & Vischer 2005), which remains almost same recently. Meanwhile, conflicts among findings from POE surveys caused by various human behaviors or environment-related factors demonstrated the lack of universality, adaptability and flexibility. Therefore, it is necessary to look beyond POEs and to promote direct feedbacks of real-time, dynamic e-participation of building users with regard to advanced ICT technologies.

With the changing concept of green buildings, the green building rating systems have gradually evolved from tools for buildings to tools for humans. Previous studies has figured out that user-led innovations with the purpose to deepen the level of user controllability of indoor environments are able to improve user perception of comfort and increase the quality of their daily life (Frontczak & Wargocki 2011). Comfort could be enhanced in the perceived built environment by deeper user-building communication and user controllability of buildings.

2. LITERATURE REVIEW

The definition of Post-Occupancy Evaluation (POE) is given by Preiser in 1988 is "the process of evaluating buildings in a systematic and rigorous manner after they have been built and occupied for some time". Evidence gathered in POE is used to identify human-oriented design strategies and to provide feedback for further research, design and evaluation of green buildings (Gou 2012). Generally, the purpose of POE surveys is to test the appropriateness of a design approach, to offer an optimized spatial solution, to understand human perceptions of environment related behaviors, and to provide evidence-based knowledge of the effectiveness of approaches and investments in practice (Wolfgang Preiser 2002). The significance of POE is because of the gap and the fact that, firstly even all the requirements and demands of green building rating systems are met, not all occupants are

satisfied with the working environment (Humphreys 1994; Brager & Dear 1998; Heerwagen 2001; Zhao et al. 2016; Brager & Baker 2009; Gou et al. 2013); secondly, green building certification is a one-time activity, fine-tunings or major renovations of design decisions are given very few opportunities for buildings-in-use (Moezzi & Goins 2011); Moreover, POE surveys are significant to identify the adaptable ranges of comfort differs due to numerous factors such as hours worked per week, time pressure, job stress, psychosocial atmosphere at work, relationship with colleagues, job satisfaction, type of job, education level, pattern of coffee drinking, pattern of smoking, health, menstruation cycle, fitness, self-estimated environmental sensitivity, height and weight, gender, age and country of origin, etc.

However, among all the POE surveys, there are only two systematic POE studies concerning green buildings' occupants: one is the Occupant Indoor Environmental Quality (IEQ) Survey and Building Benchmarking by the Center for the Built Environment (CBE) at the University of California Berkeley in North America (Abbaszadeh et al. 2006); the other is the Post-occupancy Review of Buildings and their Engineering carried out by BUS (Building Uses Studies) Ltd. in the U.K. (Leaman & Bordass 2001).

Furthermore, since the intervention of POE surveys are post occupancy, these approaches are not related to architectural design stages of the buildings researched and information gathered from feedbacks are delayed and sometimes simply ignored. In fact, the building being surveyed is not able to react according to the results of user feedbacks. Complaints might de facto only be taken into consideration for further green buildings to some extent rather than influencing the building at the operation level. This traditional POE and feedbacks are too passive for building occupants to be directly involved. In addition, the link between POE researchers and architects is week and the results from POE survey fail to get enough attention to guide design strategies (Hadjri & Crozier 2009).

3. DISCUSSION

3.1 The mechanism to encouraging pro-environmental behaviors

Socio-environmental psychology has gained notice by academia since the 1960s when environmental psychology and a variety of disciplines started to intervene in the research field of environmental behavior of human beings, seeking answers to questions such as "are human behaviors predictable?", "how do human behaviors change?", etc. However, findings from empirical research do not support the presupposition (Redclift & Woodgate 1997) which hypothesized that behaviors were determined by environmental attitudes (Maloney & Ward 1973; Maloney et al. 1975), hence environment-related knowledge - attitudes - behaviors had a linear relationship. As a result, inconsistency between attitudes and behaviors has become one of the emergent focuses in academic research, directing at the relationship among other factors such as norms, values and external factors. In architecture, researches on user behaviors and behavioral changes at the building level has emerged as a new frontier due to the fact that user behaviors have impacts on building performance and addressing the interaction between human factors and green building systems are complementary with market-driven systems in search of sustainability (Kats et al. 2010).

The core of this discussion is the added value of human-oriented buildings, which indicates that the encouragement of pro-environmental behaviors would not place a burden on occupants' reducing energy consumption at the cost of less comfort. In addition to green building whose aims are to reduce loads and enhances efficiency, (Yudelson 2008), the concept of human-oriented buildings paves the way, through a holistic integrated approach, for sustainable development at the personal level (International WELL Building Institute 2016).

The study defines those with pro-environmental behaviors as "green users". How to create green users via behavioral changes is one of the main research questions. The study proposes a model that one of the contributing factors for green buildings to create green users is a technology-enabled, human-building interaction platform (see Figure 1) based on a participatory mechanism of a e-platform of smart phones and a vote system. The preliminary interdisciplinary model of technology-enabled empowerment on the behavioral change of occupants proposes that behavioral change can be trigged by either the technology-enabled platform directly or via cognitional change triggered by a technological-enabled means. There is a substantial list of theories and models to reveal those contributing factors of environmental behaviors, including the Theory of Planned Behavior (Ajzen & Fishbein 1980), Responsible Environmental Behavior (Marcinkowski 1988; Hines et al. 1987), Value-Belief-Norm (VBN) Theory (Stern 2000), Multi-factor integration model (Bamberg & Möser 2007), Attitude-Behavior-Conditions (ABC) model (Guagnano et al. 1995), Context model for analyzing environmental consciousness and behavior (Brand 1997),

etc. Of these, the VBN theory was put forward by Stern in 2000 (Stern 2000) on the basis of the Norm-activation Theory, which claims that social norms could be converted into pro-social and pro-environmental behaviors of individuals only when it is personized. The activation of individual norms is influenced by two factors: the awareness of the consequences of the action (AC), and the assumed responsibility for these consequences (AR). When AC and AR are high, individual norms will be activated, leading to the implementation of pro-environment behavior. VBN theory combined this idea with the Value Theory and the New Environmental Paradigm (NEP) in order to explain environment-related behaviors and how they are formed. The starting point of the VBN Theory is that generic values would activate individual norms, resulting in personal (environmental) responsibility through environmental 'beliefs' (NEP), recognizing the relationship between the outcomes of individual negative behaviors and the "beliefs' in reducing threats and consequences through behavioral changes. The VBN theory has been proven in many precedent studies (Nordlund & Garvill 2003; Ã et al. 2006; Scherbaum et al. 2008). Other contributing factors to trigger green-intent behaviors are wider collaboration and engagement, design-driven strategies, incentive-driven strategies, etc. For example, in order to create green users, the WELL system (International WELL Building Institute 2016) highlights not only individuals, but more so employers. The concept behind WELL is that eventually it is people (employers) who is managing people (employees), as well as people's behaviors. That is why WELL tends to manage people (employers) who are administrators at the operation level of buildings. Similar trend and development can be noticed in the latest version of the Green Mark rating system where a Green Mark Pearl Award was launched in 2015 to encourage green promises from building owners and tenants.

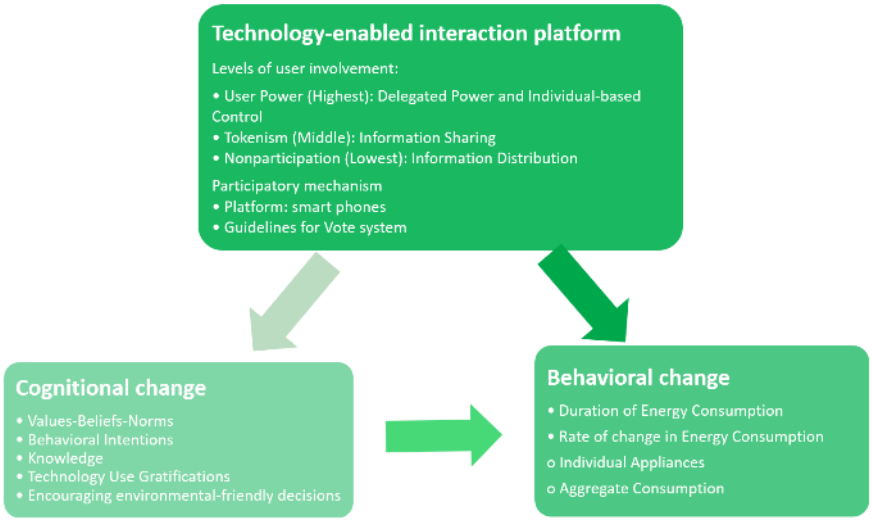

Figure 1: A preliminary interdisciplinary model of technology-enabled empowerment on the behavioral change of occupants

3.2 The "soft" (human-centric) challenges of environmental-responsive building

The shifts in the attention on the "soft" (human-centric) aspect in architectural design are due to the fact that human beings' understanding and cognition on environment, ecology, sustainability, human factors, etc. are subject to dynamic changes, and these thought waves influence green building as an evolving concept. According to a research on the financial benefits of green buildings (Kats et al. 2010) , it is indicated that the main return of green buildings are the enhancement of productivity and health benefits. Since enhanced user satisfaction, comfort and productivity will contribute to increased economic benefit, addressing human factors in green buildings would lead to the motivation that drives the green market. Under this circumstance, attitude changes have been made in various building evaluation systems. However, green building certification is a one-time activity, fine-tunings or major renovations of design decisions are given very few opportunities for buildings-in-use (Moezzi & Goins 2011). In response to the questioning of "How about buildings in use? How about user responses?" the concept of Post-occupancy evaluation (POE) was introduced. Post-Occupancy Evaluation (POE) has been applied as a systematic framework to evaluate the built environment according to responses of occupants in buildings (Brand 1994), which indicated that POE surveys aimed to collect user responses at the operation stage and provide evidence-based design knowledge for the next generation of buildings. The main deficiency with this method is that feedbacks collected in the occupancy stage are delayed, sometimes simply ignored and exert limited influence on the building being surveyed. Another drawback with this approach is that it fails to take technological updates into account due to the fact that POE system is rooted from the 1980s and methods to perform POE surveys are normally

questionnaires, interviews, observations, recording, etc. (Preiser & Vischer 2005), which remain almost the same despite the advent of advanced technologies, such as Building Informatics and ICTs. The critique is that the POE paradigm barely changes its methodology and core concept. Another drawback of POE is that conflicts among findings from POE surveys widely exist due to varied human behaviors or diverged environment-related factors, which demonstrated the lack of 'universality, adaptability and flexibility' as evidence-based design guidelines. Therefore, it is necessary to look beyond POEs by promoting direct feedbacks and communication with real-time, dynamic e-participation of building users with regard to advanced ICT technologies. For example, the control center reacts instantly by switching ventilation modes in mixed-mode buildings, changing the room temperature, lighting levels, etc. as occupant vote system via mobile and real-time management are realized by collecting quantitative indications to realize human-building interaction. This vote informed real-time building is an active system, which is turning POE from a problem-finding process to a problem-solving process, i.e. to close the loop

Human-centric, or human-oriented is the same concept as people-oriented, which is defined as "skilled at or focused on interaction with people" in the Oxford Dictionary. Potentials of POE as an ideology and means for improving operational benefits lie on the evolved concept of POE surveys with the intervention of updated technologies with a promising human-building interactive scenario. Concerns of building occupants should be comprehensively collected, demonstrated, analyzed and discussed via interactive mechanism. Previous studies have figured out that user-led innovations with the purpose to deepen the level of user controllability of indoor environments are able to improve user perception of comfort and increase the quality of daily life (Frontczak & Wargocki 2011). Comfort could be enhanced in the perceived built environment by deeper user-building communication and user controllability of buildings.

3.3 The significance of user participation in architecture

The relationship between man and machine and how they could cooperate interactively to contribute to the welfare of humanity continues to be one of main and interdisciplinary topics and challenges of the new era. In building science, "active" and "passive" have been endowed with different meanings under different contexts. For a building mechanism, passive design approaches and strategies taking advantages of natural resources and elements while an active system is employed with energy consumption (Tang 2013a; Tang 2013b). For occupants, when a building is "active", they are generally given limited or no controllability and adapt to the indoor environment "passively"; when the building is "passive", occupants have to respond "actively" to acclimatized with the indoor environment. The proposed interactive scenario, a real-time building, aims to break the boundary between passive and active, and to achieve a dynamic balance of "interactive" instead by the intervention of user e-participatory processes with interdependent individual-based control by users via Internet of Things (IoT) and ICTs.

Citizen participation has been long and widely discussed in planning, public policy and public administration literature (Davidoff 1965; Arnstein 1969; Fagence 1977; Day 1997; Healey 2006; Forester 1999). The proposed study aims to apply the citizen participation theories at the urban scale in the occupant participation at the building level. Deduced from "public participation" (Cai 2010), "occupant participation" for buildings-in-use refers to building occupants involved in building operations and maintenance through direct interaction with building systems. Occupant participation is thus empowered by the interactive vote system introduced in the real-time mechanism. Similarly, occupant participation shall become one of the soft powers of green-intent and human-oriented buildings. The Sherry Arnstein's "ladder" theory (Arnstein 1969) of public participation divides public participation into eight different steps within three levels from shallow to deep, i.e. non-participation (Manipulation, Therapy), tokenism (Consultation, Placation, Informing) and citizen power (Partnership, Delegated Power and Citizen control). Traditional collective-based POE surveys are regarded as "nonparticipation" in this research due to the fact that information from feedbacks are delayed, sometimes ignored, and even when the feedbacks contributes to the database of empirical evidences, the actions and updated design approaches do not have effects on the building being surveyed. The proposed individual-based real-time buildings may reach the "user power" level by empowering occupants to control specific buildings via the vote system. Moreover, based on the Communicative Theory by Jurgen Habermas (Habermas & Habermas 1984), John Forester pointed out that in the process of a design process, designers widely ignored the key content, listening (Forester 1989). Vote system is such a platform that enables buildings to listen to their occupants and communicate directly. Recently, citizen participation theories are trying to adapt new technologies (Foth et al. 2009) such as e-planning and e-participation (Silva et al. 2013; Silva 2010).

The application of the participation theory as a research methodology is combined with the backcasting methodology and the POE methodology to promote user controllability via the direct vote system based on previous research outcomes that individual control of building occupants over the indoor environment has been proven to have a strong positive effect on the overall satisfaction with IEQ (Frontczak & Wargocki 2011), the acceptance of a wider range of conditions (Paciuk, 1990; Leaman and Bordass, 1993; Williams, 1995, de Dear and Brager, 2002) and higher "forgiveness" (Deuble & de Dear 2012). The forgiveness factor defined in the Building Use Studies Occupant Survey and Reporting Method (Leaman & Bordass 2001), is hypothesized to be a function of the power of control, constitutes an important aspect of the research. Employing participation theory in architecture could overcome one important barrier of POEs, that of inconsistencies and conflicts which present architects with a dilemma in making a choice (Frontczak & Wargocki 2011). These inconsistencies are caused by the size of surveyed samples to a certain extent. People are individually different but collectively same. However, 100 to 1,000 occupants can be regarded as an individual compared to the entire population. Thus, findings from occupants of several buildings are more like opinions and perceptions from several "individuals" and they are "individually" different. The intervention of direct user participation is to turn collective-based feedbacks into individual-based control in buildings at the operation level, and to let occupants speak for themselves.

4. CONCLUSION

User-led, real-time controllability communication and controllability enabled by networked building components with the changing roles of buildings, users and architects could lead to a wider range of perceived comfort and wellness of building users in built environments. Furthermore, levels of user involvement in building controllability, technology-enabled interaction platform, inclusive involvements and user trust are key contributing factors in the human-building interaction.

An app run on iOS and Android to display information, to make suggestions about actions can be taken, to collect feedback from users, is an elegant solution to meeting the goal. An advanced option is to integrate iBeacon to provide location information and help researchers in identifying where (which classroom/ studio/ office/ restroom and so on) the events occurred.

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