A Foundation for HabiTech: Three Case Studies in the Built Environment

Figure 1: Three of the buildings examined in this work.

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Abstract

In this workshop paper, I discuss how HabiTech, a novel digital-civics-driven framing of HCI in non-domestic buildings, relates to the author's own prior work in Human-Building Interaction (HBI). As identified by the workshop authors, the non-domestic building has been a site of technological development on a massive scale, the implications of which for ethics, communities, and democracy are yet under-considered in HCI. In this paper, I present three prior peer-reviewed studies which engage across different dimensions. These include differing user-groups (facilities managers, office staff, and students), different technologies (pervasive sensing and IoT); and different levels of building technological enablement. I discuss the relationship of these studies to HabiTech, and offer a provocation for both the workshop and future work contributing to this new research area.

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Author Keywords

Human-Building Interaction; Sustainable HCI; Smart Buildings; Pervasive Sensing; Built Environment; Auditing; Negotiation; Thermal Comfort; Speculation

CSS Concepts

• **Human-centered computing~Human computer interaction (HCI)**;

Introduction

HabiTech builds on a legacy of HCI work not only in Digital Civics, but also in Human-Building Interaction [1] and Sustainable HCI. In brief, this workshop paper curates and explores three studies from my own prior work which I consider contribute to this novel research area. These articles report on how:

1. Pervasive sensing technologies assist building managers in the auditing of older (low-tech) buildings [3], and could provide a route to engaging interested novice building users

Figure 2: An auditor pairs an environment sensor with a base unit during deployment

The works presented in this workshop paper relate to the following four themes from the HabiTech workshop call:

- Data interfaces embedded in architectural space (paper 2);
- Encouraging the emergence of communities among building users (p 2,3);
- User-driven building design, building management, and facility maintenance. (p 1,2,3); and
- Ethics of building-based personal data. (p 1,2,3).

2. Office staff engage with their thermal comfort in a shared (modern) office, leading to shared understandings of temperature [2]
3. Students in a smart building might be better involved in the management process, through building walks and speculative futuring [4]

These case studies mainly examined university campus buildings (Figure 1) built from the 1960s to 2010s, at different stages of the building lifecycle. Engaging in workshops and discussions with both management and occupants, I investigated how technologies embedded within them act on and affect the socio-technical fabric of spaces, and the practices of their occupants. The findings of this research have often been relevant to the proposed HabiTech agenda, and I describe these links along with the context of the studies below.

Case Study 1: Augmenting Audits

Exploring the Role of Sensor Toolkits in Sustainable Buildings Management

The first study considers professional facilities management staff (FMs) and postgraduate students learning to perform energy audits [3]. Auditors gather data on facilities to correct gaps in knowledge, apply for funding, and ensure compliance with standards. Initial interviews with FMs showed that the scope for what can be audited is limited by infrastructure in older buildings (Figure 1, top). Many are served only by a single meter for electricity and gas supplies and are not connected to a BMS (Building Management System). FMs therefore had no way of knowing how much energy is in use by lighting, heating, or by occupants, instead relying on percentages and estimates in their calculations.

Pervasive sensing technologies (Figure 3) offer a way to address this information gap. “Sensor toolkits” were developed, then deployed with both FMs and novice postgraduates, allowing collection of environmental data (Figure 2). Reports produced from data afforded analysis to toolkit users, though some FMs preferred to run their own analysis. The sensors found application in addressing auditors’ questions such as “how long is the lighting switched on in this area?” but also presented challenges in their deployment and use.

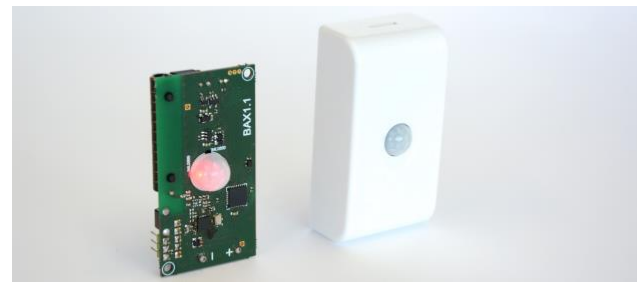

Figure 3: The BuildAX environment sensor, incorporating temperature, humidity, light, movement and magnetic sensors.

The findings, with direct relevance for HabiTech, elaborate on the experiences of these auditors, and the challenges and tensions in using sensor data. This included a tension of consent and accountability, leading student auditors to question the privacy issues in environmental data collection and ask to what extent building managers should be able to analyse the working practices of occupants. Even though it is difficult to infer the purpose of activity from PIR movement sensor data, in the workplace context this is still problematic: the provision of tools to FMs alone reinforces the manager/occupant power dynamic. Yet, novice auditors in this study demonstrated they were capable of processing and understanding sensor data, leading to possibilities for the inclusion of occupants in future user-driven building management processes.

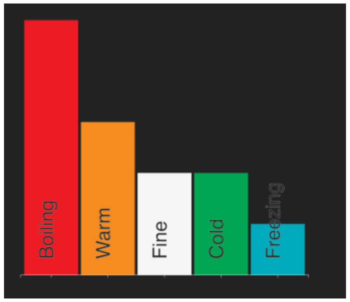

Figure 4: A bar graph showing one hour of survey results, as displayed on a tablet interface next to the HVAC controller in the study office.

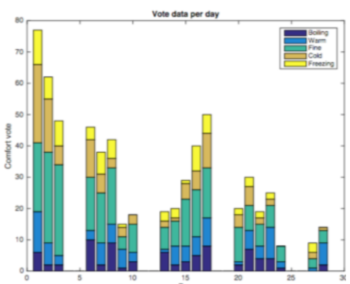

Figure 5: Engagement with the survey device over the study period. Note the considerable use of the 'fine' category (teal). We considered it important to include this category, as complaints are often driven by discomfort, leaving managers with no useful feedback when conditions are OK.

Case Study 2: ThermoKiosk

Investigating Roles for Digital Surveys of Thermal Experience in Workplace Comfort Management

While the first study dealt with quantitative sensor data, the second [2] reports on a study of thermal comfort in a modern building, built 2012 (Figure 1, centre). Thermal comfort is often contested, experience of it differing with many factors including an individual's gender, metabolism, clothing, or location in the room. The office had a history of complaints of both over-heating and over-cooling, and was temperature regulated by a HVAC system controlled by occupants using two panels on the wall. Control had been given to occupants following unresolved discomfort complaints, moving from fully automated to manual use. We wanted to study the role of subjective data in comfort, as contrary to popular understanding, occupants' feelings of personal comfort barely seemed related to our quantitative measurements of temperature at all.

A digital survey system was produced and deployed in the office, affording real-time input of personal subjective comfort. Comfort was measured along a five-point Likert-type scale, from "boiling" to "freezing," with "I'm fine" in the middle. Timestamped button-presses are logged to a remote database, along with temperature measurements from the BuildAX system described above. A sliding window of the last hour of data inputs was visualised on a tablet display, affixed to the wall next to the air conditioning controller.

With regards to HabiTech, the presence of the ThermoKiosk probe and embedded display led to improved awareness of the subjectivity of thermal comfort (and how it differed for other occupants) and therefore changed how occupants rationalised and acted on discomfort. The politics of the office included a social stigma associated with expressing discomfort, which the device overcame in a non-confrontational way perceived as being inclusive of differing opinions. As a result of the data collected, management also discovered that, regardless of the temperature, occupants were uncomfortably cold as soon as the HVAC was put into 'cool' mode, as they were blasted with cold air from the vents. Occupants hoped that these data would be useful in making changes to the way the air conditioning was programmed by management, giving a new channel of engagement for this community with the management process.

Figure 6: Interacting with the ThermoKiosk digital survey tool

Case Study 3: "No powers, man!"

A Student Perspective on Designing University Smart Building Interactions

The final study [4] examines a "smart building" newly opened in 2017 (Figure 1, bottom). This highly sensor-augmented building, backed by a reactive BMS system, claims to offer better energy performance and enhanced occupant experience. Yet, in this third paper, I argue that this is limited by established approaches to building management, delivered top-down through professional facilities management teams, opening up an interaction-gap between occupants and the spaces they inhabit. There is scope here for designing new

Figure 7: A polaroid photo taken by students on a building walk. Many photos such as this were taken, and presented back to other participants in the workshop via poster

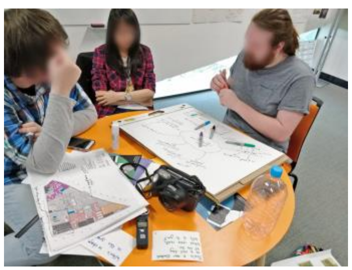

Figure 8: Students participate in a workshop discussing the future of the smart building in which they are based

management practices and exploring how university students might be engaged in an ongoing conversation.

The study investigated how democratic engagement might be fostered in the management process, to guide the design of future smart building interactions. I carried out design workshops with student occupants of the building, run in two halves, asking students to: 1) explore the building through building walks, which they documented using a polaroid camera (Figure 7) and voice recorder; and 2) through a speculative design task (Figure 8), ask what the building might look like in future, and the role "smartness" may play in it.

The findings bear a strong relationship to the HabiTech themes, engaging with the fabric of student life within the building. They advocate for better processes of user-driven building design and management, for example, by communicating to students the ways in which they have agency to change their space and engaging them in ongoing conversations and processes of negotiation around its future. The work also engaged with the ethics of building-based personal data, finding that smart building data can be "Janus faced." Data is both a powerful resource, and a resource for power, in that it can be used for both upholding and challenging existing power structures and the status quo.

Conclusion

HabiTech is an exciting starting point to unify discourse occurring in HBI [1] and Digital Civics. Explicitly communicating research through a HabiTech lens may allow it to have impact in these broader communities. Further, my own work relates strongly to digital civics concepts, with HabiTech offering a useful framing for connecting to wider work. From this, I offer a provocation for discussion at the workshop. Discourse around the future of buildings (especially "smart buildings") often focuses on automated environments, removing agency from building users. How would (and could?) a unified HabiTech research community empower occupants by challenging technologically-solutionist approaches to designing buildings?

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