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Are you sitting comfortably? A tale of two academic libraries.

Chrysoula Tsakontsi[1] and Fionn Stevenson[2]
The University of Sheffield, UK
[1]email: chresso@hotmail.com [2]email: fstevenson@sheffield.ac.uk

Abstract

The way occupants use a building not only affects the building performance but also their personal comfort. Control touch-points -the methods of building operation with which users interact- can enforce occupants' behaviour. Their usability should be understood and designed appropriately. This study examines the connection between level of personal control and usability of control features with end-user comfort. These links require more attention in case of public buildings where indoor environmental conditions are adjusted by Building Management Systems. Two academic libraries are evaluated in terms of post-occupancy performance and usability of control interfaces. Key findings show that artificial lighting and air-conditioning apertures need careful consideration concerning occupant comfort. Moreover, well-designed libraries lead to a high forgiveness factor regarding issues of thermal comfort, noise and facilities malfunctions. Finally, the paper confirms that poorly labeled control touch-points that fail to indicate what the systems they control do, are likely to hinder final occupant comfort.

Keywords: post-occupancy evaluation, control touch-points, usability, occupant comfort, personal control

1. Introduction

1.1 Previous knowledge and gaps

In order to eliminate the gap between design expectations and actual performance of buildings (Brown & Cole 2009, Bordass et al. 2004), more information about occupancy habits and energy use patterns is required. So far, most of the studies about building performance have focused on technical data about buildings, neglecting the building users that actually create the energy demand (Janda, 2011). The way occupants use and operate a building not only affects the building performance but also determines their personal level of comfort.

Brown & Cole (2009) suggested that occupant comfort is related to occupant knowledge of building environmental features and control systems. The more people are uncomfortable the more they will seek how buildings work to enhance their comfort (Darby, 2008). By taking responsibility for their own comfort, occupants are more likely to question the consequences of exerting environmental control. Stevenson *et al.* (2012) suggested that management practices that directly involve occupants end up engaging them the most. Moreover, occupants are more willing to participate in building operation when they actually see the outcomes of their action (Darby, 2008).

Researchers have suggested that by relying solely on computer technology to govern building conditions may provide the optimum environment for user comfort and energy consumption (Sharples *et al.* 1999). However, the evidence indicates that occupants have a preference for buildings that offer some element of personal control over their environment (Leaman & Bordass, 2001). Large education buildings do not generally allow great ability of individual control and it is harder for people to achieve the comfort levels they personally prefer. The few published surveys that deal with

occupant comfort in educational libraries (Cohen *et al.* 2007, Lackney & Zajfen 2005) do not pay adequate attention to the issue of environmental controls and their usability.

With the advent of new technologies buildings have become complex to operate, leading occupants to disengage from control (Chapman, 2005). To enable inhabitants to participate in building operation, building systems and controls must be readily accessible and comprehensible to users, and clearly accompanied by a willingness to use them (Cohen *et al.* 1999). The usability of building control features also considerably affects the occupant's awareness and satisfaction and is directly related to their thermal, visual and acoustic comfort (Leaman & Bordass 2001). A deeper understanding of occupant's relation to environmental controlling systems in buildings is therefore vital.

1.2 Overall aim and objectives

This research aims to identify the connection between levels of personal control and usability issues of control features with end-user comfort in educational libraries and explore the reasons behind this. In particular, the research investigates how library occupants perceive and interact with mechanical and electrical building control systems and whether the design of these helps engage users in terms of sustainability.

2. Methodology

The case studies of two educational buildings enabled targeted conclusions by capturing the field and clarifying patterns of relations between the investigated variables (Flyvbjerg, 2006). Two of the most visited libraries in The University Of Sheffield were selected: Information Commons Library (IC) and Western Bank Library (WBL). IC is a contemporary Learning Resource Centre, with innovative techniques and sustainable approaches, planned to stay open 24/7. Western Bank Library is a Grade II* listed library and a typical example of Modern architecture. Apart from their distinct contrast, the two libraries share several identifiable characteristics regarding environmental conditions and services functionality.

Three key methods were used to collect both quantitative and qualitative data about occupant comfort and usability of control touch-points. The occupants' perceptions were collected using the Building Use Studies (BUS) occupant questionnaire, modified to include questions addressing occupant knowledge and engagement with control features. Responses were grouped into staff, visitors and building system operators in each library. This helped to identify permanent and temporary occupants' responses. Only areas with open access to everyone were investigated to allow comparison between these groups. Additional questions investigated those control touch-points that were accessible to everyone and were based on the six usability criteria, that Bordass *et al.* (2007) specified as requirements of good design of control touch-points: Clarity of purpose, Intuitive switching, Usefulness of labeling and annotation, Ease of use, Indication of system response, Degree of fine control.

Spot measurements for temperature, humidity, ambient lighting, and sound were taken as well, for comparative purposes. Indoor environmental conditions were measured at several representative locations in the open access areas within each library and at regular times during the days of the survey.

Several semi-structured interviews and informal discussions with library visitors, staff members –including cleaners and maintenance team- and the architect of IC were also held. These interviews were designed to reveal the perspective of the interviewee on building performance and usability issues.

3. Results

3.1 Questionnaire results

A total of 54 people responded to the survey for IC and 43 for WBL. They consisted mainly of students under thirty years old (74% for IC, 72% for WBL) that occupied the libraries for approximately one year. The sample included both regular and intermittent visitors. 61% of the respondents use IC as their normal working area and basically for full time studying (circa 5 days/week, 8 hours/day). WBL is normal working area for only 21% of respondents and most of them occupied it for 1-3 days/week. The majority of the library users were internationals, apart from the staff members. Both staff and visitors were involved in close sedentary work that requires silence. Key questionnaire results for comfort and design are shown in figure 1.

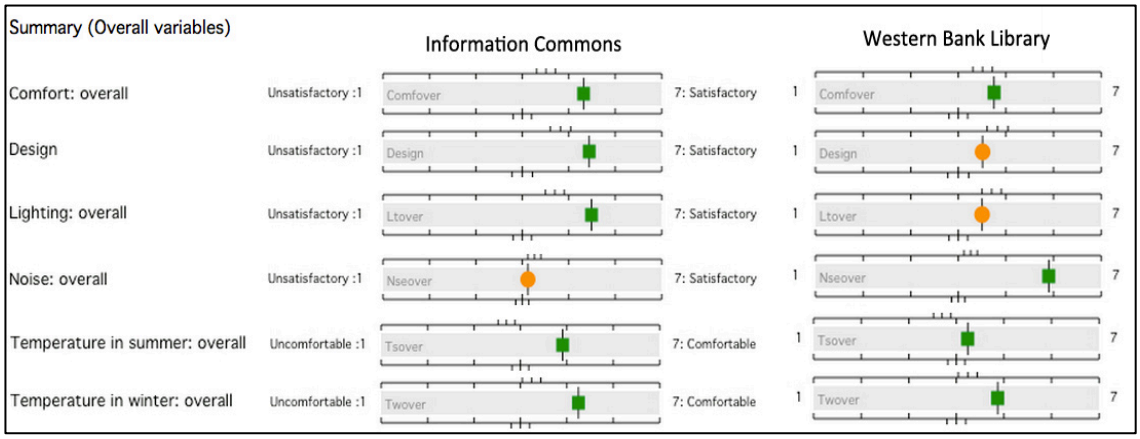

Figure 1: Comparison of key satisfaction findings for comfort and design.

3.2 Noise and Lighting

IC was rated to be a very positive and functional space and scored very highly in the benchmark scale of BUS UK 2011 (75th percentile for design). The key design intention for the IC was to flexibly accommodate current and future learning methods and technologies. The IC features, internally, a triple-height top-lit atrium, a double-height silent reading room and a variety of open spaces. The unwanted transmission of noise is well addressed by appropriate materials and acoustics and only a little noise can be heard from outside the building in spite of the location at a busy traffic junction. Natural and artificial lighting in IC did not score highly rated, but respondents did not have any particular reasons for their ratings.

The design of WBL was well appreciated by visitors needing a quiet place to study. Initially, WBL was designed with only the main reading room as open access. None of the respondents mentioned noise as being a problem, despite the quite high measured levels of sound -average 37,57dB, in comparison to the required 25-30dB for a library spaces. Actually the perception that it was too quiet in some cases made negative impression “It’s too quiet there, soon I get bored and sleepy”.

The main problem of WBL was lighting. Although respondents enjoyed the natural light coming through large windows and the good view to landscape, artificial lighting was rated as totally inadequate. WBL does not provide any task lighting. Moreover, some corners of the four underground levels -initially designed for storage purposes- were converted gradually into artificially lit study spaces. The lack of visual connection to outdoors means occupants underground remain unconscious of time and weather. Numerous comments about insufficient artificial lighting sank the library to the 5th worst place in the BUS benchmark. However, library users had no major problems with glare. Yet, when glare occurred curtains did not completely solve the problem, because when drawn, many parts of the library became too dark for reading.

3.3 Heating and Ventilation

Respondents experienced some problems with the temperature in the IC. Although the 19-21°C required by the Operation and Maintenance manual of IC was more than accomplished (mean measured value 23,7°C), the occupants described it as uncomfortably cold for their preferences. The responses in relation to WBL temperature were quite the same.

Library users in both buildings can manually control heating (only in some spaces of the libraries), lighting (individual desk lights in IC) and noise level (by being able to chose area of study). All the other building services in the libraries (large space heating, air-conditioning, mechanical ventilation, artificial lighting) are controlled automatically by BMS systems and interfaces to which only members of maintenance team have access. As a result the majority of questionnaire respondents in both libraries feel that they have control only over lighting and noise. A small number of visitors who perceived having plenty of control over heating/cooling/ventilation, were actually unaware of how to control these elements. One respondent stated: "there should be a way to control all that but I never tried to find out more." The occupants of WBL indicated that personal control over lighting was of greater importance than those of IC, probably because their expectations in this area have not been met.

The controls that were selected for the survey included several user touch-points for heating, air-conditioning, electrical equipment, water services and external building fabric. These particular control features have a direct influence on occupant comfort.

The most striking findings were found in relation to the air conditioning floor diffusers of the IC. There was a great deal of comment by students who avoid work areas close to them, due to common strong draughts of cold air. The maintenance team were also frustrated by the same air conditioning system. In theory the air conditioning system should be very flexible, with reconfigurable diffuser tiles on the floor. However, the current array of bookshelves limits the function of the diffusers, failing to heat the place evenly. The durability of diffusers is in question as well, since they were not designed for heavy wear, e.g. book trolleys. Finally, most occupants simply did not know what the diffusers were meant for or whether they were working.

3.4 Water and Curtain controls

Curtain switches in WBL gathered the lowest usability ratings of all, but also had the poorest response rate. Only staff members are allowed to operate this control, and many visitors did not know where they were located or what they were for, wondering whether they were lighting or curtains controls. The controller combined three types of buttons/switches. The top three buttons have labels, but there is no feedback as to what will happen (and for how long) when one of the rest buttons is pressed (see figure 2).

Figure 2: Curtain controller.

Toilet taps which separated hot and cold water than mixing it, were not pleasant at all to the international library users in the WBL. Continuous testing until the right pressure is reached, led to significant amount of water and energy being wasted. Someone who encountered the taps of IC wondered whether to rotate or to pull them due to the lack of design clarity. Nevertheless, the overall impression for taps was good, with every usability design criterion above 3 in a scale 1-5, as in similar usability surveys (Stevenson *et al.* 2012).

4. Key Findings

The perceptions of comfort in both libraries were very high compared to other buildings. The score for overall comfort in IC was raised at the 86th percentile of the reference data set, while in the WBL was at 55th. Respondents had specific complaints, however, despite being very satisfied in general. Although the target temperature was achieved, the sedentary activity and international background of the occupants meant this temperature did not ensure thermal comfort. The design of controls should consider users' culture and personal needs more (Stevenson *et al.* 2012).

The study confirmed that at least some level of occupant control has positive impact on user comfort, even though the university clearly requested no personal control to be given to the library visitors. Taking control away from the occupants may actually establish high-energy demand practices, as identified in this study. Only staff members could open or close curtains in the WBL regardless of visitors' direct requirements, affecting their thermal and visual comfort. IC respondents were unable to adjust draughts from the diffusers, leading to discomfort. By contrast, desk lights, provided some level of individual control consuming energy only when needed.

According to Leaman and Bordass (2007), people are more tolerant, if things do not turn out as expected, when they understand how controls work and what they are for. This is evidenced by respondents of the present survey who were more demonstrative of their frustration when the unfamiliar entrance security machines did not respond as expected, compared to the often broken, ordinary electric sockets.

Findings from the usability survey identified a variety of reasons why people do not use or do not use appropriately the available building controls, including:

. overly complex or simple control systems poorly understood by users
. unusable controls defined by whether they are properly located and labeled, clear in their intent, easy to use and indicating whether the controlled system is responding
. temporary occupancy which discourages from using controls for short period
. lack of occupant awareness about environmental systems
. occupant action taken only after discomfort levels reached.

This research also gained insight into the importance of considering maintenance and cleaning requirements during initial design phase. The 24/7 operation of the IC had clear implications for maintenance timing and access. There is a real problem with overhead ceiling lighting of the sheltered atrium. Technical team needs to use 4-floors high scaffolds to access the lights necessitating temporary closure of '24/7' library.

5. Conclusions

Contemporary library designs, like IC in this study, with natural daylight and open floor plans do not necessarily create problematic thermal, acoustical or visual issues, provided they had been addressed during design process. The findings also show that user comfort in libraries is highly dependent on good management of artificial lighting.

Heating/air conditioning systems appeared to be less understood, suggesting that more attention needs to be paid in designing their controls and communicating thermal comfort. Since occupants are highly sensitive to draughts, mechanical ventilation or air-conditioning systems need to be carefully selected with comfort needs prioritised.

Occupant perceptions were found to vary from actual temperature values measured due to several factors such as time and place, or even more complex ones like emotions and memories. This is explained by a high forgiveness factor (Bordass *et al.* 1997) in both libraries, which means people are willing to forgive functional issues because of their general satisfaction. IC is not a conventional library. The original brief was for social rather than quiet traditional library. This influences the overall

atmosphere and comfort. Therefore, the design of the IC was rated as very good, leading to a high forgiveness factor (study mean value 1,07 in a scale from -0.5 to +1.5) in relation to issues of thermal comfort, noise and facilities malfunctions. This shows the value of good design in a building over and above simply considering efficiency. In WBL, the provision of quiet reading spaces to enhance concentration led some visitors to overlook the drawback of poor artificial lighting (study mean +1.0).

The study also shows that if complaints about discomfort cannot be reported (e.g. at the 'helpdesk') automated BMS systems end up prevailing over comfort. This requires careful consideration of library management and depends on quicker response from maintenance team, finer adjustment of BMS or provision of local controls.

It should be noted that visitors of the libraries do not usually occupy them on a regular basis for very long. Moreover, the survey was conducted during summer period of 2012. This might have resulted in more positive ratings than usual. Larger studies beyond this pilot study are needed to provide a better source of data for statistical assessment of occupant satisfaction and educational building control systems. The long-term objective should be the development of an adaptive control system in buildings which relies on occupant perceptions. Moreover, further research should be done assessing the relation between usability and user comfort. This will establish a dataset of benchmarking which in turn will promote good design.

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