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# Usability of thermostat controls – an example of the UCL Energy Institute

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## Abstract

Control interfaces are the intermediary between occupants and building systems, however most research on building performance focuses on the functionality of the systems and neglects the design and usability of the controls that regulate these systems. The usability of controls can affect the energy consumption of a building, as well as occupant comfort and satisfaction. A case study of the usability of the thermostat controls installed in UCL's Energy Institute was conducted. The results showed that occupants had very little knowledge of the variety of functions available on the thermostat and how to use them. Post-occupancy evaluation (POE) surveys of buildings had no questions on the usability of controls; therefore building occupants have not been able to provide their feedback on the usability of controls. The paper addresses this omission by demonstrating how to give occupants the opportunity to assess and provide feedback on the design and usability of controls.

Key words: control interfaces, usability, post-occupancy evaluation, feedback, building systems

## 1. Introduction

Buildings and their systems are required to perform much better in order to meet the environmental and economical challenges of the 21st century. Thermostats control a significant proportion of a building's energy consumption and act as intermediaries between occupants and the building systems. A building's performance is affected by the usability of local controls for heating, ventilation and cooling as well as for lights and blinds. Case studies in non-domestic buildings have shown positive correlation between occupant satisfaction and levels of perceived control (Bordass, et al., 2007). A study by Karjalainen and Koistinen (2007) found that adequate thermostat controls are essential for the comfort, health and productivity of office occupants. Bordass, et al. (2007) also affirms that usable controls improve user satisfaction, comfort and provides higher energy efficiency whilst providing users with a faster response of the system. Buildings with well-designed local controls tend to be energy efficient because systems are more likely to operate only when occupants need them. Therefore better controls can save energy and reduce carbon emissions

(Bordass, et al., 2007). Evaluation of controls is essential to determine whether they operate effectively in regulating building systems and to identify flaws in the design and usability of the controls. This can then be improved so that a new generation of user controls are designed and produced which are easy to understand, operate and intuitive to use. This paper uses UCL Energy Institute as a case study to investigate occupants' thermostat usage, the design problems experienced by occupants when using the controls and the impact on occupants comfort.

## 2. Methodology

A mixed-methods research was conducted using both qualitative and quantitative data collection methods. The complementarity approach was adopted from the mixed-methodology to enable a number of research strategies to be employed in order that different aspects of the study can be investigated and dovetailed. The mixed-method research capitalises on the strengths of the variety of methods used, whilst offsetting the weaknesses of each method.

### 2.1. Structured Observation

Structured observation of students and researchers' interaction with the thermostat control was conducted. 12 students and 13 researchers in the Energy Institute participated in the structured observation test of occupant's interaction with the controls. An observation guide was designed that specified the observables as well as specific tasks for participants to undertake. Each participant was taken to the nearest thermostat panel where the observation commenced. Each individual was asked to perform a number of tasks as specified in the pre-designed observation guide. Participants' responses and results were recorded manually by hand on an observation form as the tasks occurred. Each individual was assessed on their ability to successfully complete a task. All participants were individually asked the same set of questions at the control panel and asked to demonstrate the same set of tasks.

### 2.2. Focus Groups

Two sets of focus groups were arranged in February 2011; one focus group with the students and another with the researchers to discuss their use of the thermostat controls and the problems encountered when using the thermostats. The researchers' and students' focus groups were held separately to prevent students from being uncomfortable and inhibited in the presence of the researchers. This may result in students not fully expressing their views and opinions regarding the use of the thermostats. The aim was to have between 6-12 participants in each focus group which falls within the recommended amount of participants for focus groups. 11 students attended the student's focus group and 6 researchers attended the researcher's focus group. A focus group topic guide was designed which entailed the list of questions and key points for discussion during the focus group. Each participant was given a copy of the topic guide before the focus group discussions commenced. The focus group discussions were tape recorded and later transcribed and analysed.

## 2.3. Occupant Evaluation Questionnaire

The occupant evaluation questionnaire was designed by myself and handed out in March 2011 to 37 occupants of the Energy Institute who all completed the questionnaire. The aim of the thermostat usability questions was to obtain both qualitative and quantitative data about occupants' experiences and opinions of using the heating and cooling system and its controls. The seven point Likert scale was used to enable respondents to express their opinions and show how strongly they felt about the usability of the controls.

# 3. Results

## 3.1. Structured Observation tests

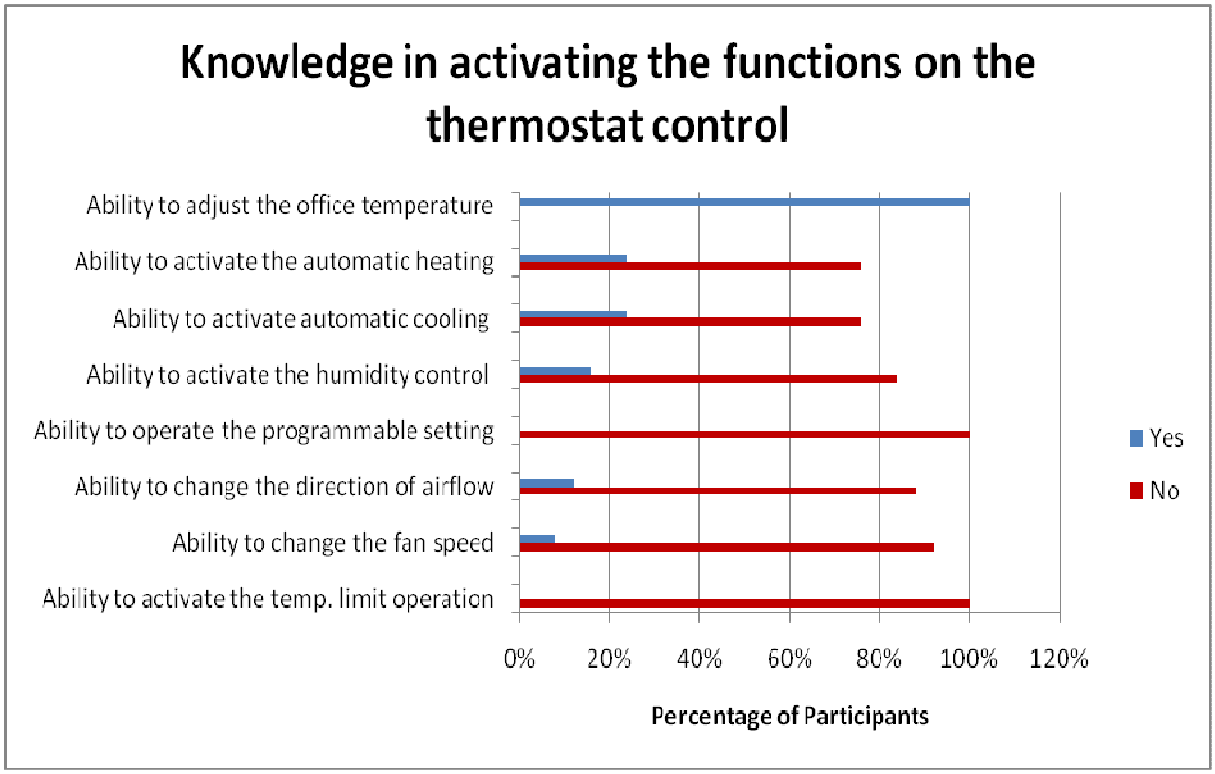


Fig 1: Knowledge in activating the functions on the thermostat

The structured observation test of occupants' interaction with the thermostat panel was performed in February 2011 and 25 occupants of the Energy Institute participated in the test. Participants were able to list 6 functions from a total of 11 functions on the thermostat control panel. The listed functions were the heating control, cooling control, clock setting, fan-speed, airflow direction and switching the thermostat on and off. However participants only used 3 functions from the control panel which were the heating control, airflow direction and switching the thermostat on and off. Participants' knowledge of using the functions on the thermostat is depicted in Figure 1. All of the participants were able to adjust the office temperature on the control panel. Only 8% of participants were able to change the fan speed of the HVAC unit, 12% were able to change the airflow direction, 16% could use the humidity control function and 24% of participants could activate the automatic cooling and heating function. None of the participants were able to activate the programmable setting function or the temperature limit operation on the thermostat panel.

### 3.2. Evaluation Questionnaires

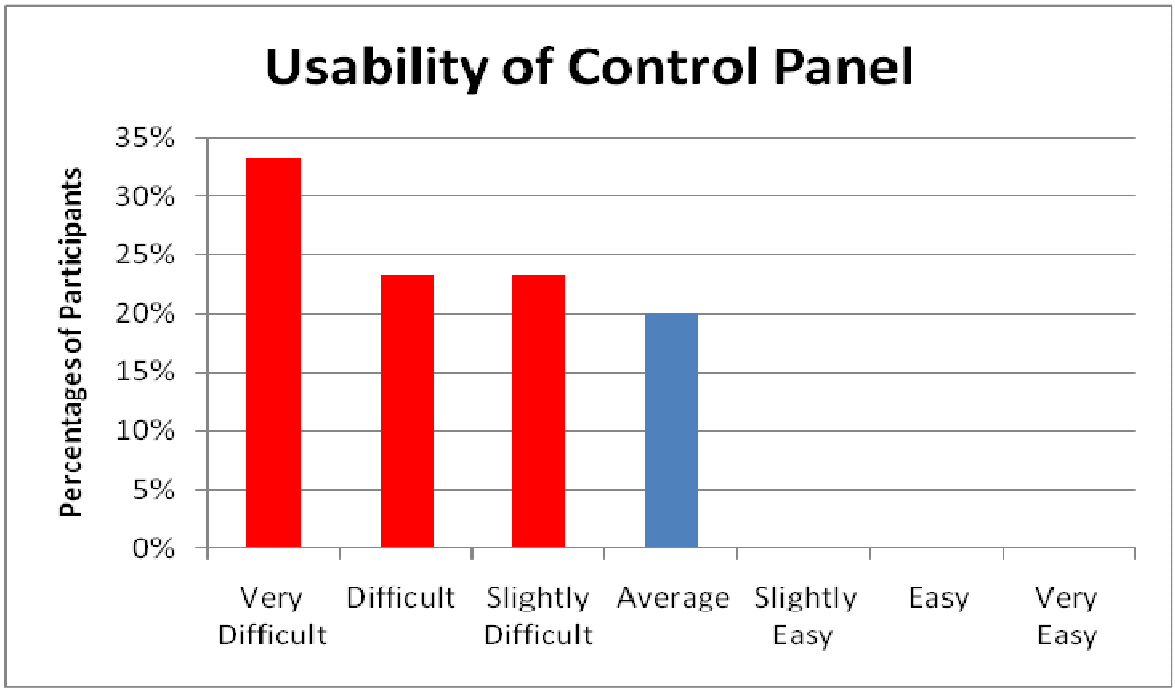


Fig 2: Participants' Usability Rating of theThermostat

The evaluation questionnaires were completed by 36 occupants in March 2011. The self-reported functions used by respondents were stated. 75% of respondents declared using the temperature control function, followed by 28% who reported using the airflow direction function. 25% of respondents stated they had used the fan-speed control function, whilst only 14% stated to have used the fan only operation function. Only 11% of participants reported using the automatic operation function and 3% stated they had used the limit operation function. Occupants were asked to rate the usability of the thermostat in the evaluation questionnaires and the results are depicted in Figure 2. The majority (33%) of participants rated the thermostat control as 'very difficult' to use. In total, 79% of participants rated the usability of the thermostats controls at below average ranging from 'very difficult' to 'slightly difficult'. The majority (36%) of respondents rated the comfort level provided by the HVAC system as poor. 69% of respondents rated the level of comfort experienced at below average, ranging from 'very poor' to 'slightly poor' comfort. Only 6% of total respondents rated the level of comfort at above average.

### 3.3. Focus Group Discussions

Students and researchers in the focus group discussions described the usability of the thermostat control as poor. They reported that the symbols and icons on the thermostat control panels were difficult to understand and the control panel was unintuitive to use. They also complained of too many buttons and functions on the control panel which they rarely or never used, hence felt they were unnecessary and contributed further to the poor usability of the thermostat control. Both student and researchers declared using mainly the temperature control function on the thermostat controls. The other functions were hardly or never used as occupants either did not know how to use them or did not know that they existed.

## 4. Discussion

### 4.1. Usability of Controls

Most of the participants reported the thermostat control as 'very difficult' to use and 79% of participants rated the usability of the thermostat as below average, ranging from very difficult to slightly difficult (Fig 2). This is demonstrated by the very small proportion of participants able to use the functions on the thermostat control during the structured observation of occupants' use of the control. None of the participants knew how to use the temperature limit operation function or the programmable setting on the control panel. Both students and researchers in the focus group discussions complained of the poor usability of the thermostat control. The results of the focus groups are similar to the findings of Karjalainen & Koistinen (2007) who noted that in a survey of nine office buildings, occupants found it impossible and awkward to use the thermostats and found the symbols and lights on the thermostat difficult to understand. A number of studies have highlighted the poor usability of thermostat controls and have listed several common complaints such as complicated interfaces, small buttons/fonts, poorly understood symbols, abbreviations and terminologies, illogical layout of the user interface and lack of feedback (Karjalainen, 2008; Vastamaki, et, al., 2005; Dale & Crawshaw, 1983; Moore & Dartnall, 1982). The technology of thermostat control interfaces have improved significantly over the past decades, however designers of thermostat controls have not listened to the complaints of end-users as the same usability issues reported as far back as 1982 are still occurring today.

### 4.2. Improving the Usability of Controls

Occupants stated their preferences for thermostats that were easy to use and understand with less functionality, bigger buttons, texts and icons, annotation of symbols and clear feedback that showed the system was working to fulfil their requests. It was also suggested that the functionality of control panels should be reduced to only features relevant and most frequently used by occupants. Another suggestion was to have thermostat control panels that held two sets of controls; one control would contain the most commonly used functions whilst the other control would contain advanced functions. The building and control industry should study occupants' use of controls and adopt a user-centred approach to the design of controls if they are to produce usable controls. This is supported by Karjalainen (2008) who stresses the importance of using user-centred design to develop highly usable controls. Usability guidelines are essential in helping designers develop interactive systems and to ensure high usability of controls. Most of the usability guidelines available are targeted towards designers of software and to those in the field of computer science. The usability guidelines by Bordass, et al. (2007) were the only set of guidelines targeted for designers of interactive systems in buildings. However, there were no usability guidelines specific for room temperature controls.

## 5. Conclusion

The results of the structured observation showed that although all the participants were able to adjust the set point temperature on the thermostat, only few participants were able to change the fan speed, the air flow direction or activate the humidity

control function. None of the participants were able to use the temperature limit operation function or the programmable setting function. Occupants complained about the poor usability of the thermostat; they found it unintuitive and complicated to use. Occupants were unable to use the limit operation function which prevented them from using it as a temperature buffer to stop the HVAC units cycling from heating to cooling mode which caused occupants discomfort. This demonstrates that the poor usability of the controls contributed to occupants' inability to create a comfortable indoor environment. There are currently no standardised or recommended usability guidelines specific for the design of thermostat controls. It is recommended that research should be conducted to develop usability guidelines which are based on a user-centred approach and specific to building controls. Once these guidelines have been established, regulators in the control industry and policy makers should mandate that all manufacturers and designers of controls follow the recommended usability guidelines in the design of controls.

It is recommended that observation tests and focus groups are used in POE of buildings, especially in the evaluation of controls. These methods reveal a lot about occupants' use of controls and the problems they encounter, whilst enabling occupants to be involved in the process of identifying solutions to the issues raised. I noticed that post-occupancy evaluation (POE) surveys had no questions on the usability of controls. The lack of questions about controls means that building occupants do not have the opportunity to give their judgements and feedback on the usability of building controls. It is recommend that post occupancy evaluation surveys of buildings are updated to include a section on the evaluation of controls with the following type of questions; occupants' rating of the usability of the controls, occupants negative and positive experiences of using the controls and their suggestions on improving the design of the control interfaces to make them more usable. This information will increase the data available on controls and help to bring the usability issues of control interfaces to the forefront in academia, industry and to policy makers.

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