MC 2020 Proceedings of 10th Masters Conference: **People and Buildings**
Online, 18th December 2020
Network for Comfort and Energy Use in Buildings: http://www.nceub.org.uk

Comparison between working/studying in a University environment and working/studying at home: Effect of the perception of thermal control on people's thermal comfort and satisfaction in the UK

Daniela Valencia Arango[1]

[1] MSc Sustainable Architecture Studies, University of Sheffield (SSoA), UK, S10 2TN, danivalen7@gmail.com, dvalenciaarango1@sheffield.ac.uk

Abstract: The research approach on the perception of control and thermal environment satisfaction has mainly been directed to non-domestic spaces. Many studies have been carried in office buildings and Universities, trying to connect energy efficiency, worker or student productivity, and thermal comfort. Little has been explored on the subject in domestic spaces. The results of this research show a significant positive correlation between control satisfaction and temperature satisfaction (R2=0.453). However, their perception of control over the thermal environment was heavily dependent on whether they were at the university or home with 81% of respondents reported being "satisfied" with the amount of control at home while 68% reported being "dissatisfied" with their amount of thermal control at the university. This difference was also large when separating the sample by gender or age. By giving effective personal thermal control devices people will feel more satisfied with their thermal environment.

Keywords: Thermal Comfort, Thermal Satisfaction, Thermal Perception.

1. Introduction

Several decades have passed since architects, scientists and psychologists around the world began to question how people felt in the style of office buildings that were being designed: user-oriented (cellular offices) and business-oriented (open plan office). Open-plan offices are commonly used in the United Kingdom, as they offer higher occupancy, improved space efficiency, easy reconfiguration, and can be cheaper to build and maintain. This type of layout does not allow individual environmental control and reduces user satisfaction (Shahzad et al, 2016). Multiple thermal comfort studies suggest that having personal control over indoor climate contributed to thermal comfort and satisfaction of building occupants (Boerstra 2016; Leaman and Bordass 1997; Dear and Cena 1998).

Although the practice of working from home has been relevant from at least the 1980's (Olson and Primps 1984), access to information technology such as computers and fast internet connectivity has increased the practice (Hampton 2017). Since the start of the coronavirus outbreak in January, affecting the United Kingdom (UK) in March, the UK government has implemented strict safety measures to prevent and control the spread of the virus to the population.

This project aims to analyse the variations on the perception of control and thermal satisfaction, and some of their determining factors by using an online survey-based methodology. This online survey is based on the American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) standard 55-2010 (2013), Thermal Environment Conditions for Human Occupancy Survey. This survey was modified to better reflect common practices in the UK and to leverage the advantages of an online platform, a necessity due to the lockdown. The survey asks the users to recall their experiences working at home and the

university during the 2019-2020 heating season during which the transition from working at the university and working from home took place due to the coronavirus pandemic.

2. Methodology

The sampled population consists of staff and students from the University of Sheffield, located in the city of Sheffield, a municipality in South Yorkshire, England. This location has a warm and temperate climate, considered to be temperate oceanic climate (Cfb) according to the Köppen-Geiger climate classification. (Met Office, 2020). With mild winters and a heating season from October to April.

2.1. Survey

The seasonal condition selected for this research is winter. An online survey was deployed to gather data comparing the thermal environment satisfaction working/studying in a University environment, to working/studying at home. The participants of the survey were asked to recall what was the thermal sensation while working/studying in the university environment and what was the perception of control they had over the thermal environment and compared it to the thermal sensation and perception of control they have working/studying at home. The responses may not be precise due to the difference between all locations, construction methods, control device systems available to control the thermal environment, personal preferences, activity levels and metabolism.

2.2. The ASHRAE Standard 55-2010 survey

The data collected for this research was gathered through an online survey, using as a reference the ASHRAE standard 55-2010 (2013), Thermal Environment Conditions for Human Occupancy Survey. These ASHRAE surveys, used as reference, were designed to evaluate the worker thermal satisfaction in a specific office environment.

2.3 Modification and Extension of The ASRAE 55-2010 Survey

In comparison with the ASHRAE 55-2010 survey, the survey used for this research is not designed for a specific location. Instead, it is divided into two parts: working/studying in a university environment and working/studying at home. The results of these two parts are used to compare thermal environment satisfaction and perceived thermal control in these locations.

The first part of the survey was designed for the working/studying in a university environment and was divided into staff and student sections to help determine the buildings where the work or study activities take place.

The second part of the survey was designed for working/studying at home. The main question that changed compared with the university section was the selection of the type of housing where people live in the United Kingdom. The final section of the survey asks generic demographic questions: gender and age of the participant of the survey.

2.4 Implementation of the survey, distribution, and data collection

The survey in this work was implemented on the Google Forms online surveying platform which is available to all members of the University of Sheffield. Here, the survey was divided into 10 sections to reduce user fatigue and facilitate navigation. A key advantage of using this platform is user familiarity with it as it is frequently used in university settings for online surveys, even before the COVID-19 lockdown period.

The online survey uses conditional section navigation (Figure 1) to direct users to the relevant survey questions. The survey is bifurcated between students and staff to give users relevant options for their workplace/place of study descriptions. Also, only the users that report being dissatisfied with their thermal environment are asked about their reasons for this dissatisfaction.

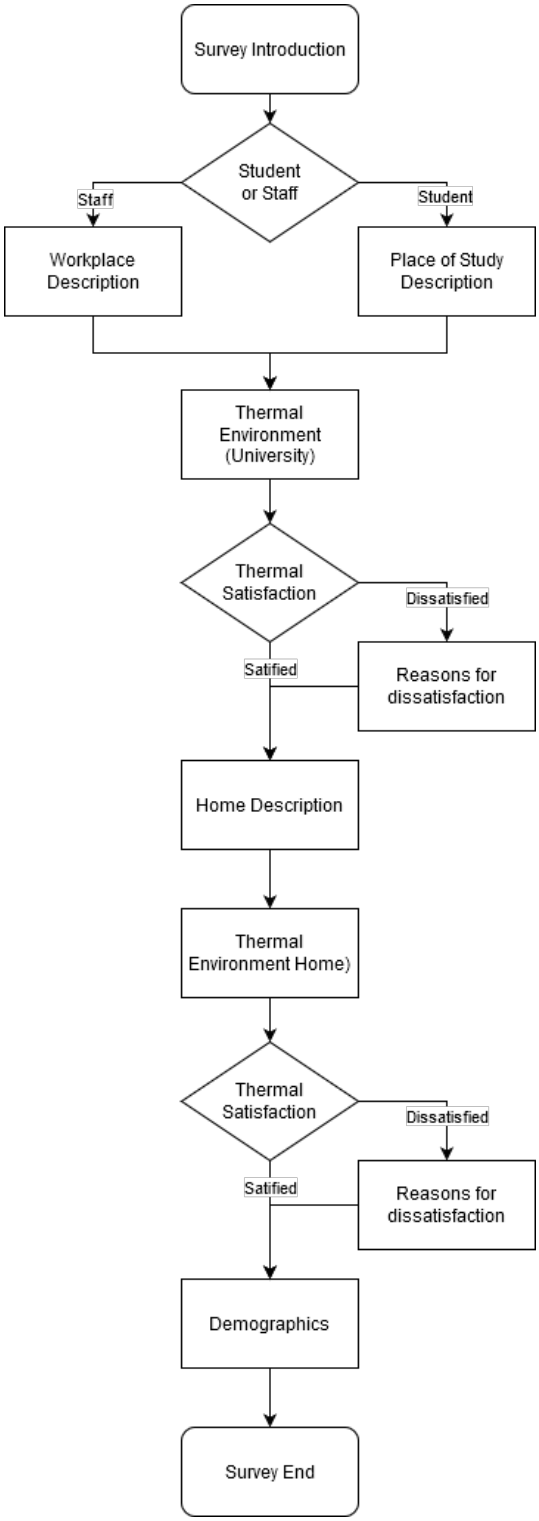

Figure 1 Survey flow diagram

The survey was distributed to students and staff volunteers at the University of Sheffield using the "myAnnouncement" system through an email list used only for research studies. The "research-studies" list has 3,700 students and 1,809 staff volunteer subscribers. The survey was distributed to the list on June 11, 2020 and collected data for a month (until July 11, 2020).

The survey collected 117 responses: 85 from staff and 32 from students. This data was automatically tabulated into a Google Sheets worksheet by the Google Forms platform. Summary statistics and graphs were calculated using additional Google Sheets.

3. Control Perception and Thermal Satisfaction

3.1. Control devices vs Control Perception

The survey results show a good correlation (R2=0.453) between control perception and the number of control devices (Figure 2). This shows that when people have less thermal control devices the perception of control is low. When people have access to more devices the control perception increases. From 5 devices onward, the control perception is as high as it can be, as it is already at "very good" or "complete". This shows that having at least 4 devices people will have a "neutral" or "good" control perception. More devices implicate more energy use, more complex architectural design, additional building construction cost and maintenance. The results of this survey show that access to thermal control systems is a key factor for improving the perception of control.

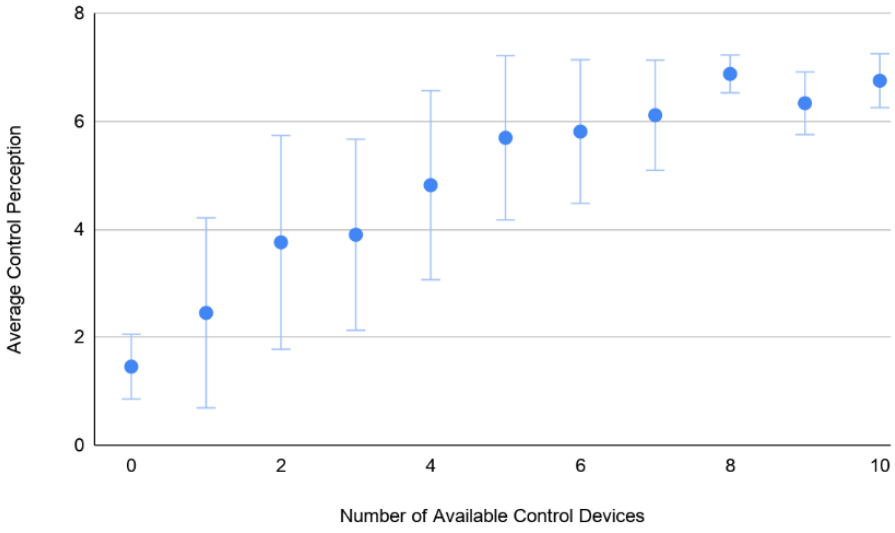

Figure 2 Number of Available Control Devices vs Control Perception. Error bars show 1 standard deviation.

3.2. Control Satisfaction vs Temperature Satisfaction

Survey results showed that there is a significant correlation between control satisfaction and temperature satisfaction (R2=0.453) (Figure 3). Temperature satisfaction did not increase substantially with the increase of control satisfaction after users reported being "slightly satisfied" to "very satisfied". Personal access to control devices increases control perception, that increases control perception satisfaction and finally raises thermal satisfaction. By giving effective personal thermal control devices people will feel more satisfied with their thermal environment.

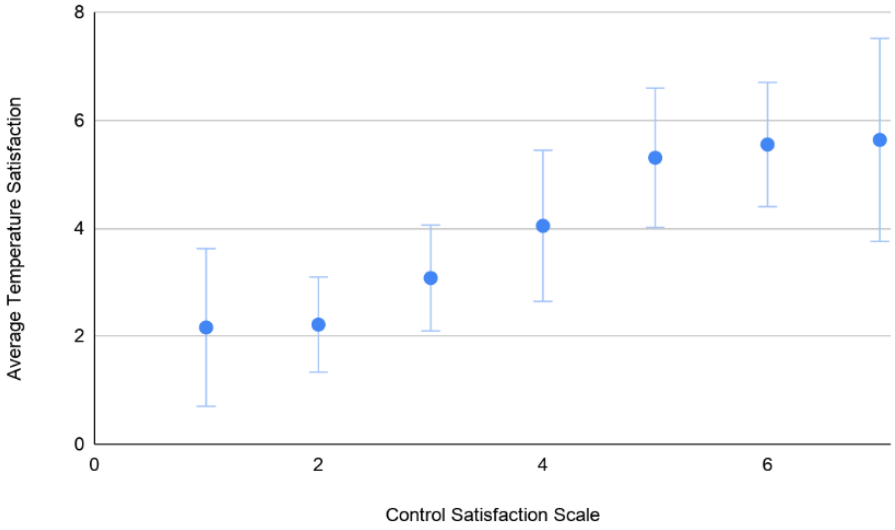

Figure 3 Control Satisfaction vs Temperature Satisfaction. Error bars show 1 standard deviation.

4. Discussion and Conclusions

This study investigated the difference of perception of control over the thermal environment and how this affects the user thermal satisfaction and comfort, working/studying at the university and working/studying at home. Previous studies have surveyed the impact of thermal control over the user's satisfaction, (Boerstra 2016; Leamon and Bordass, 1997; Dear and Cena 1998) and how satisfaction and productivity increases when people have personal control over the thermal environment in the workplace (Karjalainen and Koistinen 2007, Kwon et al 2019, Luo et al 2017). These studies were all carried out in non-domestic buildings. Studies on thermal satisfaction and control perception on dwellings and houses are less common. The present work compared and combined data from both types of environments to extend the ideas of control perception and satisfaction. This has become increasingly relevant with the rapid rise of work-from-home approaches during the COVID-19 pandemic of 2020.

For environmental and financial reasons, University buildings are designed with centrally controlled systems and do not provide most of the users with control over their thermal environment. The aim is to maintain a general thermal environment providing comfortable working space and it is expected that people will dress according to the weather and indoor thermal conditions (Riley, 2017). The survey data shows more than half of the participants (68%) felt dissatisfied with their level of thermal control and 66% were dissatisfied with their thermal control in the University.

The results of the workplace description at the University shows that most people have access to windows and doors and that they are near these windows and exterior walls. The results of the place of study description shows that students use spaces where they have no thermal control devices available. These study spaces have central thermal control systems, managed by the university following the a heating policy.

Users might not be aware of how to best use the control devices they have available. According to the survey results, access to more control devices has a moderate correlation with improved control satisfaction (R^2=0.309) or improved thermal satisfaction (R^2=0.113). Additionally, as dwellings in the UK are often poorly insulated, therefore, an abundance of thermal control devices will not be a guarantee of thermal control effectiveness and satisfaction.

The main issues of discomfort reported at the University were “Thermostat inaccessible” and “Thermostat adjusted by other people”. A study by Shahsad et al, (2016) indicates that people preferred to have individual control over the thermal instead of sharing a centrally operated thermal system due to individual differences and difficulty to satisfy everyone. Overall, the average satisfaction at home is higher for all numbers of available control devices. Even if at a specific home the number of control devices is low, they can be manipulated to fit the desired temperature levels of a single person increasing control and thermal satisfaction.

Thermal satisfaction and control perception were generally low in the University. 79% of the sampled population had 3 control devices or less in their place of study or work at the University. Only 10% reported having a “good” or better level of control, while no participants reported having complete control over their thermal environment. Survey results show that there is correlation (R^2=0.494) between thermal control satisfaction and thermal environment satisfaction. Accordingly, only 18% of participants reported being satisfied with their thermal environment at the University. This supports the previous observation of Humphreys (2002): “discomfort increases if control is not provided, or if the controls are ineffective, inappropriate or unusable”.

This research showes that there is a significant correlation between control perception and temperature satisfaction. People had higher control perception at home and lower that the University due to the lack of control available to them. Having personal access to an effective thermal control device increases control perception that increases control satisfaction and finally raises thermal satisfaction by giving effective personal thermal control.

References

Boerstra, A.C., (2016). Personal Control over Indoor Climate in Offices: Impact on Health, Comfort and Productivity. [online]. PhD Thesis: Eindhoven University of Technology. [Viewed 8 March 2020]. Available from: https://www.researchgate.net/publication/330116736_Personal_Control_over_Indoor_Climate_in_Offices_Impact_on_Health_Comfort_and_Productivity

Cena, K. & de Dear, R.J., (1999). Field study of occupant comfort and office thermal environments in a hot, arid climate. ASHRAE Transaction, 105, 204-217.

Hampton, S., (2017). An ethnography of energy demand and working from home: Exploring the affective dimensions of social practice in the United Kingdom. Energy Research & Social Science, 28. 1-10. Available from: https://doi.org/10.1016/J.ERSS.2017.03.012

Karjalainen, S. & Koistinen, O., (2007). User problems with individual temperature control in offices. Building and Environment, 42(8), 2880-2887. Available from: https://doi.org/10.1016/j.buildenv.2006.10.031

Kwon, M., Remøy, H., van den Dobblesteen, A. & Knaack, U., (2019). Personal control and environmental user satisfaction in office buildings: Results of case studies in the Netherlands. Building and Environment, 149, 428-435. Available from: https://doi.org/10.1016/j.buildenv.2018.12.021.

Leamann, A. & Bordass, B., (1999). Productivity in buildings: the ‘killer’ variables. Building Research & Information, 27(1), 4-19. Available from: https://www.tandfonline.com/doi/abs/10.1080/096132199369615.

Met Office, (2020). UK climate Averages: Sheffield Cdl [Online]. [Viewed 22 January 2020] Available from: https://www.metoffice.gov.uk/research/climate/maps-and-data/uk-climate-averages/gcqzwq04e.

Olson, M., & Primps, S., (1984). Working at home with computers: work and nonwork issues. Journal of social Issues, vol 40, No. 3. pp 97-112.

Shahzad, S., Brennan, J., Theodossopoulos, D. et al. (2 more authors) (2016) A study of the impact of individual thermal control on user comfort in the workplace: Norwegian cellular vs. British open-plan offices. Architectural Science Review, 60 (1). pp. 49-61. ISSN 0003-8628