BUILDING LIGHTING AND HEATING SYSTEMS AND EFFECT ON BUILDING PERFORMANCE AND OCCUPANTS

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Abstract

The study investigates the commonly used lighting and heating systems; examined the level of users' satisfaction in the use of lighting and heating systems; identified the challenges associated with the lighting and heating systems; examined the effects of building lighting and heating systems; determined the commonly applied temperature and lighting control systems among the users; and examined the levels of effectiveness of the applied temperature controls all at the workstation buildings. These are with the view of establishing the effects of building lighting and heating systems on building performance and occupants.

Primary data were collected from respondents which included university staff working from home, university staff working from school and the university students in the School of Art Design and Architecture. Data were collected during the Covid-19 pandemic seasons, as such online survey was adopted as the means of primary data collection. 60 university staff working from the university were surveyed and 46 responses were retrieved. Also, 60 universities working from home were surveyed and 33 responses were retrieved, 15 University department staff were surveyed of which 7 were retrieved while a survey of 120 students were conducted and 98 responses were retrieved. The additional data or responses from the students were obtained after the COVID pandemic when the students were able to be accessed on campus. Furthermore, the data obtained were analysed using various descriptive statistics such as averages, percentages, pie-chart and inferential statistics, Chi-Square.

The results revealed that 71% of the respondents chose a hot water radiator as the most common heating system at the workstation which happened to be the most used heating system. In addition, the result also showed that the most common lighting system being used at the workstation was a wall switch with a room sensor with a percentage of 53%. The result also showed that 68% and 63% of the respondents were satisfied with the lighting and heating systems respectively at the workstation which both represent the highest percentages. The identified challenge of the heating and lighting systems at the workstation was the glare, though few percentages of the respondents 28% identified that the glare problem was the challenge of heating and lighting. A larger percentage of 68% of the respondents did not identify glare problems at the workstation as the challenge of heating and lighting systems. The study also established that the heating and lighting systems had positive effects on the workstation buildings. This was inferred from the level of satisfaction of the respondents as larger percentages of the respondents were satisfied with the lighting and heating systems at the workstation buildings. Conclusively, the study showed that 39% of the respondents chose thermostatic radiator valves as the most commonly applied temperature control at the workstation, while 19% identified a time switch.

The study, therefore, concluded that the lighting and the heating systems had positive effects on the occupants who constituted the respondents. To this end, the occupants were satisfied with the heating and lighting systems at the workstation buildings. Similarly, the effects of the lighting and heating systems on the workstation buildings were as well found to be positive as larger percentages of the respondents were satisfied with the lighting and heating systems at the workstation buildings.

TABLE OF CONTENT

List of Tables

List of Figures

Dedications

This thesis is dedicated to Almighty God, the real and all-loving, who has made this study a massive success despite all difficulties and barriers. I could not have done it without the help of God. I will be forever thankful. Also, to my wonderful parents, ENGR. and MRS L.O ANIMASHAUN, and to my rock, Fauziyah Ebunoluwa. Yetunde and Olamide, for their unwavering love, wisdom, and moral support, physically, financially, spiritually, and morally. I hope that God, in his boundless mercy, bestows bountiful pleasure and blessings to you all. I adore all of you.

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List of Abbreviations

EPR:	Energy Performance Regulation
POE:	Post Occupancy Evaluation
IFMA:	International Facility Management
UV:	Ultraviolet
LED:	Light-Emitting Diode
OLEDs:	Organic Light-Emitting Diodes
CFL:	Compact Fluorescent Lamp
EU:	European Union

CHAPTER 1: INTRODUCTION

1.1 Background

Light is a critical tool for both completing tasks and visual comfort. In most situations, the sun and sky have been the dominant light sources during the day, while artificial lighting is necessary at night. As a result, most of the illumination required by humans may be met by diffused natural light (daylight), especially when the structure's orientation is appropriate. On the other hand, artificial lighting cannot be avoided when daylight is unavailable or in locations without access to natural light. For over 60 years, a diverse range of building energy model programmes has been created, modified, and implemented within the building energy community (Yoomak et al., 2018). There is a considerable amount of debate and input in the built environment about the quality of services provided by buildings. These services assist building operations daily to accomplish the structure's purpose. Occasionally, when a new building or renovation is for public use, there is a problem in sustaining the facility's performance via its services. This problem causing these unsustainable issues may vary and not be recognized and addressed depending on the organization (Zuhaib et al., 2018).

Due to the nature of this study, the study intends to investigate the influence of lighting and heating system performance on users with a view to enhancing the performance of lighting and heating system at the University of Huddersfield. Buildings need the use of resources in conjunction with systems or services that cover the whole process or operation of the structure (Thomsen et al., 2015). The generation of various types of pollutants and waste throughout these processes and activities influences the environment. Additionally, a building that lacks sustainability and adequate maintenance may result in occupant discomfort and poor productivity in the long run. However, with older or existing buildings and facility systems, the less efficient and effective the buildings, utilities, or facilities are, the less performance they provide, leaving owners or occupiers with the choice of upgrading or replacing these utilities or buildings (Grover & Grover 2015).

Similarly, when contractors take over completed structures to customers, these facilities are often neglected, resulting in structure degradation (Mohamed et al., 2017). The performance of a building is comparable to that of other categories of performance. This is related to the different components of building performance that concern the design of the building and its ability to be sustainable during its life span. A building structure is sustainable if it can run intelligently with the appropriate technology and practices. A building may tend to function and be sustainable if it conforms to a subset of sustainable development, which is a constant process of balancing the three systems socially, ecologically, and economically in a sustainable manner (Deambrogio et al., 2017).

Balancing a structured system such as lighting and heating brings about the accomplishment of the heating method via the employment of a space heating system. This process is therefore referred to as the device used in transporting heat from the medium to the enclosure. To this end, the term “space heating” refers to the heating of interior areas and facilities. Examples of these interior areas could be found in residential, commercial, and industrial structures, animal-raising units, greenhouses, and commercial and industrial buildings (Antonopoulos & Quintana-Orti, 2018). Space heating systems may be indigenous, in which heat generated by a heating device is transferred directly into the heated area. Also, the space heating systems may be central, in which heat generated at a central location, warms the medium, which subsequently distributes its thermal capacity to the heated space. As a building’s thermal resistance rises, extra thermal insulation on energy efficiency diminishes. This physical law compels nations with stringent insulation standards to implement Energy Performance Regulations (EPR). EPR examines not just thermal insulation but also the energy efficiency of ventilation, lighting, hot water production, and heating systems, as well as the advantages of passive and active solar energy (Kapedani et al., 2019).

When properly processed and controlled, these technologies can significantly enhance building and occupant performance since performance is also dependent on the health and comfort of the facility's occupants (Mulville Callaghan et al., 2016). According to Nielsen et al., (2016), company owners should prioritise the occupant's well-being since a better working environment may enhance productivity by 19%, confirming the previous assertion. However, according to Mulville, Jones, et al., (2016), the interests of workers are not always a top priority in the corporate environment, and organisations often prioritise enhancing performance above cost reduction. To rectify this, the primary objective of this study is to provide a framework for evaluating the functional and environmental effect of lighting and heating systems on the performance of buildings and their occupants using workstation buildings as a case study. Most of the research in this sector has used a cross-sectional or comparative office-type strategy (Danielsson & Bodin, 2008; Lee, 2010; Feige et al., 2013; Akimoto et al., 2013).

In contrast, others concentrated on certain variables such as the ambient atmosphere, control, noise, and natural and artificial lighting (Fang et al., 2004; Lan et al., 2011; Haans, 2014; Seddigh et al., 2015; Lamb & Kwok, 2016). However, Bodin Danielsson & Theorell (2018) argued that other behavioural components are equally important but are not often recognised or regarded, though some research indicates that behaviour modification in connection to energy conservation has grown more established (Mulville, Jones et al., 2016; Gulbinas and Taylor, 2014; Darby et al., 2016). Various elements might affect job performance and productivity, including workplace culture, industry performance, and social environment (Lamb & Kwok 2016).

Scofield (2019), therefore, opines that although some of these elements may seem to be external to the immediate building, they have a significant influence on the physical building environment, especially the ambient environment. According to Stre-Valen & Lohne (2016), conventional ways to analyse these building performance indicators are focused on physical measures, while modern approaches integrate biological data with user behaviour. Building performance is a field that emerges from the intersection of building science and social science (Fionn Stevenson & Leaman, 2010). In carrying out an accurate assessment of this performance, assessment methods exist that facilitate the knowledge of structures and property. Hartmeyer et al., (2016) stated that one of these assessment methods is the building performance evaluations (BPEs), which serve as helpful assistance to decision-making by providing vital information on how the building performs in use, how it operates, and its flexibility.

There are various characteristics in the kinds of buildings, which presents obstacles in establishing performance requirements for structures. Stre-Valen & Lohne, (2016) claim that the hospital sector has various problems, including administrative, environmental, human, and financial resources, which may have a direct or indirect effect on performance. Likewise, there is unexplored connectivity between workstation performance and building performance to about heating and lighting systems. For very few studies such as Raj Kumah (2017) whose study identified the connectivity between workstation performance and building performance, the study claimed the emission of heat from the workstations poses effects not only on the occupants but also the building energy structure. Furthermore, Sigel et al. (2018) explained that conventional reading rooms often encountered setbacks in the operation of workstations especially when soft copy reading tools such as computer reading glasses are not available. The study emphasised that such poor workstation performance leads to functional obsolescence in buildings, the worn-out of building due to the ineptitude nature of the facilities. Having established this connectivity between the building performance and workstation performance, the research study will explore the related issues to this relationship using the university buildings; a few of these variables are noted below concerning the built environment. Hence this study focuses on how the building interior, specifically heating and lighting systems affect the performance of the Oastler and Percy Shaw workstations and the users of the workstations. This was done with a view to enhancing the performance of the lighting and heating system at the University of Huddersfield.

The area of lighting and heating in buildings, particularly those that are occupied throughout the year, has continued to attract increased interest due to the correlations between environmental conditions and job satisfaction, as lighting, heating conditions and comfort received the highest satisfaction rating, followed by thermal comfort, noise, and air quality, indicating the level of importance they have in such environments (Sakellaris et al., 2016). Because universities have various and often connected structures, campuses would be less likely to be abandoned to relocate than other significant organisations may need to renew, renovate, and upgrade existing facilities to meet future demands efficiently.

This research focuses on how individuals respond to and adapt to these changes and the environment. The university environment strives for sustainability on occasion without jeopardising the demands of its users or residents. This study has focused on the University's estate and facilities to identify a more effective method for consistently delivering the desired outcome.

1.2 Justification of Research

Resources are used in the making and operation of buildings. The operation of resources in buildings depends on the quality of facilities and systems available in these buildings. These resources, which can be energy use, water, waste, space, and the pollution it produces, are much of a concern to the users, owners, and the environment.

Furthermore, another aspect to consider in building structures is the comfort and productivity it brings to the occupants. The role buildings play in the process of comfortability and productivity is significant, and these roles should be considered in the overall structure of buildings. The design of buildings varies from one form to another, and this depends on how the buildings perform over time.

It is therefore important to note that an interesting fact about existing buildings is that it sometimes undergoes redesigning, renovations or refurbishments, most especially in a university setting where there is a continuous demand for performance and improvement; this could be a result of the need to change in style, technology and taste or as the business demands. This statement was corroborated by (Amber et al., 2017) that educational establishments and university campuses consume significant amounts of energy due to operation all year round and occupancy of offices, libraries, lecture halls, seminars, conference rooms and laboratories. One of the interesting utilities considered during the redesign process is lighting; it is interesting to note that lighting has a direct and indirect effect on how people work efficiently and effectively with the desired comfortability in their spaces. As poor lighting conditions can cause discomfort, a well and better lighting condition would improve visual comfort for the occupant’s work efficiency and environment (Zuhaib et al., 2018). The area of lighting in buildings, most especially buildings that are mostly occupied almost all year round, has continued to attract more interest because of the linkages between environmental conditions and job satisfaction as the highest satisfaction rating was given to lighting conditions and comfort followed by thermal comfort, noise, and air quality to show the level of importance it has in such environment (Sakellaris et al., 2016).

These are the areas the research needs to investigate how people react or adapt to these changes and the environment. The university environment is an environment that wants to be sustainable from time to time without comprising the needs of the users or occupants. This is why this research has identified with the University's estate and facilities and wants to find a better way to achieve the desired result on a consistent and sustainable basis.

1.3. Statement of Research Problem

Apparently, the heating and lighting systems in buildings as well as other real building energy affects human activities over the years. Considering the effects of lighting and heating effects on buildings and occupants, studies have therefore inquired into building heating and lighting from different perspectives. The variance in the results of these studies arises from the fact that some of the studies established the effects of the lighting and heating systems on building structures while others considered the effects of these systems on the occupants. Evidently, DiLouie (2022) in a study carried out in Malaysia established that lighting contributed 19% of the entire energy consumed in commercial and public buildings. Consequently, because the lighting system was generated through electricity, this contributed adversely to the excessive emission of Carbon Dioxide (CO2) which had effects on the occupants.

With these existing problems, Monteiro (2012) submitted that “lighting conditions in the majority of the workplaces are below recommended guidelines and the normalized values ate more representative in workplaces with general and localized lighting.” Furthermore, Lyons (2001) posited that poor lighting systems and inadequate enhancement in the lighting facilities as well as using the daylight appropriately are the major challenges organizations and learning environments confronted. Building on this submission, Johnson (2011) cited an example that the absence of a well-controlled window and lighting affects students' performance. All these being said, the lighting system remains one of the most relevant sub-systems in buildings aside from ventilation, air conditioning, plug loads and heating.

In the decision-making process as regards building modernization, estimating building energy consumption is very germane. This consumption, therefore, is influenced by factors such as weather situations, building structure and most especially the heating system. Supporting this assertion, studies by Robinson (2007) and Chen et al., (2015) stated that building energy demand is dependent on several factors with heating as one of the leading factors. However, despite the management of heating systems in the present world, there are still existing peculiar challenges and difficulties. Lombard et al., (2008) while buttressing this point, the study emphasised that despite the numerous recommendations on building retrofit technologies and heating management, the implementation of these recommendations is difficult and exuberant. Nevertheless, it is important to reinstate the fact that a building's energy demand is not affected by construction choices only but also by user's behaviour and internal heat gains (IHGs) (Wang et al., 2012; Zhao et al., 2012; Gul et al., 2015 and Chen et al., 2018). IHGs arise because of building facilities such as solar radiation and building occupants. Furthermore, the level of IHGs is related to the occupants' behaviour and as such, the more people are present in a building, the more the heat is emitted. Likewise in the offices, the use of computer systems contributes to heat generation which constitutes to IHGs. To this end, buildings are occasionally designed with a view to minimizing heating and avoiding unnecessary cooling demand. This is often carried out by implementing solar shades to prevent solar heat gains in buildings.

Apparently, there have been intensifying efforts to reduce the problems associated with lighting and heating systems in buildings. One of these efforts is the invention of energy software such as Building Energy Simulation (BES) and the enactment of building construction standards which vary from country to country. Despite these efforts, there are still challenges of lighting and heating systems which are predominant in the university environment and which the existing literature has failed to cover.

While other studies only focused on the effect of lighting and heating systems on either the building or the users of the building, this study intends to differ from the previous studies by exploring the effects of lighting and heating systems on both the workstation as a building and the users of the workstations. What informs this study therefore can be likened to the recent renovations of fittings carried out at the workstations at the University of Huddersfield. Before the renovations, it was reported that the workstation's heating and lighting systems were bedevilled with functional obsolescence. Hence, this study intends to fill this existing gap by exploring the building lighting and heating system as well as the effects of these systems on the building's performance and occupants.

1.4. Research Aim and Objectives

1.4.1. Research Aim

Physical, technological, and environmental elements impacting or restricting the achievement of optimal lighting performance and the influence on buildings and the user's occupants, as well as the client or organisation, have been found in previous research. However, building lighting systems, in general, have performance issues. To sustain the performance of these lighting systems, some decisions must be made in terms of design solutions, information supply, quality standards, facility maintenance, and day-to-day operations. More importantly, due to other circumstances such as a lack of finance, a set of goals, insufficient personnel, and resources, other functional areas are sometimes overlooked. As a result, essential stakeholders such as maintenance teams (facilities managers), user occupiers, and the business may face socio-economic consequences.

Likewise, another challenge peculiar to the building structure is the heating system. It is believed that heating systems are meant to ensure buildings have increased thermal and olfactory comfort (Olesen, 2008). However, from the perception of the analysis of thermal transfer in relation to heat, the common problem confronting heating systems is the convective heat transfer (Sarbu, 2014). The convective heat transfer constitutes factors such as the position and temperature of the heater, furniture positions in the rooms and indoor air perturbation all of which contribute to the uniform air temperature distribution in the building and as such subdue effectiveness of the heating system.

If the above challenges are not adequately handled, the challenges may have a direct or indirect negative impact on the occupants, allowing them to use the limited resources at their disposal to address the variables that have a greater impact on them. Significant studies/researchers have not looked at the social and economic effects of building lighting systems on buildings and the influence on the stakeholders mentioned above.

Hence, the research aims to investigate building lighting and heating systems and their effect on building performance and occupants with a view of establishing the satisfaction level and performance of lighting and heating systems on the building performance and occupants.

1.4.2 Research Objectives

Objective 1: To investigate the commonly used lighting and heating systems at the workstation building.

Objective 2: To examine the level of users' satisfaction with the use of lighting and heating systems at the workstations buildings.

Objective 3: To identify the challenges associated with the lighting and heating system at the workstation buildings.

Objective 4: To examine the effects of building lighting and heating systems on the performance of workstation buildings.

Objective 5: To determine the commonly applied temperature controls among the users at their workstation buildings.

Objective 6: To examine the levels of effectiveness of the applied temperature controls at the workstation buildings.

To achieve the aim and objectives of this research, the following questions below have been formulated.

1. What are the commonly used lighting and heating systems at the workstation buildings?
2. What are the levels of users' satisfaction in the use of lighting and heating systems at the workstation buildings?
3. What are the challenges associated with the lighting and heating system at the workstation buildings?
4. What are the effects of building lighting and heating systems on the performance of the workstation buildings?

5. What are the commonly applied temperature controls among the users at their workstation buildings?
6. What are the levels of effectiveness of the applied temperature controls at the workstation buildings?

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6. What are the levels of effectiveness of the applied temperature controls at the workstation buildings?

1.4.3. Scope of the Research

In conjunction with this research purpose, the study will begin with an overview of the overall building idea and its significance in terms of building sustainability. The role of facilities management in the University's sustainability strategy regarding the University's estate and facilities and the benefits to the institution was discussed. Another part discussed the building performance regarding the inhabitants' role and behaviour. The architecture of lighting and heating systems in buildings was reviewed, and the strategies for measuring and managing them considering what others have accomplished in this field. Having considered all these, the study will stream down its building assessment focus to workstation buildings at the University of Huddersfield and these buildings are called, Percy Shaw Building and Oastler Building. The study therefore focused on the building functional performance assessment using the post-occupancy evaluation methodology to explore occupants' subjective satisfaction using the survey to collect data. The considered occupants were the university staff and the students.

This conversation was guided by the input gathered and analysed by the facilities team to compare before developing a guideline for future usage. This aspect of building performance is equally important, as (Fabi et al., 2016) highlighted various psychological (attitudes), physical (direct sunlight), social (occupancy), and contextual (orientation) factors as contributing to visual comfort in buildings. However, exploring is critical in determining whether other topics may be addressed after an examination. Although buildings and their associated infrastructure or utilities must run efficiently and effectively, this is even true. However, the potential savings from better energy consumption are negligible compared to total expenses, which are often more substantial when accomplished via improved conditions that boost productivity and occupant well-being. More crucially, having a more significant influence on the balance sheet's bottom line (Spigiliantini et al., 2017).

In one of his research projects, Mulville, Callaghan et al., (2016) note that a lack of productivity in the workplace may be compared to various concerns, including early departures, late arrivals, absenteeism, and overall workplace dissatisfaction. According to Lange et al., (2021), worker performance may be related to productivity; yet both are seldom quantified in the workplace due to the inherent difficulty of measuring office productivity since there is no universally acknowledged metric (Langford & Haynes, 2015). In terms of occupant productivity in the building and environment, Bodin Danielsson & Theorell (2018) said that personal control is a critical characteristic of human behaviour and is significantly associated with environmental happiness.

Additionally, Haans (2014) suggests that when occupant productivity is the primary goal, the desire for natural illumination, based on the human preference for natural goods, may have extra health advantages, albeit these benefits are not entirely understood. This is also supported by Scofield (2019), who asserts that employee happiness is contingent upon visual access to windows. However, the effect should be carefully balanced against the possibility of glare and warming caused by excessive glass (Heale & Twycross, 2015). In summary, the research will examine the interaction between the building's occupants and its lighting and heating performance, with an eye toward comfortability and productivity over time. This influenced the research's purpose and aims, discussed in further detail.

1.5. Research Methodology

This study methodology was built on the notion of 'the research onion' (Saunders & Tosey, 2016). The study strategy established the philosophical perspective for the research, resulting in selection appropriate research procedures and techniques for data collection and analysis. This study was primarily a theory-building effort rather than a theory-testing effort, despite certain testing theory-testing parts being included. It involved a comparison of the characteristics of the current top-down lighting design and performance process to the characteristics of a bottom-up lighting performance process in a real-world situation or environment, and in that sense, the research-validated existing concepts; however, the research ultimately developed a concept based on the validated elements from existing concepts (Townsend et al., 2017). Additionally, this research was context-specific, focusing on in-depth examinations of small samples from a controlled setting. The nature of this study put it mainly under the interpretative research paradigm, philosophically. This study was selected for inductive mode.

Additionally, the study is more likely longitudinal in nature and employs a quantitative research technique. Strategically, it was determined that this research would use a case study as the research approach. For instance, in one empirical inquiry, data collection was primarily conducted via non-participant observation, emphasising structured questionnaires meant to comprehend what was seen. The other empirical inquiry collected data primarily via closed and open-ended questionnaires. Document evaluations accomplished the triangulation of data from both empirical studies. The study was conducted using the Statistical Package for Social Sciences, a specialised qualitative and quantitative data analysis programme.

1.6. Contribution to Knowledge

By examining building lighting and heating systems and their influence on building performance and occupants. As such, upon conclusion of this research, it should add to the field's theoretical framework. Suggestions emphasizing adequate and acceptable building and heating systems are welcome. Additionally, this research adds to empirical results by determining the influence of lighting and heating/cooling systems on building performance and occupant productivity. Similarly, this study contributed to empirical research by measuring risk management to increase sustainability and use building lighting systems the most. At the same time, the results will benefit practice by assisting relevant policymakers in comprehending frequently used building and heating systems for residential and commercial spaces.

Similarly, the results will be beneficial since they recognized the existing and future socio-economic, technological, and environmental difficulties confronting building owners, facility managers, and users concerning personal and public lighting systems. Finally, this research assisted in identifying novel metrics, methods, and tactics for addressing the issues and risks related to the school's lighting structure and performance. This would aid in the development and implementation of relevant policies.

1.7 Definition of Terms

1**.** Lighting System: In the last recent years, the concept of lighting gradually changes from a functional point of view, where lighting system is referred to as natural and artificial light in buildings. In the contemporary definition of the lighting system, it is referred to as an instrument which ascertains the comfort and environmental well-being of building occupants (Faranda et al., 2010).

This conventional model of lighting had a crucial impact on the "CIE Symposium on Lighting Quality" of 1998. The outcomes of the symposium are adopted by the Engineering Illuminating Society of North America (IESNA) which fostered the development of a new lighting system model. The model states that the lighting design quality depends on the interaction of factors such as individuals (occupants), the light integration with architecture and environmental consequences (Blaso et al., 2015).

2. Heating System**:** The heating system in a building is the process of increasing the space temperature in buildings or industrial processes (Dincer and Erdemir, 2021). Heating is generated through the conversion of energy sources into heat or using fuel. One of the main purposes of a heating system is to increase the air temperature to be blown into a building or increase heat transfer fluid which is to be transferred to a heat exchanger in a building (Dincer and Erdemir, 2021).

3. Building Performance: A building is an asset which contributes to a secure and aesthetic environment if properly maintained. Douglas et al. (2014) defined a building as a heterogeneous asset which is unique and different in its way in terms of location,

accessibility and soil condition. Holistically, a building requires a certain level of performance to provide safety and a healthy environment. Bluyssen (2009) defined building performance as means of ensuring quality assets are integrated with user perceptions with a view to achieving desired satisfaction. Furthermore, McDougall et al. (2002) identified that building performance is strongly related to the building design and the occupants therein.

4. Workstation: A workstation is a high-performance computer system designed for a single user with advanced graphics capabilities, vast storage capacity and a powerful central processing unit (Britannica, 2020). Workstations are predominantly found in modern study rooms and offices in universities. This development has generated concerns among scholars on how heat from workstations has affected buildings in which workstations are installed. Hence the need to conceptualize workstation building cannot be overemphasized.

5. Workstation Building: Apparently, no workstation exists independently without a structure in place to accommodate them. To this end, Woo et al., (2016) defined a workstation building as a structure where workstations are installed and must consist of convenient working tables, convenient chairs with backrests, arm rests and good lighting system among others.

1.8. Thesis Structure

1.8.1. Chapter One: Introduction

This chapter discusses the thesis's introductory phase. It summarises the study context and reasoning, research justification, purpose and goals, scope, the technique used, additions to existing research knowledge, and thesis structure.

1.8.2. Chapter Two: Literature Review

This chapter summarises the literature pertinent to the thesis's topic area. The chapter's opening few parts define the topic area and growth of the study field, highlighting significant work on the concepts of buildings, building performance, and its relevance to the notion of sustainability. Next, the following sections examine contemporary concerns with lighting and heating performance in the built environment and their ramifications for occupants and building management or owners. Finally, the literature review examines the notion of regenerative design, which served as the foundation for analysing the second empirical study.

1.8.3. Chapter Three: Research Methodology

Chapter three describes and defends the methodology used in this study. The chapter explains and justifies using the "onion model" as the research model, the interpretive philosophical stance of the research, the inductive and deductive research approaches, the mixed research strategy, the qualitative and quantitative research approaches, and the research methods chosen.

1.8.4. Chapter Four: Conceptual Framework

This chapter introduces the study conceptual framework, highlighting the essential principles discovered in the literature that serve as the study basis. The chapter discusses the significance of the conceptual framework and argues the empirical study need.

1.8.5. Chapter Five: Analysis of Case Study

This chapter focuses on explaining the investigation concerning the findings from the case study. Accordingly, this chapter is further structured as follows: the background details of the University of Huddersfield as a case study, the reason for choosing the case study with the process taken (Observation, document reviewed, interviews) to achieve and building performance based on investigating the lighting performance as well as how this is expected to affect productivity from the university environment with a presentation which includes a description of the data collection from the case study. After that, prior to providing and presenting the primary analysis, the process and features of building performance and lighting performance expectations are expected.

1.8.6. Chapter six: Quantitative Analysis from the survey

Chapter 6 presents the analyses and findings from the survey. These analyses were conducted using descriptive statistics of percentages, bar chart, and the mean and standard deviation to address the research objectives and answer the research questions.

1.8.7. Chapter Seven: Other Closed and Open-Ended Questionnaires Analysis

This chapter focuses on structured questions designed to reach out to the University's estate department members to evaluate the lighting and heating performance in some parts of the University and the University at large. Feedback gotten were analysed in quantitative form.

1.8.8. Chapter Eight: Findings and Outcomes

The chapter first discusses the findings and outcomes in the analysis concerning literature reviews and research areas. The chapter concludes with recommendations, a summary and links to the chapter.

1.8.9. Chapter Nine: Conclusion

Chapter Nine presents the synthesis of the objectives, and the conclusion from the research area and further reinstates or establishes the contribution to knowledge, limitation of the study, further research and the final note for the study.

1.9. Summary and Links

Light plays a crucial role in tasks and comfort. Humans rely on natural light when available, turning to artificial lighting in its absence. Building energy models have evolved for over 60 years, enabling sustainable structures with the right technology. Higher thermal resistance reduces insulation's energy efficiency benefits, leading to Energy Performance Regulations in well-insulated areas. Properly managed technologies can boost building and occupant performance, impacting occupants' health and comfort. Prioritizing occupant well-being can improve productivity by 19%. Building performance integrates physical and social sciences, considering biological data and user behavior. Universities may need to renovate and upgrade structures due to interconnected campuses. This study focuses on improving consistent outcomes in university estates and facilities. Building performance encompasses both building and social sciences, with various building types presenting unique challenges. Neglecting functional areas due to financial, goal-related, or resource constraints can have socio-economic consequences for stakeholders.

CHAPTER 2: LITERATURE REVIEW

2.1. Introduction

The purpose of this chapter is to review pertinent current literature in the built environment, especially as it pertains to the performance of building heating and lighting systems. The objective is to conduct research and examine literature to inform the University of Huddersfield's study of building lighting and heating performance and its influence on users and productivity. It begins with a description of essential concepts and addresses other critical aspects of the discipline related to the study topic. The preceding chapter examined some significant and pertinent concepts concerning the study aims. This portion of the literature review chapter discusses the built environment and the history of sustainability. The function or significance of buildings in the built environment sector, the idea of sustainable building performance, and the link between sustainable building performance and lighting performance. It will also highlight gaps in pertinent literature and help create or shape the questions that would assist in bridging the knowledge gap relevant to the study. Following the study area's deficit, the paper will also examine the general building idea and its significance regarding the sustainability of structures. The role of facilities management in the University's sustainability strategy regarding the University's estate and facilities, and how this will benefit the institution. Another part will discuss heating systems, their kinds, and their influence on the building performance concept related to the inhabitants' function. The architecture of lighting and lighting systems in buildings will be discussed, and the strategies for measuring and managing them, considering what others have accomplished in this field.

2.2. The Built Environment and Sustainability

Buildings inherent nature necessitates using resources in conjunction with systems or services that include the whole process or operation of buildings (Thomsen et al., 2015). Various types of pollution and waste are generated during these processes and operations, which affect the environment. Additionally, if the building is not sustainable and well maintained throughout its life, this can result in occupant discomfort and decreased productivity in the long run. However, the older or current buildings and facility systems work at lower efficiency and effectiveness, leaving owners or occupiers with the choice of upgrading or replacing these services or structures (Grover and Grover 2015). Similarly, when contractors turn over completed structures to customers, these services or facilities are often neglected, resulting in their decline or degradation (Mohamed et al., 2017). Buildings have historically been seen as intermediary structures between production and consumption processes or as a physical concentration or cluster of end consumers. Another researcher defines a structure as a shelter that serves as a physical partition of the human habitation, such as a location where security and comfort are practically guaranteed to some level, and which sometimes serves to keep people away from potentially dangerous elements outside (Mohamed et al., 2017). One of the reasons why demand and expectation for buildings or housing have continued to rise is the growing global population, as well as the building's condition, which has become a primary concern for humans, creating an increased need to thrive to improve the indoor conditions and comfort provided by the building.

Buildings are a critical component of the built environment and urban ecosystems; various industry sectors represent vital stakeholders throughout the building's life cycle, including architects, engineers, building constructors or managers, and, of course, building occupants/users, who are policymakers (Lange et al., 2021). Each of these stakeholders acts as an agent throughout a defined period of the building's life cycle; during this time, the building tends to change via systematic interventions to continue fulfilling its primary function of providing a pleasant and safe environment for its residents. Thus, comfort and safety have developed as crucial aspects of the structure in the constructed environment. Thus, leading to a debate about the built environment and its relevance to buildings.

2.2.1. Importance of Buildings in the Built Environment

The four walls that create the framework define the structure and the various components that comprise the fabric of the structure, such as the interior and exterior finishes, waste, air, and energy. According to Spigliantini et al., (2017), the construction sector consumes more energy than industry and transportation in many cities and regions, with the European Union (EU) and the United States serving as prominent examples. Furthermore, buildings account for 37% of total final energy consumption in the EU and the United States and 39% in the United Kingdom (Scofield 2019). This demonstrates the importance of the construction sector to the built environment. However, as the statistics continue to climb, the issues associated with maintaining buildings in excellent condition over time increase, affecting the health and well-being of its inhabitants directly or indirectly. This has made it more challenging as, in 2020, a decade later, more than half of countries cannot have compulsory building energy codes, which means as of last year, more than 3.5 billion m2 did not have compulsory energy-related performance requirements (Delmastro & Abergel, 2021). Due to these developments and in line with the NET Zero Emissions by 2050 Scenario, the need for all countries to develop zero-carbon-ready building energy codes by 2030 would be the latest, where all new buildings should aim at, as a standard from 2030 (Delmastro & Abergel, 2021).

The impact of these challenges is directly related to the health or well-being of people who are exposed to problems associated with the built environment; these problems or challenges expose the building to deterioration, resulting in a variety of health risks and illnesses associated with the condition of the facilities or the quality of utilities ranging from indoor air quality, energy, heating, and lighting (Abdul Malik et al., 2015). It is also worth noting that some of these utilities are more critical than others depending on the structure (Guerra-Santin et al., 2018). An earlier study by (Konseyi 2014) indicates that the design and circumstances of office building amenities may substantially impact the inhabitants' health and well-being. A typical example is a study conducted by (Darby et al., 2016) on the relationship between view quality, natural and artificial lighting, and sick leave among employees in the administrative offices of Northwest University (Washington State, USA). The study concluded that employees in offices with better natural and artificial lighting took 6.5 per cent fewer sick days.

In contrast, building-related illness is one of the most common ailments linked with occupants' complaints when inside the building and these complaints sometimes are gone as soon as the occupants leave the building; these can be irritation of the eyes, mental fatigue and headaches (McHugh 2021). However, the examination did not establish if other circumstances support or alter the study outcome. The following section will explore sustainable building and their effect on the occupants and the built environment.

Thus, if recognised, it may result in a more sustainable construction state. The following section will discuss sustainable buildings in the built environment.

2.3. Sustainable Building

The most effective way to solve global challenges affecting the built environment is to ensure that buildings are sustainable since buildings use significant resources and energy during their lifetime (Lamb & Kwok, 2016). The projected lifetime of architectural components varies; for example, support systems such as the building structure and exterior fabric might have a lifespan of more than 50 years (Edward, 2021). Consequently, several worldwide organisations have continued to advocate and invest considerably in creating sustainable buildings in the built environment (Fabi et al., 2016). However, the importance of understanding the notion of sustainable construction cannot be overstated to emphasise the built environment's implications.

According to (Sahlol et al., 2021), sustainable building applies sustainability concepts to the design, construction, and management of buildings to minimise the building sector's and its surroundings' environmental impacts, and therefore on people. Some problems may hinder accomplishing the sustainable building agenda due to applying the principles to the design, construction, and management of buildings.

The challenges connected with sustainable buildings sometimes stem from the nature of the design, which falls short of the standards frequently required of construction experts in the built environment. These difficulties are sometimes related to the location of specific amenities as intended, which may conflict with real-world conditions when occupied or used by the building's residents or users (McArthur & Powell, 2020). To attain sustainable building status, it is critical to include sustainable development concepts in building envelope design, including all stakeholders in the built environment. It is also worth noting that gaining sustainable building status may require considering all competing sustainable development considerations.

There are five stocks associated with the level of sustainable building success; these are the level of success of traditional project performance, the level of success of sustainability economic performance, the level of success of sustainability environmental performance, the level of success of sustainability social performance, and the level of success of participant satisfaction (Haruna et al., 2020). While these five indicators of sustainable building performance are critical, the interaction between end-users and facilities is equally critical for obtaining the intended outcome. The performance is also critical in the research's focal area, mainly affecting users or occupiers regarding lighting and heating systems. The following section discusses the connection between facility management and sustainability.

2.3.1 Sustainability and Facilities Management Relationship Review

The importance of considering the link between sustainability and facilities management cannot be overemphasised since the benefits accrue to all parties involved, including occupants/users and maintenance personnel. (Shealy, 2016) identified several benefits, including decreased energy and water consumption, increased occupancy rates, and improved psychological and physical health. The sustainable design incorporates technological advancements such as high-performance ventilation systems to prevent respiratory illness and increased desk lighting to reduce computer glare. It also considers building orientation, with windows facing space-enhancing occupant comfort and mental focus. If these advantages are applied periodically using these ways, it is projected that productivity rates would increase by more than 20% when compared to traditional buildings (Edward, 2021).

Facilities management professionals are invited to enrol in this course to learn how to make buildings more sustainable using tried-and-true principles. Sustainability has been a political and professional priority for decades, but the IPCC assessment indicates that present sustainability policies are inadequate to break the cycle of unsustainable global development practices. The importance of professional attention from the facility management sectors cannot be overstated, with a particular emphasis on specific categories or areas that support the built environment, as indicated below.

• The performance of the building (e.g., life cycle assessment (LCA), CO_2 emissions).

• Construction and environmentally friendly construction materials.

• Tools and standards for sustainability (indicators, certifications, and management systems).

• Urbanization.

• Increasing performance.

• Sustainable building design and construction (design and design principles).

• Management of sustainability in the built environment (strategy and implementation).

• The advantages of green buildings.

• Perception, contentment, and productivity of the user.

• Unclassifiable (Others).

Building performance plays a significant role in these areas, as seen by emphasising monitoring and improving buildings' energy performance, energy consumption, and CO2 emissions. Al Dakheel et al., (2020) listed health, environmental, and economic implications as a criterion to consider when evaluating property kinds. Building usage scenarios often guide modern decision-making to minimise future overheating concerns. Environmental control is a vital capacity in which organisations should spend considerably while also considering the effective execution of carbon audits. According to Scholars quoted above, a direct and indirect interaction exists between the building, its surroundings, and its users. These interactions should be encouraged more to reduce the performance disparity over time. Additionally, the project will examine this feature critically by including many stakeholders inside the institution to bridge the seeming divide.

Concerning more sustainable tools and standards, some studies concentrate on the sustainability analysis of specific tools, green/sustainable building indicators, and certifications, with a particular emphasis on developing tools and measurement systems or analysing the performance of tools concerning the performance of support services (Ding et al., 2021). These studies generally explore sustainability at the building level and use environmental indicators, but there was no substantial research addressing sustainability from an environmental, social, or economic standpoint (Nagpal et al., 2021). However, in terms of property kinds, "green/sustainable buildings" and "traditional buildings" are under-researched, with a disproportionate amount of office buildings. There is a correlation between the style of building and its performance; this study will examine these correlations and their impact on users, occupiers, and the organisation; the University is one of the places to get fair input on this. According to Wanigarathna et al., (2019), when it comes to buildings, homes, hotels, and universities should be a matter of worry. As said before, these studies on sustainable construction were conducted via typical surveys or case studies; the study also confirmed that they are often rational in character, with no critical fundamental ideas being visible and implemented. As a result of these studies or research, caution is necessary or critical in utilising key performance indicators and establishing a well-integrated design team that applies the concept to achieving the sustainable agenda via a user perception and satisfaction survey to track building performance over time. The following section will explore the "building performance concept."

2.4. Building Performance Concept

Building performance may be compared to other types of performance. More so, the issue of building performance is concerned with the design of the building and how the design can be sustainable over time based on its performance. According to Michell (2013), building performance should be measured more than life cycle buildings, building functionality, and energy saving. The user's viewpoint on the building should also be considered when measuring performance. The most critical criterion in determining a building's success is if it satisfies the design goals via a high degree of user satisfaction (Gharehbaghi et al., 2021).

As substantiated, these satisfaction requirements must span various domains, configurations and disciplines within the built environment and management and social sciences (Abdallah et al., 2020). A building may be configured to function and be sustainable if it is seen as a subset of sustainable development, which is a constant process of balancing the three systems socially, ecologically, and economically in a sustainable manner.

These technologies, when properly handled, have the potential to increase occupant performance, but this also relies on the health of the buildings (Mulville, Jones, et al., 2016). However, according to Nagpal et al., (2021), the interests of workers are not always a top priority in the corporate environment, and organisations often prioritise enhancing performance above cost reduction. However, this is contingent upon the method and policies used to accomplish the organisation's objective and vision; sometimes, a balance of enhancing performance and cutting costs is implemented while taking the occupier of the building into account.

Organisations see building performance as a critical factor influencing maintenance processes and policies (Marzouk & Fayez, 2018). However, companies prioritise this based on their goal and vision, with varying methods of performance development and actions undertaken to guarantee they accomplish their objective. As a result, adopting strategic choices to ensure that the organisation meets its social, economic, and environmental demands is critical to maintaining its aims and aspirations. These choices assist components in communicating what must be done to attain the asset's performance. It is critical to quantify these assets using key performance indicators to monitor their performance. This performance includes ensuring that the current asset meets business objectives, providing a comfortable working environment for occupants and customers, minimising operating and maintenance costs by managing the condition of existing facilities, and assessing the facilities' performance as functional, operational assets supporting business processes (K. Dixit et al., 2014). With these performance indicators in place, it is critical to estimate the cost of maintaining the asset's performance level, considering the organisation's short- and long-term advantages.

2.4.1. Performance-Based Built Asset Maintenance Process Model

The growing investment class in the built environment and its opportunities have increased views and knowledge within the industry. This model demonstrates the role and operation of the asset, with the use and management of the built asset having a significant impact on the entire building sector, society, and the planet soon (Nielsen et al., 2016). However, it notes that knowing how constructed assets and their components affect an organisation's essential variables and considering crucial maintenance aspects is vital to maintenance planning. The following sections describe these critical components.

a. Determination of requirement by using a set of performance indicators that may be used to determine how effectively a component/system/space supports commercial, physical, economic, and environmental functions. These indicators highlight detrimental changes in employee productivity (objective measurements of task completion; business dynamics) for each work area (from a different viewpoint) (customer perception; operating costs; responsive maintenance costs.

b. Determining the reason by identifying an area performing poorly without justification for a maintenance intervention. The indications enable facility managers to identify the root cause of a building's problems and any associated issues. These variables enable qualitative analysis (interviews, focus groups, and case study reports) to elicit collective explanations for failing venues. This factor evaluates the effect of the building's physical condition on its asset value.

c. Following an underperforming facility or area study, an action statement is necessary. The action statement is used to express the underlying issue and its apparent cause. In other words, it serves as a project brief against which offered and reviewed solutions may be evaluated.

d. Develop alternative solutions with scenarios that will be assessed against various business criteria using a multi-criteria prioritisation process. For example, a responsive approach is appropriate; where business risks are significant, a preventative strategy is appropriate. It enables a strategic approach to the solutions that will be implemented.

e. An evaluation solution is implemented using a collection of impact toolkits, post-completion assessments, and key performance indicators, which enables real performance improvements associated with maintenance interventions to be compared to the project brief through the action statement. The evaluation's findings will influence the organisation's near-term strategy.

The consequence of adopting a performance-based model for facility managers is a fundamental shift in the direction and style of maintenance teams, which might affect the building's and its components' condition. The choice to maintain or not to maintain is entirely strategic and business-driven, aided by the business toolkits. However, one apparent shortage is productivity, company dynamics, or asset value rather than a condition survey. This survey should be examined to conduct a more thorough procedure review. Nielsen et al., (2016), on the other hand, said that if the process is not well managed, it may have a significant impact on the well-being and health of building users, including service staff and operators. This impact has increased expectations for building support services. These supportive services include lighting systems that provide occupants/users with the comfort and pleasure they need to be in a particular area at a specific moment. According to Aduda et al., (2014), a study of green buildings in New Zealand identified the importance of facilities managers setting energy performance strategies and the need for improving operational level management tools to ensure the buildings' energy-efficient performance when in use. Haans (2014) supported this research by claiming correlations between energy-efficient design strategies, tenant behaviour, and organisational structure. Mulville, Jones et al., (2016), however, conclude in their study of sustainable facility management using the building information modelling concept that, while the model is still in its infancy and is not currently used by facility managers, there has been progress in its development and potential applications in facility management. This progress might strengthen the facilities manager's position by providing the evidence essential to support the business case for refurbishment, adaptation, and maintenance measures that result in an enhanced built environment.

Additionally, building performance rating schemes enable efficient systems to provide a greater service to address maintenance and refurbishment concerns. This system should include the following three components, as defined by Borgstein et al., (2016):

i. The building's architecture, systems, and technology must be energy efficient.
ii. The building must have facilities and characteristics that are appropriate for its type.
iii. The building must be energy efficient; in other words, it must operate efficiently.

These features, however, cannot be done without conducting a thorough examination of the performance. Borgstein et al., (2018) begin their investigation with the premise that six variables influence energy usage in buildings. Climate, building envelope, systems, operations and maintenance, tenant behaviour, and interior environmental variables are among these aspects. According to Amber et al., (2017), various elements might affect job performance and productivity, including workplace culture, industry performance, and social environment. Clements-Croome, (2015), however, states that while some of these factors may appear to be external to the immediate building, the physical building environment, including the ambient environment, has a significant impact.

If not properly managed, these consequences might result in a performance gap between the facilities offered and the output from their occupants since a drop in user or occupant comfort can influence productivity (Darby et al., 2016). The degree of productivity may be determined by using a performance measurement tool to conduct an in-depth analysis of the facilities given.

However, prior to conducting a thorough evaluation, as is the case with higher educational buildings, one of the goals identified by Khalil & Obiedy (2018) should be viewed as improving the building delivery process by incorporating an efficient evaluation process into daily learning activities. Additionally, it is noted that the delivery process is just one of many processes; it should assist all phases of the building management system to increase student learning efficiency. According to pilot research done by Khalil & Obiedy (2018), 40% of students in one of the higher institutions in Perak, Malaysia, believed that an inadequate supply of indoor environmental conditions might impair their learning process. This research demonstrates one of the critical areas that might influence the degree of output expected of users in a higher learning setting such as a university. Indeed, the assessment technique utilised to quantify these performances or levels of satisfaction is the post-occupancy evaluation approach, which facilitates comprehension of the strategy or idea.

2.4.2 Analysis of Assessment Methodologies Suitable for Building Performance

According to Stre-Valen and Lohne (2016), conventional building performance analysis methods depend on physical data, but modern techniques incorporate physical measurements with user behaviour. Building performance is a field that emerges from the intersection of building science and social science (Fionn Stevenson & Leaman, 2010). To conduct an accurate evaluation of these buildings, assessment methods exist that facilitate the knowledge of buildings and property. As described by Fionn Stevenson & Leaman, (2010), one of these assessment methods is the building performance evaluations (BPEs), which serve as a helpful aid to decision-making by providing vital information on how the building performs in use, how it operates, and its flexibility. There are various idiosyncrasies in buildings, which presents difficulties in establishing performance evaluation standards.

More precisely, various scholars Stre-Valen and Lohne (2016) & Mohamed et al., (2017) highlighted that these issues exist in the hospital sector, mainly due to several underlying causes. Similarly, these issues may be compared to university buildings in terms of their usage by occupiers with varying origins, situations, and orientations; these challenges are discussed below.

a. The organisational issues inherent in the healthcare business are astounding. Modern hospitals are multidimensional, often lacking complete coherence in prioritisation amongst the many sub-entities.
b. Hospital buildings must serve various purposes and perform various duties, making facility management and operations difficult, expensive, and sometimes unpredictable.

c. Hospitals offer a diverse range of services, and the objectives of hospital operations are many and frequently contradictory.

After reviewing a variety of literature to identify key performance indicators to reduce the obstacles associated with facility performance, the authors classified these indicators into four categories, as defined by (Anule & Umeh, 2016):

i. Indicators derived from surveys (POE, learning environment, community and appearance).

ii. Indicators of functionality (productivity, space utility, adequacy of space and logistics).

iii. Physical indicators (degree of physical depreciation, resource consumption, interior environment, property, and real estate)

iv. Financial indicators (current replacement cost of the FM, maintenance backlog, capital renewal, and maintainability).

However, the KPIs did not consider the building's usability or flexibility as an indicator of how the building performs in use. Riratanaphong & van der Voordt (2015) conducted research to support this claim, analysing performance data in buildings with dynamic work environments. The analysis's findings show that performance assessment has historically focused on efficiency and effectiveness. Additionally, the report noted a need to create FM-related key performance indicators that assist organisations in focusing on the cost/performance connection. The time to act is now to guarantee that highlighted instances are handled soon via assessment, but it is critical first to establish the goal, advantages, and challenges of using one evaluation procedure.

2.5. Post-Occupancy Evaluation and Approach

In the United Kingdom, the United States of America, New Zealand, Australia, and Canada, post-occupancy evaluation is often used to analyse any performance aspect of a building, sometimes for short-, medium-, and long-term advantages (Khalil & Obeidy, 2018). Carlos et al., (2015) define post-occupancy evaluation as the phase in the building process that follows the sequence of planning, programming, design, construction, and ultimately, occupancy of a structure. This assessment method is critical in designing both basic and complex constructed environments. As this provides a better understanding of how a building should function in use based on robust facts/evidence, it enables the development of a design process capable of producing a built environment that meets or satisfies the needs of the larger environment, the owner, and the users in terms of the purpose for which the building was built (Adeyeye et al., 2013). From the post-occupancy assessment idea, evaluating the buildings' performance against the ostensibly designed needs is critical. Sustaining performance requires an understanding of user perception, contentment, and productivity and the outcomes of staff satisfaction surveys and post-occupancy assessments of buildings (Tookaloo & Smith, 2015). Tookaloo & Smith (2015) research aims to identify user views or satisfaction with ecologically sustainable buildings by focusing on the building, process, and management as a whole and the social and environmental viewpoints.

The study also corroborated the methodological approaches, relying heavily on surveys and literature reviews to accomplish the research's goals and objectives; however, Benammar et al., (2018) argue that experiments are also necessary but were omitted, as are walk-through investigations, focus group meetings, and public hearings (Alshibani & Hassanain, 2018). Deliberations continue to expand due to meetings and public hearings, and expectations from all essential stakeholders in the built environment cannot be overstated. Riley et al., (2010), discuss the importance of applying theories to the built environment, specifical theories on productivity management and business areas, which demonstrate in their studies that some tenants are more satisfied or productive in a green building than in a non-green building. These findings state that tenants are more likely to occupy green buildings than non-green buildings.

According to Riratanaphong & Van der Voordt (2015), in research on developing best practices and standards, using case studies as a technique for assessing best practices and surveys, and interviews and focus group studies to provide suggestions on tactics for establishing best practices practises and demonstrating value. On the other hand, Nielsen et 1al. (2016) explained with a different viewpoint or method in a study of university buildings in Malaysia by stating that concerns surrounding upkeep or facilities are known to be tactical rather than strategic. It is important to note that different facility management methods might result in varying responses to surveys conducted to assess the performance of facilities over a specific period. The importance of facilities management to an organization's social and environmental profiles cannot be overstated since building maintenance and operational buildings are considered in terms of material usage and energy consumption. However, if not handled appropriately, it may impact the well-being and health of building users, including operators and service workers (Nielsen et al., 2016).

2.5.1 Post-Occupancy Evaluation: Purpose, Benefits and Barriers

Additionally, it is vital to know that the substantial economic advantages derived from investment in buildings, or the property sector are a consequence of the favourable effects of buildings on occupant satisfaction, which is one of the primary drivers of interest Post-Occupancy Evaluations (Akimoto et al., 2013). Building constructions are built for various functions, including shielding people from the elements, wind, and water. However, the narrative has shifted in recent years as people have come to demand more from their buildings; they want more suitable buildings with some advantages, or they want their buildings to be more efficient or suited for their users over time.

Occasionally, the emphasis is on the inhabitants and meeting their demands regarding the insights and repercussions of the original or previous design choices that resulted in the building's performance. According to Durosaiye et al., (2019), buildings operate best when they provide an atmosphere that supports the inhabitants' activities, inspires and delights, and has a minimal long- and short-term effect on the environment. However, some indications are required to demonstrate the buildings' performance. These indicators include the following: is it financially viable to run and maintain? Is it resilient and adaptable enough to change? These improvements are possible by considering the interests of critical stakeholders in the built environment, which are contingent upon the degree to which buildings satisfy the needs or expectations of their occupants (Thomsen et al., 2015). Adeyeye et al., (2013) established three performance levels for buildings: functional, efficiency, and workflow, health, safety, and security, and psychological, social, cultural, and aesthetic performance. Adeyeye et al., (2013) researched a steering group comprised of various stakeholders with various job titles, including facility managers/premises offices, building experts (architects, engineering consultants), finance/business managers/bursars, academic experts, school heads, governors, and county councils. It corroborated that the performance of school buildings depends on the facilities that are resource-efficient (e.g., lighting, heating, water, and electricity) and have a low long- and short-term effect on the environment.

Additionally, the steering group discussed how, from the user's perspective, the criteria for quality are defined by the building's performance and functionality, which was corroborated as a building that fits its context, is sufficiently sized and contains functional spaces that are fit for purpose. Finally, the group's conclusions indicate that improving the quality and competence of construction, design and craftsmanship, procurement, and budget limits while allowing for appropriate time would enhance the process and performance of building delivery. However, performance cannot be quantified without first evaluating the buildings or systems to determine their current performance state. The post-occupancy assessment is a frequently utilised evaluation approach.

Post-Occupancy Evaluation is a technique facility manager, and maintenance teams use to detect and analyse a building's behaviour. These tools are used to guide the design of future facilities. According to (Tookaloo & Smith 2015), post-occupancy evaluation enables institutions to maximise space use and save time and money on operational expenditures, including maintenance. Additionally, (Tookaloo & Smith 2015) stated that one of the purposes of POE, particularly in higher education, is to determine whether facilities management is accomplishing the goals of constructing and maintaining buildings and spaces that support the University's educational vision and mission over time. The importance of POE concerning the life cycle of a building cannot be overstated, as it provides a wide range of benefits and activities, including the assessment of building performance, the exploration of relationships between building resource use and occupant behaviour, the optimization of the indoor environment for occupants, the ability to make more informed decisions about future building design, and opportunities to improve communication within design teams and their clients.

2.5.2 Challenges Faced by Facilities Managers in Managing University Facilities

Due to the nature of the job daily, the importance of a facility manager or estate manager in maintaining the property or its amenities cannot be overstated. This maintenance varies according to the extent, users, and size of the facilities. Depending on the facilities' size, the problems vary as well. Aishah Kamarazaly et al., (2013) researched some of the issues encountered by facility managers, utilising university facilities as a case study. Facility management as a career "incorporates numerous disciplines to maintain the physical environment's functioning via the integration of people, place, process, and technology" (IFMA, 2009). However, a facility manager's key responsibilities include "developing, adapting, and maintaining an organization's buildings and other infrastructure to create an environment that strongly supports the organization's principal goals" (International Facility Management Association, 2012).

Aishah Kamarazaly et al., (2013) states that the complexity of facility management, combined with the demands of an organisation, has resulted in a growing shift in emphasis away from operational to a more strategic role for facilities managers, who are more inclined toward the traditional role of business process enhancement to achieve a competitive advantage aligned with corporate goals and objectives. These restrictions, which may be internal or external, determine the organization's strengths and weaknesses and are under the facility managers' control. On the other hand, external constraints are not within the organization's control (Michell, 2013). When correctly harnessed, these obstacles may sometimes be put to the most effective and highest use in obtaining the intended objective. However, this depends on the strategy used to address the issues.

However, Kamarazaly and Mbachu (2013) concluded in this research that while previous studies identified a variety of factors impeding the strategic facilities manager's ability to perform his or her function in the management of university facilities, none of these factors was prioritised to determine the impact on major functional areas in facilities management. Additionally, the study contends that the four most critical future issues confronting university facilities managers are emergency management, statutory compliance, and sustainability considering global climate change concerns as well as effective management of heating system. Lange et al., (2021) bolstered this case by asserting that sustainability is the single most critical problem confronting the facilities management profession and growing its importance. Financial/budgetary appropriations have been significant in advancing the sustainability goal and improving the facilities.

After identifying the difficulties confronting the university's facilities management and assessing the effect on business processes and organisational structure, the importance of identifying additional possibilities arising from these problems cannot be overstated to close performance gaps in these facilities. Energy, garbage, water, heating and lighting systems are just a few of these facilities. All these systems affect the inhabitant, the environment, and the performance of the building, but for this study, lighting and heating will be the emphasis since they are crucial systems evaluated when planning to renovate or remodel older or existing buildings. When doing these restorations and refurbishments, it is necessary to examine the many design procedures for supporting systems and services (heating, lighting, and furniture, for example) to obtain the best and desired outcome. To this end, lighting and heating will be the key emphasis of this study.

2.6. Lighting Design Process and Performance

Lighting is one of the building's physical characteristics, and it is from this perspective, a physical performance assessment may be conducted. One of the primary goals of building and service design is to provide the optimal indoor environment for the inhabitants (Lynes, 2013). Additionally, lighting and its conditions substantially impact energy consumption, occupant pleasure, and productivity. Warmsley et al., (2019) state that lighting design integrates light into the fabric of a building. More so, the effectiveness of lighting solutions is dependent on and varies according to the characteristics of each building type and the unique requirements of each project.

Warmsley et al., (2019) corroborated that the design method is always the same regardless of the kind of places to be lit, such as an office, gallery, restaurant, residence, or retail, regardless of the available light sources. Though it is critical to understand the lighting design process to ensure consistency in terms of quality and performance, a typical case study is that of the Augsburg municipal library in Germany. Located in the heart of the ancient city, the library's "open architecture" promotes public transparency. A 400-mirror skylight directs light into the structure's centre, while a vibrant interior design, vibrant vertical shading mechanisms, and double-skin glass on the sides all contribute to this quest for natural light. The new municipal library is well-known for its significant commitment to sustainable design, as seen by its low power consumption and use of primary energy and the building's inhabitants' well-being (Shishegar & Boubekri 2019).

Another aspect of the case study lighting performance emphasised is that the artificial lighting in this building primarily augments natural light. It is feasible mainly because the electric lighting system is often switched off, and the building is fully automated. A central control system (building automation) regulates the daylight that enters the structure (Shishegar & Boubekri 2019). The association between lighting and occupant happiness may be strengthened if occupants control their space's changeable illumination settings. However, these controls vary considerably amongst tenants. Boyce (2019) research shows that the bulk of switching on events occur with the occupants' arrival in the workplace, which depends on the occupants' personality or mood and the quantity of available natural light at the time of the lighting adjustment. These aspects will be examined to see if this remains true regarding the research field and case study. However, it is critical to conduct assessments of the technologies used to manufacture these lightings and to determine their efficacy in occupant satisfaction since some offer benefits over others. This will be discussed briefly in further detail.

2.6.1. Lighting Technologies

According to Yu et al. (2016), lighting technologies have shifted paradigms from fire in the ancient world to electrical technology today. For instance, in the prehistoric world, the light was obtained through fires made of wood, grass, and twigs. In contrast, in the ancient and Middle Ages, the light was obtained using oil and candles until the modern era, when new light sources emerged, ranging from the use of incandescent and fluorescent lamps to the recent significant shift toward the use of light-emitting diodes (LEDs) and now Organic Light-Emitting Diodes (OLEDs) for commercial lighting products.

Koden et al., (2020) adds that OLEDs lighting offers some benefits, including being flat, thin, and lightweight, having a high colour rendering index, being theoretically flexible, containing no toxic elements, emitting no UV radiation, and emitting just a faint blue light. To aid in comparison and comprehension, the table below compares several types of illumination.

Table 2.1: Comparison of forms of Lighting

Incandescent Fluorescent lamp LED lamp				OLED	
				Commercial level	**Development level**
Mechanism	Radiation by Joule heat	Inorganic Phosphor excited by plasma	Inorganic semiconductor	Organic semiconductor	
Shape	Ball	Tube	Point	Planar	
Efficiency	~ 15lm/W	~80 lm/W	~ 140 lm/W	~80 lm/W	~130 lm/W
Lifetime	1000~3000 hours	6000 ~ 12,000 hours	~40,000 hours	10,000 ~ 30, 000 hours	~40,000 hours
Cost	1 dollar/Kim	1 ~ 3 dollars/K1m	~5 dollars/Kim	Higher than 100 dollars/Klm	
Hg	None	Present	None	None	
UV light	None	Present	Present	None	
Blue light problem	None	None	Present	None	

Source from Koden et al., (2020).

After discussing the various types of lighting and their comparisons, it is essential to examine the management and maintenance of these lights in the building for them to continue performing to a specific quality. The lighting system concerning performance will be next in the following section.

2.6.2 Lighting System Characteristics and Performance Review

According to Haans (2014), the desire for natural illumination, which stems from the human inclination for natural goods, may have additional health advantages that, although yet unknown, must be addressed when concentrating on occupant productivity. According to de Bakker et al., (2017), electrical energy usage in office buildings is substantial. However, it is confined to a certain kind of structure to boost energy savings in lighting use, apart from adopting more energy-efficient luminaire systems.

The study technique allowed for a deeper examination of the influence on occupants' comfort, health, and well-being of local variables such as layout, closeness to windows, and ambient environment. The study was done only during the summer months, affecting the overall findings and being considered a restriction. Therefore, the proposed technique should be repeated periodically to benefit the building, considering the critical nature of lighting as a resource.

Lighting systems account for a significant portion of the power used in office buildings. Because these lighting systems are utilised throughout the day in offices to improve job performance and comfort in industrial operations and work environments (Kocabey & Ekren, 2014). Lighting uses a significant portion of global energy resources. (Gorgulu & Kocabey, 2020). Lighting consumes at least 19% of the world's power (Yilmaz, 2021). Due to the rising need for energy efficiency and effectiveness in lighting usage, the necessity to transition from inefficient lighting such as incandescent bulbs to high-intensity discharge lamps, tubular and compact fluorescent lamps have increased.

Furthermore, this is already the case in some nations, as Mao & Fotios (2021) suggest that the later lights are a more mature technology with a longer lifetime and higher luminous efficiency than the former (Incandescent bulbs). This significant success is primarily the result of a transition from incandescent to more efficient compact fluorescent lamps in the residential sector and from T12 to more efficient T8 and T5 fluorescent lamps in the commercial and industrial sectors (British Standard Institution, 2020). However, the research showed that the targeted proportion of incandescent light replacement with compact fluorescent lamps in the residential sector is still relatively low. According to British Standard Institution (2020), CFL consumption in the residential sector was just 23%, whereas IL utilisation was 62% in 2010. This graph illustrates the pace of decrease over time. However, it is vital to highlight that lighting system maintenance might be ignored due to expense and inattention if not effectively handled. Perhaps this is why the sale and consumption of various incandescent bulbs have been severely restricted due to rules and laws.

Additionally, it is vital to comprehend the various lighting systems and technologies and assess their energy consumption and power quality performance. Several illumination lights will be discussed in the following section.

2.6.3 Discharge Lamps

In contrast to incandescent lamps, discharge lamps produce light by an electric discharge inside a gas or a vapour. Mercury "Hg" trace is put into the fluorescent tube for illumination purposes. The conversion of ultra-violet light to visible light is achieved using a specific phosphor material (Aman et al., 2013).

However, the primary contrast between a fluorescent lamp and a compact fluorescent lamp is that the compact fluorescent lamp has a point source of light, while the fluorescent lamp has a linear source of light. Due to its downside of not being too energy-efficient, other energy-efficient lamps are being introduced and more affordable. Delmastro & Abergel (2020) suggest that the government use this opportunity to increase the growth of the LED market, with the lower LED costs to consider, which will invariably increase the performance to a minimum standard without compromising the requirements as it concerns the lighting products quality.

Perhaps, the suggestion resulted from the vote passed by the EU member states in 2018 to phase out halogen lamps and compact fluorescent lamps that are inefficient in 2021, though presenting LED lamps and luminaires for quality standard and minimum performance (Zuk et al., 2019).

2.6.4 Light Emitting Diodes (LED) Lamps

LEDs are semiconductor devices that are filled with gases and coated with a variety of phosphor pigments. LEDs are used to create artificial light, and unlike other kinds of lighting, their output is not naturally white (Aman et al., 2013). According to the Department of Energy

(2012e), phosphor conversion and the Red Green Blue (RGB) technique produce white light. However, the lifespan and efficiency of LED bulbs are greatly dependent on the luminaire's optical design and rate of heat dissipation.

According to the US EPA (2014) Solid-State Lighting Multi-Year Program, it is projected that LED lamp efficiency would grow to 235 lm/W and lifespan of around 50,000 hours by 2020 and that the cost of LED lamps will likely reduce to 0.7$/kilo lm by 2020. (US EPA, 2014). Additional forecasts from the (US EPA, 2014) state that by 2030, LED lighting is predicted to save 46 per cent of power and capture 74 per cent of the market, with significant growth in all industries. Because of these forecasts, demand for LED lighting is expected to expand due to the efficiency and cost savings associated with its ability to sustain performance and satisfaction over time.

The table above highlights and contrasts the distinctions between these three types of light. Welz et al., (2011) state in their research on the environmental impacts of lighting technologies — Life cycle assessment and sensitivity analysis that between 80% and 90% of the environmental impact is due to its direct use (the lighting); this result was obtained through an environmental impact assessment review; the remaining portion is due to the manufacturing and disposal of such systems. However, in their research on sustainability constraints in techno-economic analysis of general lighting retrofits, Vahl et al., (2013) expressed concern about the amount of electric energy consumed over the lifetime of an illuminating device, stating that its manufacture determines only 15% of that energy consumption.

Salata et al., (2015) noted similar concerns when comparing lighting sources or types, noting that the average amount of energy consumed during the exertion of incandescent lamps with low luminous efficiency affects total consumptions up to 90%, which is also approximately four times the amount required by compact fluorescent lamps and LED systems with comparable values. After comparing the various lighting sources, adhering to specific criteria and regulations is necessary to guarantee efficient and effective production. This standard is intended to encourage designers to plan for and implement appropriate lighting controls in conventional lighting schemes and buildings and act as a reference for facility and maintenance management. These professionals responsible for building systems such as lighting are looking for energy-efficient lighting solutions. LED lighting represents the next generation of lighting evolution that can provide efficiency, as it is also considered the fourth generation of lighting as applied to illumination systems (Yoomak et al., 2018).

Numerous studies have been undertaken on the performance of different kinds of luminaires, including LEDs (Aman et al., 2013). The study findings indicate a reduction in power usage compared to typical luminaires. However, before LEDs can be deployed, the lighting system's illumination quality, productivity, and occupant comfort must be addressed. Additionally, (Yoomak et al., 2018) opined that technology is critical to achieving comfort and quality, which is an advantage LED luminaire to have because technology can be developed with an applied control strategy used to reduce light output. The harvesting of natural light and daylight versus artificial light from the luminaire further reduces energy consumption in light systems in the long run. It is critical to determine what is most appropriate for a given building design and the characteristics of the intended lighting users.

In summary, previous research has highlighted a variety of issues arising from physical, technological, and environmental aspects that influence or impede optimal lighting performance, the effect on buildings and their occupants, and the client or organisation. Unfortunately, building lighting systems, in general, have performance flaws, and to sustain the performance of these lighting systems, specific choices about design solutions, information supply, quality standards, operations, and maintenance must be made. Other functional areas are ignored because of these changes. These maintenance systems might be given less priority, which could have a socioeconomic effect on essential stakeholders, such as maintenance teams (facilities managers), user occupiers, and the organisation (Building owners).

If not correctly handled, this influence may have a detrimental effect on them directly or indirectly, allowing them to focus their limited resources on the elements that have the greatest impact on them. Significant studies/research have not examined the social and economic effects of building lighting systems on buildings and their influence on the vital stakeholders.

Furthermore, given the variety of illumination sources and user requirements, it is sometimes impossible to determine what satisfies one user but not another. Certain people just need the ceiling lighting, which is plenty to get them through the day. While some users need more than ceiling lighting to be fulfilled, this may include reading, dressing, and other ambient uses. For some, the conditions and size of the illumination lights are also critical. It might be for environmental, functional, or emotional reasons, depending on the user's degree of enjoyment. These are only a few of the concerns or obstacles that might affect the productivity and performance of building occupants and maintenance crews.

2.7. Lighting System Key Performance Indicators

The lighting performance may sometimes be influenced by the lighting circumstances, such as lighting distribution, colour temperature, and illumination density. Furthermore, this has a direct and indirect effect on the visual perception and performance of the building's inhabitants. Improvements in these characteristics and performance have been recommended to boost productivity in the past (Abd El-khalek et al., 2017; Hwang & Kim

2010). Many images demonstrate the effect of lighting on job productivity elements such as accidents, mistakes, and production.

Several of these studies lack quantitative and comprehensive evidence to establish the association, making it difficult to quantify the effects of improved lighting environments on job productivity. The lighting environment and system may be customised and developed to meet the goal of flexibility based on visual environmental parameters on an individual basis. However, this cannot be achieved in a communal atmosphere or area.

Like other essential support services in buildings, lighting performs differently depending on how building owners and facility managers judge its performance over time. (Li et al.,2020) According to Li et al., (2020), the critical areas to examine when assessing performance from many viewpoints are energy utilisation and the efficiency with which a building system offers support services using a certain quantity of energy. Energy consumption intensity and energy efficiency are two typical key performance indicators for energy use. The energy usage intensity is a measure of cumulative energy consumption as a function of the yearly lighting energy consumption or the floor area of the structure. In contrast, energy efficiency refers to the energy provided to the energy consumed.

Additionally, power consumption in building operations and utility structure is a vital indicator that significantly influences performance. This key performance indicator offers a more precise assessment of peak demands on building systems.

Responsiveness to Control may be challenging to measure at the system or component level since key performance indicators for control techniques and technologies only give possibilities to discover control flaws in individual systems. Finally, consumption should be proportional to actual service demand. The consumption will assist in determining which system is operating optimally and in determining efficiency. This efficiency is referred to as service demand responsiveness, controlled and maintained by a team.

2.7.1 Management and Maintenance Analysis

The management and upkeep of buildings or facilities may significantly impact their overall performance throughout time. For this level of performance, it is essential to involve building engineers, facilities managers, architects, and services engineers from various disciplines such as design, planning, engineering, psychology, and economics. This management and maintenance analysis is accomplished through the integration of physical surveys, physical interviews, and laboratory analysis and the collection of empirical data for the evaluation (Fionn Stevenson & Leaman, 2010).

In terms of sustainable building performance, a company's management style may make or break the structure and performance. If a company's management styles are not effectively and efficiently controlled, it can create even more harm soon. By asking the questions of why, what, how, and when certain things are done. This research will determine where the university can improve to continue to promote the sustainability agenda, with a particular emphasis on the area of lighting as part of the building's facilities as a case in point.

Some of the supportive services in the building are related to the well-being and health of the inhabitants or users of the building, and sometimes, it can influence the building's performance and productivity. Turin developed a demand-side analysis technique in partnership with the ITER (Educational Institution of the city of Torino) research study by (Deambrogio et al., 2017) to produce the demand-side needs analysis of what is being examined. This example was taken as a novel strategy in conjunction with the technical analysis operations and user engagement. Following the technique outlined above, the following conclusions may be drawn from the analysis conducted:

a. As administrative employees, including instructors, were questioned using participatory procedures, such as direct experimental experiences, group discussions, and questionnaires, the users were involved in evaluating the alleged environmental comfort. This study will use interviews with university employees, some of whom will be contacted via questionnaires and focus group conversations with administration or maintenance team members.
b. Define an audit model and pick appropriate ad hoc indicators, including all the aspects that might influence environmental comfort, such as light, indoor air temperature, and noise, while also accounting for all the ergonomic considerations, such as the arrangement of space and the purposes of the design.
c. Technical study and development, with a particular emphasis on lighting systems such as lighting systems, illuminance maintenance, and periodic maintenance.
d. Functional distribution analysis and the conditions of natural and artificial lighting with building plans and orientation as a determinant and actual lighting conditions as a stimulant, using the intended use of the classrooms, laboratories, teacher rooms, utility rooms, and other rooms associated with the building as a stimulant. It is anticipated that some or all the highlights mentioned earlier will be used in the study, which will be conducted utilising the audit model, technical analysis development, and questionnaires to assess the comfort, lighting conditions, and lighting distribution in specific university buildings.

The above-mentioned demand-side analysis and results from the survey, which were conducted on lighting conditions and lighting systems, assist in identifying an essential element for identifying the innovation requirements for the building to continue to perform at the desired levels. Performance-based specifications that were developed because of the invention include, for example, criteria for:

i. The expense of maintenance.

ii. The amount of energy used.

iii. Environmentally friendly practises

iv. Convenience in use.

v. Technological advancement; and

vi. Integration and interoperability with the systems and functions of other parts of the building

A typical structure that falls below the performance requirements in conformance with standards and regulations.

Table 2.2 Performance Specification of Lighting

Lighting Systems	Lighting Controls	Finishing
Environmental lighting requirements (quality and comfort)	Environmental lighting requirements (quality and comfort)	Environmental requirements (quality and comfort
Energy performance requirements	Energy performance requirements	
Ease of use and maintenance requirements	Ease of use and maintenance requirements	
Safety requirement		

Source: Deambrogio et al., (2017).

A study conducted by Kocabey et al., (2014) found that natural lighting, which stems from the human preference for natural products, can have additional health benefits. Although these benefits are not fully understood, they must be considered when considering building performance and occupant productivity. According to Li et al., (2020), for a building to achieve the desired performance over time and meet the expectations of its occupants or owners, the following requirements must be met: it must be able to withstand wear and tear, loose fit, low energy consumption when operating at total capacity, weatherproof against wind and watertight, as well as comfortable in terms of a secure and healthy indoor environment. In contrast, the older a structure and its systems get, the less efficient and effective its performance becomes, and the owners or occupiers are occasionally faced with the dilemma of upgrading or replacing these systems or the building (Grover & Grover 2015). Similarly, in new buildings, following completion and handover by the contractors to the customers, these services or amenities are often left without sufficient maintenance, resulting in a decrease or degradation of the building's condition (Mohamed et al., 2017). Given the nature of buildings, it is necessary to use resources in conjunction with systems or services that cover structures' whole process or operation (Thomsen et al., 2015).

There are a variety of resources available to support operational systems or services. These include visitor perceptions of the facility and space at the desk and cleaning services, availability of conference spaces, storage arrangements, and other amenities. It is crucial to consider aspects such as temperature to determine if the air is excessively hot or cold, stable or variable in the air, and whether the air is still or draughty, humid, fresh or dry, stuffy, odourless or stinky in both the winter and summer. Aspects to consider include lighting, whether neutral or a mixture of natural and artificial light, glare from the sun and sky or artificial lighting. The next part will examine the various lighting conditions, quality, control, and dynamics to understand better how they influence the facilities' people.

2.7.2 Lighting Control

Facilities are constructed to create a healthy and pleasant working environment; certain of the components of the buildings, such as lighting systems, are designed to facilitate the provision of these comforts to the occupants (Clements-Croome, 2015) To provide a pleasant working atmosphere while also reducing energy usage, it is necessary to have complete control over your lighting system. As well as the design of the lighting systems, poor design and commissioning of control systems may result in uncomfortably high levels of indoor air temperature and humidity, excessive noise due to plant cycle, inadequate ventilation, and low lighting conditions (de Bakker et al., 2017).

When combined with appropriate lighting controls, these circumstances serve as critical components of a building's lighting system. These lighting controls may serve various functions, ranging from basic to complex control. Depending on the system in place in the building, these controls can take many forms, ranging from manual controls to occupant sensors. According to (Choi, 2016), five primary lighting control methods can be combined or separately. These methods are localised manual switching, time control, reset control (timed off, manual on), occupancy control (presence detection), and photoelectric switching and dimming, which can all be used in combination or separately. Some of the most significant advantages received from lighting controls may be divided into two categories: to assist in creating a better lighting environment and the conservation of energy, hoping that this would result in improved performance on visual tasks. However, several studies have shown that lighting energy usage may be reduced dramatically in daylit or seldom-used rooms, with the possibility for rapid payback times in these situations (Yeom et al., 2017).

Lighting energy consumption may be influenced by the functioning of lighting controls, which can be directly tied to the number of people who use a building at any one moment (Choi et al., 2020). Because of the demands and behaviours of users/occupants, this connection is critical, and it is considered throughout the design of lighting control systems. Some studies have confirmed this, with their findings indicating that the absence of lighting controls in workstations or a lack of understanding of how to properly utilise lighting controls results in poor satisfaction and energy waste (Yahiaoui, 2017). Nevertheless, high levels of user happiness and energy efficiency are related to high levels of control and high levels of knowledge of these controls among users (Bayneva, 2019).

During their interactions with environmental systems, occupants and users gain happiness and awareness, which helps them maintain comfortable living environments for more extended periods. It has been discovered via on-the-ground research that these interactions and adaptive behaviour of the building's inhabitants are a significant element in determining the structure's energy consumption (Yamin Garretón et al., 2018). More specifically, Alnusairat et al., (2021) occupant/user behaviour may also substantially impact building performance evaluation, and building designs can be altered to better meet real users' demands. It is critical to have a clear and integrated control plan early in the design process to improve and produce a pleasant, energy-efficient building continuously. While establishing a clear and integrated control strategy, it is also critical to pick appropriate control systems that are simple to use and enable users to handle the controls efficiently and effectively while avoiding unnecessary complexity.

In some instances, improving the control systems of existing buildings is the most significant modification that can be performed to raise the structure's energy level and efficiency. Notably, even well-designed building services will malfunction if the controls are inadequate, wrongly implemented, or not understood by the building operators or end-users. Carlos A. C. Niemeyer & Lucila C. Labaki, (2015) reports that in an evaluation of the usability of a lighting control panel equipped with several erudite lighting scenarios that were installed in a sustainable building, the occupants only preferred the simple switch on/off scenarios and ignored the use of any other scenes, which resulted in high levels of lighting energy consumption and poor visual conditions in the built environment (Choi et al., 2020). A further observation has been made automated control typically works best to turn lights off or lessen their brightness when there is enough natural light or when there is no one present in the area (Delmastro & Abergel, 2021). According to the findings, another finding revealed that users generally prefer local lighting control; occupants or users detest automated controls that turn lights on when they are switched off under human control. Based on many research findings, Gharehbaghi et al., (2021) indicates that in most workplaces, schools, and residential accommodation, even if an automated switch off is given, switching on should be performed manually.

Moreover, caution should be adhered to when lighting control systems abruptly alter light levels since this may adversely affect occupants' comfort and productivity. Keeping personnel informed about the purpose of the control system, which might serve as input to the building's maintenance team on how the control system works and how the tenants can interact with it, could also help lessen the likelihood of a problem developing over time. It is vital to remember that only the occupants can specify the absolute level of switching to meet their requirements. Control systems should be maintained proactively and responsive, which necessitates a responsive maintenance staff.

2.7.3 Lighting Condition

The condition of the lighting is critical to both human and building performance. With the widespread expansion in the use of computer-based learning, performance assessments have grown more challenging to quantify, and the impacts of artificial lighting conditions on new learning forms have not been studied in greater depth.

Among those working in architecture, the connection between a building and its users is often discussed. These interactions occur due to several elements such as acoustic, thermal, and lighting, which have been extensively researched for their significant influence on learning performance and human working environments. According to ongoing investigations conducted by (Bournas & Dubois, 2020)), the lighting environment impacts mood, circadian rhythms, attention, vision, circadian rhythms, cognition, and other factors. The norms of lighting design, on the other hand, differ depending on the setting and the country. Most spaces with a learning purpose, such as working offices and university classrooms, should have illumination more significant than the default setting of 300 lx.

According to several experiments and studies conducted by Boyce, (2019), some beneficial impacts might impact a subject's behaviour and cognition due to lighting conditions that have been recognized. It was discovered in the field research by Boyce, (2019) that lighting impacts on motivation and focus from the users or occupants of the building were either minimal or non-existent.

However, the increased light intensity may improve vitality and alertness, objective performance, and physiological arousal. Additionally, the use of low illumination rather than high illumination can be improved with long-term memory, improving feelings of vitality and alertness. Meanwhile, lower illumination levels below 500Ix, an acceptable threshold, would not hurt the user's overall experience (Choi et al., 2020). The lighting levels and colour significantly affect the user's area and surroundings, and the high correlated colour temperature significantly impacts this. Fluorescent lights appear to improve overall wellbeing and productivity, particularly when the light is blue-enriched, which corresponds to a relatively high colour temperature. According to Mohamed et al., (2017), performance, subjective alertness, and evening fatigue significantly improve when using fluorescent lights. These lighting configurations created a wild feature space, but some setpoints are not often seen in real situations. When investigating learning performance, more research should be conducted to support university buildings' realistic lighting setting size to ensure that the experiment's dependability is further tested. According to the research findings conducted by Pandharipande & Newsham, (2018), illumination and colour temperature are two essential elements of lighting settings to consider while investigating the human-light interaction. The nature of this relationship is complex and diverse in many ways. People may have a variety of emotional, physical, and psychological reactions to lighting and the built environment, and these responses directly impact their ability to work, be productive, and learn well.

2.7.4 Lighting Quality

The importance of a high-quality constructed and working environment for the users/occupants cannot be overstated. Most industrialised nations, including the United Kingdom, increasingly focus on providing high-quality rather than high-quantity work settings. These work settings are particularly true in environments under the supervision of a top-level management team, such as universities and other places of employment. Existing research indicates that poor indoor environmental quality, such as lighting and heating, significantly impacts occupants' health. According to the findings, this is particularly true in the workplace, impacting their job performance and productivity. Working circumstances like punctuality, excellence, truancy, interruptions, and the accident rate are sometimes influenced by the lighting conditions in the workplace (Bellia et al., 2016). More specifically, for many years, light has been recognised for its essential tasks of improving ocular performance and helping the occupants feel more comfortable, pleasant, stimulated, colourful, and less oppressed 19. Poor lighting in the workplace is a primary cause of visual discomfort and physiological and psychological strain among workers. These symptoms include anxiety and fatigue, lethargy; headaches; eyestrain; migraine. These symptoms result in decreased work performance and efficiency (Hye Oh et al., 2014).

Providing appropriate or high-quality lighting conditions in a working environment, on the other hand, is more than just supplying enough light. A variety of aspects are considered, including illuminance uniformity, luminance distributions, light colour and features (such as colour rendering and colour temperature characteristics), the type of the light (whether natural or artificial), flicker, and glare management, to name a few (Despenic et al., 2017). The workplace lighting environment influences light source characteristics, such as location and mounting height, luminaire type and light distribution, and workplace illuminance quantity, quality, and uniformity. Researchers have discovered that providing the proper intensity and consistency of illumination improves occupants' visual perception while simultaneously decreasing indicators of weariness, such as eye discomfort and headache (Li et al., 2020). Moreover, correctly maintained illumination levels improve occupants' mood and alertness (while simultaneously decreasing tiredness), both of which are critical variables in improving occupants' performance (Lange et al., 2021).

As a result, incorporating suitable Correlated Colour Temperature into the workplace raises occupants' motivation, improves their health and cognition, promotes working efficiency, and, as a result, increases their output. In addition, existing research has shown that occupants exposed to daylighting working settings report better job satisfaction and superior performance (Koden et al., 2020). Although earlier studies have conclusively proved that an insufficient lighting environment in offices hurts employees' well-being, job productivity, and efficiency, further research is needed. However, studies have indicated that giving employees the flexibility or autonomy to modify the lighting in their workplaces according to their preferences positively impacts their job satisfaction, motivation, alertness, and visual comfort (Yamin-Garreton et al., 2017). Additional research by the Riratanaphong & van der Voordt, (2015) found that workplaces where employees cannot manage their surroundings result in greater discomfort and stress. Because of this, it is believed that the user-centric lighting system would increase the pleasure and comfort of inhabitants in contemporary office buildings. A significant amount of study has shown that illumination may have nonvisual effects on biological rhythms, usually referred to as the body's circadian cycle (Ransom, 2016).

Other research has shown that working in an insufficiently illuminated environment causes both mental and physical exhaustion, impairs the ability of the person to focus on the job at hand (Despenic et al. (2017), diminishes the employees' vitality, causes drowsiness during work hours. Furthermore, insufficient illumination in the office has been connected to increased accidents, job unhappiness, and other types of discomfort in the workplace. Improved occupant happiness necessitates an integrated lighting design approach (Hye Oh et al., 2014). The use of a design that allows occupants to modify various elements of their office's lighting environment is encouraged. User-centric lighting design is an excellent approach for improving the health of building inhabitants and ensuring long-term performance.

2.7.5 Lighting Quality Vs Lighting Performance

The lighting quality does not always supply the quantity of performance necessary in an area or location, especially in low-light environments. Various elements influence how well a product performs compared to its quality. A typical example is an educational institution such as a school or university, where the illumination levels, quality, and performance are all critical to maintaining the appropriate educational standard.

Education refers to any actions that are planned and meant to have a specific influence on a person's physical and mental health, particularly in the case of children. The university process is intended to improve student's skills, knowledge, and talents, and various variables are in place to help them reach this goal. These elements influence the physical conditions of classrooms and offices, which are critical to the success of the teaching staff and the achievement of students in school. (Despenic et al., 2017) found that visual comfort in the interior environment is a critical aspect of learning and is recognised to improve the educational process, particularly children's visual comfort.

However, several research studies have shown that maintaining high-quality lighting in an educational setting like a university is time-consuming and challenging. In the classroom, collections of varied visual activities such as writing on desks and reading aloud on the classroom writing board, communication between instructor and students, and other activities are gathered and displayed. It is necessary to have appropriate ocular conditions to carry out these tasks properly. Overheating and glare are examples of classroom circumstances due to poor daylighting performance; (Smadi, 2015).

The illumination may be insufficient because of the levels. It will be necessary to comprehend what the various illumination levels truly signify. European Standard EN 12665:2011 defines lighting levels as "the quality of visual sense," but "visual comfort," as described by the same standard, "is a subjective state of visual well-being caused by the visual environment." To achieve visual comfort, many factors must be taken into consideration. These factors include human eye physiology, spectrum emission of the light source, physical variables characterising the quantity of light and its dispersion in space, and others. Amina Ismail et al., (2021) conducted a series of studies in which they evaluated a succession of factors regulating the relationship between the lighting environment and human needs, including the uniformity of light, the amount of light, the quality of light in rendering colours, and the prediction of glare risks for users.

There have been changes in the necessary lighting level in educational facilities throughout the years: Current rules and specifications, such as the CIBSE Guide A and the IESNA, the minimum illuminance on the working plane for classrooms should be 300lx on the working plane. More specifically, the expectations of quality vs performance of lighting at an educational institution such as a university are changing, sometimes due to changes in taste, management teams, and technological advancements. However, the method must be dynamic or adjustable to balance lighting quality and performance. The quality and performance should influence the user's comfort, productivity, and overall well-being.

2.7.6 Workplace Lighting Dynamics

Any organization's office environment is critical to achieving the intended outcome or meeting the expectations of the organization's customers or clients. For example, at a university, the office, lab, studio, hall, or classroom are all examples of places where students and faculty might work. The employer or organisation is often responsible for making the office environment (including lighting, aesthetics, furniture, and other elements). The more flexible and dynamic the working environment is, the more likely the workplace will continue to develop over the long term. If the working environment is not as accommodating as anticipated, particularly in lighting conditions, it may lead healthy persons to encounter light-induced health and performance-related concerns, which can be dangerous.

This danger may be because the illumination conditions are substantially reduced during the daytime hours at work. The authors highlight the benefits of supporting people's physiological reactions and psychological behaviour throughout work periods, particularly in Europe, according to Akashdeep Joshi et al., (2019). The sustainability and consistency of some of these advantages are required to have a more significant impact than the continual regulation of lighting in terms of supporting dayshift workers' psychophysiological wellbeing indicators throughout peak hours and during work periods. As lighting is a vital utility in the workplace, the sustainability of these advantages is crucial because artificial lighting exposures are relatively modest during the day (typically 500lx in the office) and may be overly bright at night when compared to natural daylight and moonlight levels (Abd El-khalek et al., 2017). It is possible that the improper handling of these two opposed environmental lighting scenarios will contribute to light-induced health problems such as circadian disruption, also known as circadian desynchronization, from an entrained condition due to the inappropriate artificial lighting exposures throughout the day and photosensitivity (Shishegar & Boubekri, 2019). More specifically, Abd El-khalek et al., (2017). points out that living in natural darkness throughout the day may result in light-induced health and performance-related concerns as well as other problems. There should be a balance in lighting supply as a utility in the office environment to limit light-induced health and performance-related issues in the workplace. In the long run, this will impact the users' performance in terms of productivity.

Users who operate in a facility with no windows and rely only on artificial lighting and those who suffer from light-induced health issues should be concerned about the circumstances of their work environment. In-office skyscrapers, where the deep-plan architecture generates a windowless mid-zone workspace with no natural daylight contribution, these conditions are most often seen. These individuals who operate in these settings are not only subjected to prolonged biological dark and consistent artificial lighting conditions, but they are also denied natural sunshine, which is vital for their health and well-being (Scofield, 2019). Because of this, identifying artificial lighting settings that support dayshift workers' psychophysiological wellbeing indicators is critical in the working environment and must be prioritised and implemented.

The findings of a large-scale field test conducted by Huiberts et al., (2017) on the effects of human rhythmic dynamic and constant artificial lighting conditions on office workers revealed no significant differences between the two lighting conditions, except that workers who were more satisfied with the dynamic lighting condition. However, according to Scofield (2019) the Huiberts et al., (2017), the research did not distinguish between the impact of considerable natural daylight and human rhythmic dynamic and continuous artificial lighting settings. The study was conducted during the darker months of the year, when uncontrolled natural daylight contribution, particularly from large windows, may have been insufficient to establish a relationship between the study outcomes and the two lighting conditions, could have confounded the relationship between the study outcomes and the two lighting conditions. It is important to note that this area is a significant source of concern for both users and the maintenance team, as it pertains to achieving the desired level of satisfaction for users as well as maintaining the performance of the lighting conditions without compromising the impact on the user's productivity in the workplace (Sithravel & Ibrahim, 2019).

Even more so, given the variety of illumination sources available and the varying requirements of users, it might be challenging to determine what would satisfy one user while not satisfying another. Some customers need the installation of ceiling lighting, which is sufficient to get them started for the day. Some users, however, want more than just ceiling lights to be fulfilled, whether it is for reading, dressing, or other atmospheric reasons, such as in a bedroom. The quality and size of the illumination lights are also important considerations for certain people more than others. It might be for environmental, functional, or emotional reasons, depending on the consumer's enjoyment of the product or service. These are some of the concerns or obstacles that might influence the building's tenants' productivity and the maintenance personnel's productivity. The influence of design characteristics and tenant preferences on the performance of a building's lighting system will be discussed in the next section.

2.8 Impact of Design Features and Occupant Choice upon Lighting for Building Performance

At the very least, it is critical to understand the user occupants and their interactions with amenities such as the lighting to increase efficiency and productivity in buildings because of the intricacies of buildings and human behaviour (Baker & Steemers, 2014). Because preferences depend on satisfactory lighting conditions, it is challenging to isolate occupant interactions with one of many different lighting systems and understand occupant decision-making processes regarding the usage and control options because preferences depend on satisfactory lighting conditions (Sithravel et al., 2018). When the needs of the inhabitants are considered, the importance of the design aspects cannot be overstated. It is one of the most critical factors affecting the performance of buildings in the built environment.

It is important to stress that the influence of tenant behaviour on a building's overall performance and energy consumption cannot be overstated. After researching with the goal of understanding occupants' lighting-use behaviour, Heydarian et al., (2015), investigated the influence of manual and semi-automatic control systems on the lighting used in a single-occupancy office space in the United States of America to ascertain the level of impact that building lighting systems have on the working environment.

According to the United States Environmental Protection Agency's National Awareness of Energy Star (2013) report, approximately 41 per cent of total energy consumption in the United States is attributed to building energy use. In contrast, this figure varies in the European Union and the United Kingdom, 37 per cent and 39 per cent, respectively. According to the data, this has a statistically significant impact on the functioning of the building. This demonstrates the important role that building energy consumption plays in the construction industry; the significance of this influence and the other components of a structure cannot be overstated. The researchers decided to concentrate their efforts on examining different control options that adjust the obtainable lighting levels in a single-occupancy office environment because lighting consumption invariably impacts the overall energy consumption of the building. Natural lighting and artificial lighting are the two types of lighting.

In contrast to natural lighting, which is derived from architectural features and orientation such as window sizing and shading positioning, artificial lighting is derived from the physiological system provided for lighting an area or environment, with controls that can be manual or automatic (Ryckaert et al., 2010). Lighting systems are the second most energy-intensive source of energy consumption in commercial buildings in the United States, behind HVAC systems (US EPA, 2013). On the other hand, buildings or building systems, due to their complex nature, are specially constructed to accommodate occupant comfort at various levels of brightness to maintain appropriate lighting conditions (Heydarian et al., 2015).

Heydarian et al., (2015) experimented as part of their research. They used a virtual model of a single-occupancy office explicitly created for the experiment and was designed to be like an actual office at the University of Southern California to experiment (USC). Several illumination sources were used in the model, including two artificial light fixtures, each with three fluorescent light bulbs and natural light streaming in via a window. Each participant was given a different control option to modify the lighting levels in the room throughout the experiment, which consisted of four versions of the model as initially designed. Participants in this experiment were required to increase the lighting levels in the room to effectively measure the influence of lighting control options in the office space. Several comparisons were made between the model version and the actual office space, and different hypotheses were formed because of these comparisons.

Research suggests that adding semi-automatic controls for the shades alone would be an effective technique to encourage residents to open the shades and utilise natural light rather than artificial illumination after the experiment. Alternatively, having one remote control option to open the blinds semi-automatically is more successful at motivating consumers to utilise natural light than having two remote control alternatives, according to the findings. However, the researcher aims to look at how various design choices affect occupants' energy consumption habits and how occupants behave when it comes to lighting control in the presence of other people who work in the same office space. As a result, the researchers concluded that providing end-users with a remote-control option to manipulate the shades may be a more successful technique for motivating them to enhance the illumination levels by using natural daylight rather than artificial light.

2.8.1 Impact of Lighting on the Physical, Environment, Functional and Human

Although various supporting services help keep the built environment running well in the built environment. The users and occupants of these spaces are often most affected by the effect. Some may be physical, such as in the building or the surroundings, where the aesthetics are taken into consideration, while others can be functional and human, which can have an influence both directly and indirectly. One of the most important support systems in a structure, lighting, has a significant influence that cannot be overstated. Because this can either encourage or demotivate people in the building. One such study is Lights, building, action: Effect of default lighting settings on occupant behaviour, conducted by Sithravel et al., (2018), in which one of the significant findings is that the only motivating factor that all respondents who kept the default lighting setting recognised was that the default lighting was adequate for them to perform the task given. Ninety-five per cent of those who "just opened the shades" said that they preferred natural light over artificial light, while 5 per cent stated that it was more straightforward for them to open the blinds rather than increase the number of electric lights. Among those who responded in conditions where they kept the default electric lights on and reduced the amount of simulated daylight, 20 per cent stated that they preferred electric light over simulated daylight, 40 per cent stated that it was easier to adjust the shading systems, and 40 per cent stated that they preferred to have less lighting available, regardless of the source of lighting. Another research of users' views of sustainable buildings, conducted by Baird (2015), explores whether the lighting default settings substantially influence people's total lighting choices.

Further research revealed that participants were more likely to choose open shades in their final option if the default setting had the most considerable amount of simulated daylight accessible rather than closed shades if the default setting did not have any simulated daylight available. It was found that if the default option had all the electric lights turned on, they were substantially more likely to have all the electric lights turned on in their final decision. This shows that the default conditions are "sticky" and that individuals are more likely to make a final option like the default condition than not. Prior study has shown how defaults may influence a wide range of other options. However, to the best of the researcher's knowledge, this is the first study to investigate how defaults can significantly impact people's lighting choices, particularly the choice between daylighting and electric lighting, to be more motivated to choose a more energy-efficient option. Because lighting systems account for a significant portion of total electricity consumption in buildings, and changing occupant behaviour is an effective method of reducing energy consumption, the outcomes presented in this paper have significant implications for "unconsciously" influencing the energy-consumption behaviour of building occupants and visitors. Having explored the lighting conditions, quality performance and the various effect on the users. The aspect of heating systems, the types of quality, performance and their impact on the users will also be explored in detail below.

2.9 Heating Systems

Heating is one of the essential commodities in the buildings; due to this, the demand for heating equipment continues to rise, such as the sale of heating pumps, renewable heating equipment like solar hot water systems have increased. According to (Delmastro & Abergel, 2020), the sale of heating pumps and renewable heating equipment represents more than 10% overall in 2019, and by 2030, in line with the Sustainable Development Scenario, it will continue to rise more than double 50% of the sale. These statistics corroborated the increase in demand for this essential commodity. However, this heating procedure is accomplished by employing a space heating system, which refers to the medium employed and the kind of device used to transmit heat from the medium to the enclosure that is being warmed. The term "space heating" is generally understood to refer to heating interior areas and buildings. This heating interior might apply to residential, office, animal raising units, greenhouses, as well as commercial and industrial structures (Cabeza et al., 2014). Space heating systems can be classified as either indigenous or central, depending on whether the heat from a heating appliance is distributed directly into the heated room or whether the heat produced at a central location heats a medium that then delivers its thermal capacity to the heated room. Space heating systems are used to replace heat losses that occur anytime the indoor temperature is higher than the outside temperature but lower than a predetermined threshold, such as 20oC. In addition to heat transfer through the building's structural shell, which is ultimately lost to convection, the heat emitted from the structure's exterior surfaces and heat lost to air infiltration and mechanical ventilation is all examples of heat losses from a building (Kreith & Krumdieck, 2013).

Another heating system concept identified is the concept of floor heating. Veken et al., (2005) explained that floor is conceptualized for its high radiant level and its low water temperature. Consequently, this results in lower air temperature and a possible high efficiency system coupling such as condensing boilers or heat pumps which in turn supply low temperature heat. In addition, the integration of thermal mass with floor heating system is always considered to reduce peak heating loads as well as increasing the usage of solar gains (Arneodo et al., 2018). Also, increases in thermal resistance of a building enclosure result in a reduction in the influence of any extra thermal insulation on the energy efficiency of the building enclosure. This physical law pushes nations with stringent insulation standards to resort to the Energy Performance Regulation (EPR). Not only is thermal insulation evaluated, but the energy efficiency of ventilation, lighting, hot water production and heating systems and the advantages of passive and active solar energy are also considered (Jarboe et al., 2019). The heating system's effectiveness is significantly unknown in such a vast universe of options. In addition to its high amount of radiant heat and low supply water temperature, floor heating is also known for its ability to be coupled to high-efficiency systems such as heat pumps, condensing boilers, and other systems that deliver low-temperature heat. Using efficiency, the ultimate heating system delivers just the quantity of heat required to maintain interior conditions at a level that provides thermal comfort to the room's inhabitants. Air temperature, air moisture content, airspeed and quality, and mean radiant wall temperature are the primary factors that influence thermal comfort in addition to clothing (Barber, 2020).

Furthermore, thermal mass combined with a floor heating system is often recommended as a solution for reducing peak heating demands, reducing temperature fluctuations, and increasing the utilization of solar gains (Kummert & Kummert, 2016). On the other hand, little attention is devoted to the control challenges arising from the substantial thermal lag inherent in these systems. It is possible that when intermittent heating is used, the control efficiency will be so poor that all advantages would be negated. As measured by the ratio of net heat demand to total heat consumption, the overall building efficiency does not seem to be any greater. Four significant kinds of heating systems are examined to determine their overall efficiency. High-Temperature radiators, Low-Temperature radiators, and two systems with floor heating in the day zone and Low-Temperature radiators in the night zone are among the options. The floor capacity of the latter two systems is different between them (Gawande et al., 2014). The impact of regulating the operative or air bulb temperature and installing a condensing boiler paired with a variable boiler exhaust temperature is explored. In addition to controlling the air temperature, space heating is also responsible for regulating the mean radiant wall temperature of interior surfaces around the enclosed space (Barber, 2020). These two temperatures are combined to generate the indoor (or sensible) room temperature, which should be maintained uniformly as possible in any horizontal or vertical direction throughout the heated area for thermal comfort.

- It is necessary to design heating systems in line with the needs of the technological process that will be used in the building (Zaniboni et al., 2017). It is necessary to evaluate the desired degree of comfort and clients' individual needs. Heating system components (heating devices, pipe materials, control and regulating equipment) must be selected following the fire safety and hygiene regulations (Pistore et al., 2019). According to Torresin et al., (2018), the heating system of a building must be constructed so that the boiler room of the building offers the technological tools to assure heat transmission to all devices. Unit buildings' heating systems are constructed so that it is easy to estimate the amount of heat used in each apartment without entering it. According to the Technical Construction Regulation criteria, the systems must be tested and certified for use, which was updated in 2017. When designing the most energy-efficient building engineering systems (Barber, 2020), priority should be given to the systems that report the lowest non-renewable primary energy factor and the highest value of the renewable primary energy factor, as well as the maximum efficiency of the installations in these systems (Torresin et al., 2018). In addition, when designing the most energy-efficient building engineering systems (Pistore et al., 2019), priority should be given to the systems that report the lowest non-renewable primary energy factor and the highest value of the renewable primary. More so, the deployment of low- carbons high-efficiency heating technologies should help reduce average global energy in the next decade by about 4% annually when building envelopes improvement are done with a combined effect of fuel- shifting, decarbonization of the power sector and efficiency improvements, which will reduce about 30% emissions due to building heating by 2030 ((Delmastro & Abergel, 2020).

2.9.1 Energy Performance design requirements for a Building Heating System

The following requirements apply to building heating systems (US Environmental Protection Agency, 2014):

- Priority should be given to energy-efficient heat sources when designing heating systems.
- When designing heating systems, priority should be given to control devices that comply with heating in the entire building via thermostatic valves and indoor or outdoor thermostats.
- The yearly thermal energy consumption anticipated for heating in Lithuania's building energy performance class should conform (US Environmental Protection Agency, 2014).

2.9.2 Classification of Heating Systems

- Water heating systems are another kind of technology. Typically, water or ethylene glycol transports heat in these systems when there is a threat of frost forming.
- Heating systems that use steam. They were often seen in industrial buildings that had steam boiler rooms.
- Heating systems that use electricity. They are used for independent heating homes or small buildings and structures located long distances from another energy source. The drawback of these systems is that they have a high maintenance cost.
- Heating systems fuelled by natural gas. In industrial and non-residential buildings where heating may be switched on and off regularly, they heat the space. The infrared heating system may be used to heat non-residential and public buildings and heat

places with high thermal losses, such as covered terraces, exposition halls, airports, and other similar spaces, among other things.

In recent years, air-heating systems have become more and more popular for heating and cooling areas and situations where a high volume of fresh air is necessary. Water-heating systems offer the benefit that thermal energy is transferred more effectively by water than by air, resulting in a lower energy need for the same heating capacity when using water instead of air.

According to Seyler (2019), the surface temperature requirements for panel surface heating systems with heating elements mounted in building structures (floor, ceiling) are as follows:

1) 33 degrees Celsius for the bathroom floor, as well as for the heated swimming pool tracks and chairs.
2) For rooms where people temporarily sleep on the floor, the temperature should be 35 degrees Celsius.
3) For rooms where people are continually on the floor, the temperature should be 29 degrees Celsius.
4) For the ceiling, if the structure's height is between 4-6 metres, the temperature should be – 38 degrees Celsius.
5) for the ceiling, in the case of a structure with a height of 3.5-4 m, – 36 degrees Celsius.
6) For the ceiling, if the height of the structure is between 3-3.5 m, the temperature should be – 33 degrees Celsius.
7) For the ceiling, in the case of a structure with a height of 2.8-3 m, – 30 degrees Celsius.
8) For the ceiling, if the height of the building is 2.5-2.8 m, the temperature should be – 28 degrees Celsius.

Zuhaib et al., (2018) specify that the surface temperature of special-purpose buildings, such as kindergartens and hospital wards, in the underfloor heating system shall not exceed 35 degrees Celsius. Radiating heating equipment with a surface temperature of more than 150 degrees Celsius must be positioned above the working area to ensure that the radiation intensity in the working area does not exceed the maximum permissible. Nafisi Poor & Mohammadi Zive, (2021), developed the taxonomy of heating systems. Heating systems may be classified into the following categories based on how they generate heat:

1) The use of renewable sources of energy (geothermal or solar energy),

2) the heating systems in place (the heat is supplied from the city heating networks), Electrical sources for the heating system are number three.

4) The fuel systems for gas, solid, and liquid fuels.

According to Salimi & Hammad (2020), heating systems may also be categorised according to the sort of people they serve:

1) Local (direct) heating systems are used when all the major components of the system (boiler, radiators) are present.

pipes, heating equipment) are intended for a single individual.

2) Heat is transferred when central (indirect) heating systems are isolated from the rest of the system. Created in a boiler and then distributed to some different consumers.

2.9.3 Local Heating Systems

The local heating systems release heat in heated spaces only. The released heat is carried straightly into the room without any distribution system. In addition, the local heating systems are mainly suitable for small and occasionally used areas. Papadopoulos et al., (2015) added that the advantage of local heating systems includes quick installation without extra distribution systems, low cost as well as flexible operation. The study further identified that the basic disadvantage of local heating systems is the uneven distribution of temperature. Studies have therefore identified the different types of local heating systems which are elaborated below.

2.9.3.1 Fireplaces

Fireplaces are local space heating devices that descend from open pit fires, which served as their predecessors. The presence of fireplaces may be found in buildings all around the globe, although they are more common in areas with mild or moderate winters. Since ancient times, it has been known that people have used fireplaces in the form of circular pit center chamber fires. The earliest surviving examples of such circular pit fires, which were strategically situated in the middle of the most crucial chamber, may be seen in the palace of the ancient Greek city of Mycenae. In the center of the room, below an aperture in the inclined ceiling that looks up at the sky, is a central fireplace that serves as the family altar (Abdulkadir, & Ibrahim, 2020). It is considerably later, around the beginning of the 9th century, that fireplaces are first seen in their usual appearance, with improvements continuing up to and through the 12th century. When the chimney was initially established in the 13th century, its usage expanded quickly across Europe. Conventional fireplaces may seem warm and inviting, but they are often inefficient since they heat rooms primarily by radiant heat escaping from the front aperture towards the inside (Fay, 2017).

In addition, open fireplaces are mainly home heating units with less efficiency rate of about 10-20% (Obyn et al., 2014). However, to increase this efficiency rate, extensive modifications are often carried out in the design of open fireplaces to reduce the amount of heat lost through the chimney. In the actual operation, one of the reasons behind the less efficiency of open fireplace heat is that it is a radiant heat with about 80-90% of the heat being released up the chimney and discharged outwardly (Papadopoulos et al., 2015).

The following are some fundamental guidelines for the safe functioning of an open fireplace:

A minimum of 1/10 of the area of the base surface of the fireplace must be present in the cross-sectional area of the chimney.

For the fireplace to function properly, the surface area of the base where the fire sits, stated in m2, must be equivalent to 2-4 per cent of the number of m3 representing the volume of the room to be heated.

When a fireplace's back wall surface is reached, it must be slanted upwards and forward, generating a Venturi's neck, while the rear wall behind the fireplace's back wall must continue its upward journey until it meets the far down end of the chimney's back wall behind the Venturi's neck. Consequently, the V-shaped area generated behind the Venturi's neck will deflect upwards the flow of cooled smoke that had previously trailed down the chimney's back wall surface to the top of the chimney. The effect of this will result in an amalgamation of the diverted cooled smoke rising with the rapidly rising hot flue gases that have gone through the Venturi and are now ascending via the chimney (Hay et al., 2017).

2.9.3.2 Local Space Heaters

The EU (2015) defined a local space heater as a device for space heating which emits heat through direct heat transfer with a view to reaching and maintaining a specific stage of human thermal comfort in a closed space with one or more heat generators which convert electricity, gaseous and liquid fuels into heat via the use of fuel combustion. Moreover, the EU (2015) grouped local space heaters basically into two which are luminous local space heaters and tube local space heaters. The luminous local space heater referred to a local space heater which makes use of a gaseous or liquid fuel burner and is installed above head level (Hinchliffe et al., 2017). It is operated in such a way that the burner heat emission warms the heated subjects. Just like the luminous local space heater, the tube space heater is also a local space heater which uses gaseous or liquid fuel in a burner and is installed above the head level. However, what makes it different from the luminous local space heater is that it is located near the subjects to be heated and it primarily heats the space by infrared radiation from the tube heated by-product internal passage combustion.

Stoves are confined devices used for local space heating and cooking, and they may be powered by almost any fossil fuel. The cylindrical metal pots utilized in ancient Egypt and Greece are the world's earliest known stoves (Latham et al., 2016). During these early days, the created smoke was first allowed to enter the room, and then it was either assisted to naturally depart via room openings or steered outside through a hole in the ceiling. According to historical records, iron stoves have existed since the 15th century, with the first cast iron stove being constructed in the 17th century. Benjamin Franklin modified the iron stove by adding sliding doors, which better regulated the passage of air into the combustion chamber (Kummert & Kummert, 2016). Compared to older models, modern iron and cast-iron wood and coal-burning stoves have improved thermal efficiency that can reach up to 65-75 per cent (for wood stoves with catalyst), flue gas temperatures that range from 250oC to 300oC, body surface temperatures that range from 200oC to 250oC, and heat emission abilities that range from 2-6 kW m-2 of body surface area. Many types of stoves are available today, each burning a different kind of fuel (Seyler, 2019). Local heaters made of oil, gas, kerosene, and electricity are produced to meet the highest safety requirements available today. Additionally, although electric heat pumps are more energy-efficient than primary electric heaters, hundreds of thousands of end-users in developed and developing nations have opted for electric heat pumps as their primary source of year-round air conditioning. As a result of this abrupt spike in energy consumption, the stress on power providers has significantly increased, and they seem to be unable to meet peak load demand at both the national and local levels.

2.9.4 Central Heating Systems

A central heating system distributes heat throughout the whole interior of a structure (or section of a building), from a single location to several rooms, all at the same time. Basically, there are two major types of central heating systems which are the forced air otherwise known as the dry systems as well as hydroponic which is also known as the wet systems. Furthermore, the installation of a central heating system comprises three different parts which are, a unit section where heat is made, a distribution unit which distributes the heat produced and a control system which regulates the different device operations. The most used central heating systems in Greek residential buildings are the hydroponic systems. The hydroponic systems comprise several interconnected devices namely a boiler, a burner, a circulation water pump, a fuel tank (for oil), piping, radiators, various safety devices and control equipment.

The heating, ventilation, and air conditioning (HVAC) system may comprise some systems that work together to manage the temperature of a structure (Salimi & Hammad, 2020). When air or water is heated at a central location and distributed throughout the inside of the structure via vents, pipes, and radiators, it is known as central heating. It may give warmth in many rooms or areas of a building. Boilers for oil, gas, biomass, and solar heating systems are all examples of central heat sources. A central heating system can take on a variety of configurations depending on the size of the building and the available energy sources (Plytaria et al., 2018). The heating system is designed as a continuous circuit that circulates steam from the boiler through each radiator in turn before returning to the boiler to take up additional heat. The water is permanently sealed within the system (unless emptied for maintenance), and the same water flows around your house daily, regardless of the weather.

1. Natural gas is delivered to the house via a pipeline on the street.

2. All heat used to warm the house is held in the gas itself, in chemical form.

A boiler uses gas to generate hot jets of water that play on a copper pipe filled with water. When passing through the gas jets, the copper pipe repeatedly bends, allowing it to absorb a significant amount of heat (in other words, the pipe works as a heat exchanger). The heat emitted by the gas is transmitted to the water via conduction.

3. The hot water is pushed through the system using an electric pump.

4. The water circulates within each radiator in a closed loop, entering on one side and exiting on the other. Because each radiator emits heat, the water is colder as it exits a radiator than when it enters. Water has cooled substantially after passing through all the radiators and must be returned to the boiler to take up further heat. As can see, the water is simply a heat-transfer medium that absorbs heat from the gas in the boiler and distributes part of it to each radiator in turn.

5. The pump is strong enough to send the water up to the second floor and via the radiators on the second floor.

6. A thermostat installed in one room monitors the temperature and turns off the boiler when the room is sufficiently warm, then turns the boiler back on when the room becomes too cold.

7. Waste gases from the boiler exit via a tiny chimney known as a flue dissipate in the surrounding atmosphere (Thomsen et al., 2015).

2.9.5 Heat Load

Heat load (also known as heat loss or heat gain) is the phrase used to describe the amount of heating (heat loss) or cooling (heat gain) required to maintain target temperature and humidity in a controlled environment (e.g., in a structure) (K. Dixit et al., 2014). The heat that a structure absorbs from warm air or sunshine and the heat it loses to cold air or radiation depends on how effectively a building is insulated and sealed (Heinicke et al., 2018). Engineers use heat load calculations to calculate the amount of cooling or heating required in each area.

Furthermore, studies by Chairani et al., (2017) identified that the heat load can be divided into two namely the internal and external heating load. The study further explained that the internal heat load is the heat that emanated from the electric appliances in the room while the external heat load is the heat that occurred because of conduction, radiation and convection. The external heat load includes solar radiation which passed through the glass, wall solar radiation and roof with irregularities through door and window glasses convection and heat conduction which are due to the opening of door and the window gaps. Internal heat load on the other hand includes heat from the occupants, heat from lighting and electrical appliances. Although the internal and external building heating load is influenced by a few occupancies, it is also affected by factors such as the external and internal building environment.

2.9.6 Heating Loss Factors Affecting Comfort in Winter

Heat loss occurs primarily because of temperature differences between its interior and outside during winter. Heat loss is rapid when the difference between the two temperatures is significant enough. Because most buildings are maintained at a constant interior temperature by their inhabitants, more heat loss occurs when the outside temperature is lower.

2. During the winter, the second most significant cause of heat loss is the wind. Winds may gust strongly during the coldest nights, and when they do, heat loss may be increased due to the air scraping the outside of the space covering. Winds may also push their way into a

structure via gaps, allowing infiltration and draughts to enter the building. In fact, up to one-third of the yearly heating energy is used to heat this flowing infiltration air, which circulates many times throughout the day each winter day (Lamb & Kwok, 2016).

3. The degree of humidity in a building may also impact the level of comfort. In most individuals, deficient humidity levels (less than 20% relative humidity) cause itchy throats and dry noses.

4. Radiation sources may also impact the level of comfort. In the winter, the light streaming through a window will make a room quite cozy; in the summer, the same sun might make the space unbearably hot. Radiation is also emitted and absorbed by walls and windows. A Trobe wall that has been heated by the sun can keep a room feeling warm even if the air temperature is less than 60 degrees Fahrenheit. An immense expanse of cold glass windows may also contribute to the feeling of being chilly in space (Plytaria et al., 2018).

2.10 Identified Gaps in Literature

The results of previous research have revealed a variety of obstacles, ranging from the physical, technological, and environmental aspects that influence or restrict the accomplishment of optimal lighting performance to the effect on buildings and their occupants and the client or organization.

However, building lighting systems, in general, suffer from performance deficiencies. To maintain the performance of these lighting systems, some decisions must be made regarding the use of design solutions, the provision of information, the establishment of quality standards, the maintenance of the facilities, and the day-to-day operations of the facilities. Furthermore, throughout these transformations, other functional areas are frequently overlooked due to other causes such as a lack of funds, a lack of priorities, a lack of workforce, and a lack of resources. As a result, it is possible that the major stakeholders, namely the maintenance teams (facilities management), the users/occupiers, and the organization, would suffer socio-economic consequences (Building owners).

In addition, there are existing problems in building heating systems as well. These existing unexplored problems include reduction in the interior air temperature as well as ventilation tightness of each building element. The reduction in air temperature only arises because of water circulation violations. Disorderliness in building water circulation is a result of heating system obstruction. Mershchiyev et al., (2013) and Mershchiyev et al., (2019) also explained that impediment in the heating system is because of careless installation which results in leaving dirt in the heating system. The studies further identified that blockage of the heating system with dirt could also be a result of damage to the sediment box and dislocation of corrosion pipelines at the internal surface.

However, studies have therefore failed to explore the effects of the on-university buildings and how these have affected university building performance, hence the need for this study. If the influence is not adequately handled, it might have a detrimental impact on them either directly or indirectly, allowing them to use the limited resources at their disposal better to address the problems that have a greater impact on them. Significant studies/research have not been conducted on the social and economic effects of building lighting systems on the buildings and the influence on the primary stakeholders indicated above.

2.11.Summary and Links

This chapter provides an overview of the built environment and sustainability. It emphasizes the importance of sustainable building practices and building performance evaluation. Buildings consume a significant amount of energy and resources, making it crucial to adopt environmentally friendly practices. The link between sustainability and facilities management is highlighted as a critical aspect of achieving positive outcomes. The chapter also discusses the impact of building performance on user satisfaction and outlines the use of key performance indicators to monitor and improve building efficiency. The goal is to create energy-efficient buildings that promote user satisfaction and align with sustainable development objectives.

CHAPTER 3: METHODOLOGY

3.1. Introduction

In the preceding chapter (Chapter 2), the literature relevant to the research study is reviewed, and it is explained how the research synthesises with other works comparable in the research field of study by finding and validating the gap in the research study that must be filled. This chapter will explain the research approach used for this study. In the beginning, the theoretical framework of the philosophies that underpin the techniques is discussed, followed by a discussion of the philosophical thinking that led to the selection of a specific methodology. It will justify the study research design, describing the reasons for the decision. Additionally, there will be a discussion of the methodological model, instrument measures and scales, data collecting, pilot data, and data analysis techniques, among other things. However, it is critical to comprehend the significance of research techniques in general. An approach to research methodology is described as a systematic technique aimed at answering research questions and channelled toward attaining the goal(s) of a particular study ((Creswell & Poth, 2018).

3.2. Methodological Framework

There are many various approaches to doing research, and it is important to investigate the underlying assumptions that underpin the researchers' selection. These assumptions direct the researcher on the road to take and the assumptions to make to get better knowledge. According to Lyon et al., (2015), philosophical beliefs or concepts differ from one layer to another based on the strategy, techniques, and choices appropriate for the study carried out. A methodology is a set of instruments used in research to support concepts and theories that might be useful to produce a standard output in the study domain and are considered desirable (Torreano & O'Kelly, 2021). Scholars like Amaratunga et al., (2015), the methodology may be regarded as a platform on which these approaches formed the part of the researcher's process in doing the study. As a result of the contributions of these scholars in explaining the relevance of methodology to research, it is necessary to confirm that there is a need to comprehend research techniques and methodologies that guide the process in academics. As a result of this advice, the model, which is a framework depicting interaction with components and designs of the research study, is developed.

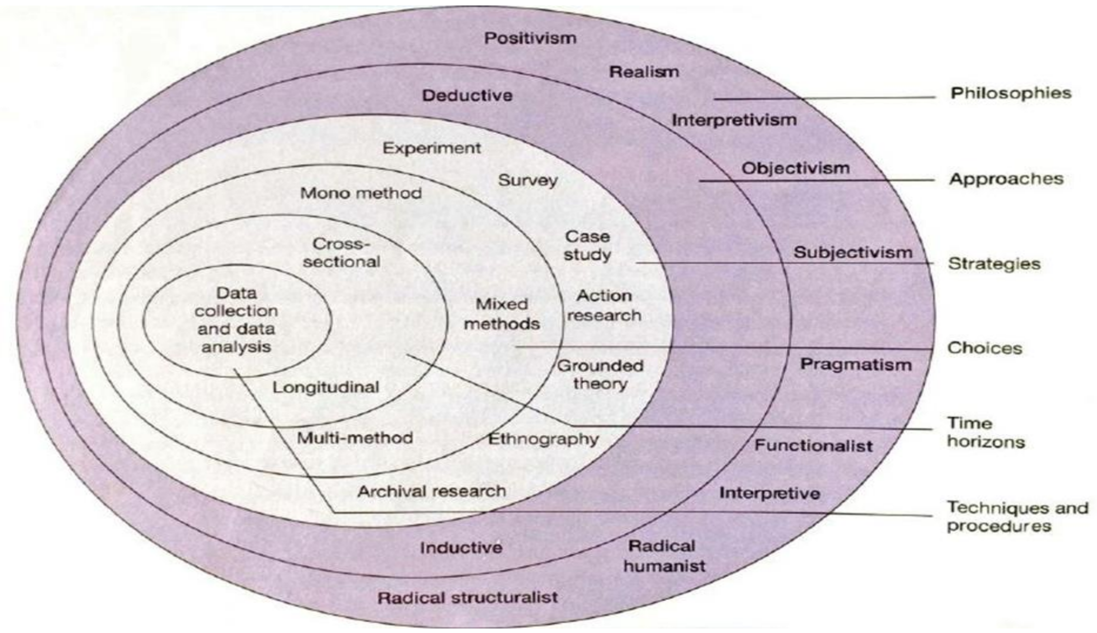


Figure 3.1 The Research Onion Model, Source from Saunders et al. (2012).

With this framework, it is vital to emphasise that to prepare for a research study appropriately, and researchers must comprehend the philosophical world-view assumptions that impact and support various investigations. These concepts impact research practice, and the classification are Postpositive, Social Construction, Advocacy/Participatory, and Pragmatic by (Creswell 2018).

For this research and philosophical considerations, the pragmatic method is considered. The pragmatic method is unwavering in its commitment to any philosophy or reality system.

It contains all possible solutions to a research topic. This theory applies to mixed methods research in which quantitative and qualitative assumptions are made (Creswell 2018). In a nutshell, it is problem-centred, pluralistic, grounded in real-world experience, and concerned with the repercussions of actions. It provides researchers with freedom of choice in methodologies, strategies, and processes consistent with the study purpose and goals. Additionally, it enables researchers to choose what and how to investigate depending on the expected effects, which may justify mixed methods research (qualitative and quantitative data). The pragmatist assumption is appropriate for this study since it enables the researcher to do a mixed-method analysis comparing the real-world practice to theory.

Other perspectives, such as post-positivism, are more suited to quantitative research than qualitative research. "It is a post-positivist mode of thought that challenges the conventional concept of absolute truth in knowing" (Siegel, 2012). On the other hand, the assumption tends to condense the concepts into tiny, distinct groups of ideas to test, such as the variables that compose the hypotheses and research questions. Several fundamental assumptions behind this perspective include speculation and anti-foundational knowledge, implying that absolute truth will sometimes not be discovered. That is, research begins with the validation of a research study area. Knowledge is shaped by data, facts, and practical reasoning.

Additionally, it transcends the social constructivism method, which is well-suited for purely qualitative research since it depicts people generating subjective meanings for their experiences based on their unique viewpoints on a specific item or thing. It is widely used in qualitative research to elicit as much information as possible about the participants' perceptions of the situation under study (Fetters et al., 2013). It is concerned with comprehension, theory development, and social and historical formation. However, prior to Fetters et al., (2013), Klykken, (2021), noted many assumptions, including that participants, mainly qualitative researchers who often utilise open-ended inquiries, can express their perspectives. Researchers' interpretations of their results are often influenced by their personal experiences and background. Finally, the study is inductive, with the inquirer deriving meaning from field data.

Advocacy/participatory approaches are inappropriate for this research since they imply participation with politics and political agendas. This agenda gives people a voice, enhancing their awareness and pursuing a change agenda to better their lives. It enables a unified voice for reform and change by including participants in all phases of study design, data collection, and analysis (Mertens, 2014). In summary, the premise is collaborative, empowerment-oriented, change-oriented, and discourages underprivileged or disenfranchised groups and people in our society.

3.3. Research Philosophies and Research Paradigms

A systematic assumption, surrounded by the belief of the researcher position on reality, is defined by Saunders & Tosey, (2016) as research philosophy. Together with the researcher's stance on reality, this assumption impacts how knowledge is obtained and sustained. Figure 1 shows the first layer of research onion, a philosophical approach to study. Considering these philosophical viewpoints is a valuable tool for the researcher since it serves as a guide for approaching research issues and conducting research throughout its design and implementation phases. According to Fetterman (2019), philosophical viewpoints or paradigms assist the researcher in comprehending challenges and determining how to deal with these issues effectively. According to Saunders et al., (2019), how researchers perceive the world influences their choice of study technique and strategy, in line with the paradigm shift. Assumptions are made while researching to help in the development of an answer. As Coates et al., (2016), point out, these assumptions also result in a variety of distinct perspectives on the nature and reality of the world (ontology) and approach to investigating the nature of reality (ontology) (epistemology). The next part will examine these assumptions in further detail and indicate which ones are most appropriate for the study field under consideration.

3.3.1 Ontology

Ontology is the nature of reality in a field of social beings, and it is defined as follows: This category of social entities may be divided into two categories: objectivism, which holds that social entities exist as objective realities that are unaffected by human action, and subjectivism, which holds that social actors are constantly altering social phenomena and their meanings. Subjectivism asserts that social phenomena are generated by the opinions and acts of social actors and that this is true (Coates et al., 2016). While the objectivity viewpoint holds that reality is entirely independent of human perspectives, it also believes that only one truth can be discovered via the appropriate study application. Objectivism necessitates taking an objective and pragmatic stance toward facts, which are often quantitative. This ontological perspective supports many quantitative research studies nowadays (Saunders et al., 2016). To provide a better understanding of the various situations. Investigating the concepts of positivism and interpretivism is essential. The positivist position holds researcher is autonomous or apart from the research and that the study indicates what exists in the universe. Positivism is a fact-seeking paradigm, and the goal of social research conducted following this paradigm is to establish abstract and universal theories about how the world works by testing hypotheses about how the world works (Creswell et al.,2017; Coates et al., 2016).

On the other hand, Interpretivism tries to explain, and knowledge of social realities produced via the interpretation of qualitative data (Coates et al., 2016; Starkings, 2012). The interpretive recognises that the researcher's interpretation of the world around them will inevitably play a part in constructing new knowledge through research. The researcher's assumptions or points of view, on the other hand, are based on what he or she has seen in various locations throughout the globe. This might take on either a subjective or an objective form. However, it must be fair regarding the reader's knowledge (Saunders et al., 2016). In contrast, it concludes the extremes of "constructive" epistemology, which believes that researchers should seek knowledge with the assistance of humans based on their social status. The "realist" epistemology believes that research should be conducted following specific rules through an observable reality; it is important to consider the following: The epistemological assumption will be discussed in detail in the next section in connection to the research investigation.

3.3.2 Epistemology

In any area of study or subject, epistemology is typically concerned with interpreting what is considered valid and legitimate 'knowledge' (Saunders et al., 2016). In other words, the essential question is how the researcher chooses which information to put his or her faith too. A natural science epistemology is predicated on the assumption of a direct link between the universe and what we perceive the world to be. When doing research, it is common to use a deductive method, in which the goal is to test hypotheses. On the other hand, social science epistemology is often predicated on the assumption that knowledge is subjective. Because the world is perceived in connection to specific social and cultural settings, it argues that study findings may disclose more than one 'truth' (Starkings, 2012). Accordingly, researchers held various perspectives on the unique research and how such a field of study portrays such information as either subjective or objective, depending on their perspectives. Using solutions that the University's estate team may adapt to their needs, this project hopes to build a framework for improving the lighting performance at the University of Huddersfield. As a result, this study is guided by a philosophical perspective that analyses subjective truth, which indicates that reality is a socially produced construct. In contrast, researchers who study subjective reality are regarded as practising social constructionism, which implies that their opinions on what constitutes reality in any form are socially constructed. However, this can be promoted with people who hold the same ideology in various ways depending on their beliefs. The pragmatic strategy is used in this research to support this investigation. Axiology is another philosophical assumption field that considers the inherent worth of a scientific research system. The axiology will be described in further detail in the next section.

3.3.3 Axiology

According to Saunders et al., (2019), axiology tackles issues such as "What is the role of values and ethics in research?" and "What is the role of values and ethics in science?" When doing the study, it is necessary to consider this. The study should attempt to be ethically neutral, or the researcher should ensure that the research field gains value due to the research. A further question is how the researcher should deal with the values of the research participants. It also examines one of the vital axiological choices that the researcher must make, which is to what extent the research view positively impacts the values and beliefs of the research participants. Unlike most quantitative research, which is value-free and unbiased by nature, most qualitative research is value-laden and prejudiced. In contrast to most quantitative research, most qualitative research is value-laden and biased by nature ((Bernard & Bell, 2015). Finally, ontology is defined as the picture of social reality upon which theory is built, and epistemology is defined as the theory of knowledge upon which theory is built. The ontological, epistemological, and axiological assumptions made in a research study are substantially interconnected and are referred to as the features of the research philosophy in this context. According to Creswell & Poth, (2018), the interaction between the features mentioned above is such that ontological foundations are typically regulated and thus permit judgments to be made on the epistemological and axiological foundations of research to be taken into consideration. See the diagram below for a graphical representation of the philosophical assumptions as a multidimensional collection of continuous variables.

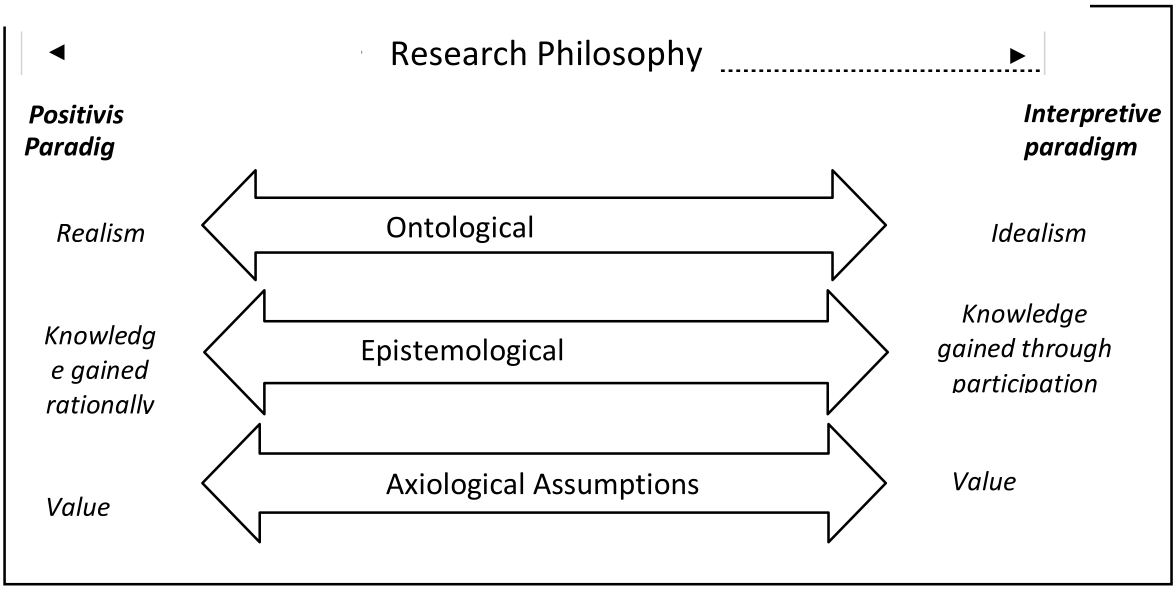


Figure 3.2: Philosophical assumptions as a multidimensional set of continua

Source from Saunders et al. (2019)

The ontological viewpoint taken in this study is that reality does indeed exist. According to the assumptions made in this reality, the reality is anchored by the beliefs and attitudes of people in connection to global concerns and sustainability, which makes this reality subjective. The research design at the University of Huddersfield considered this subjective viewpoint by picking the buildings more suited for the study topic than the others. The nature of the study area will be better understood thanks to the construction of these facilities. This influenced the selection of the methodologies that were used in this investigation.

The research considers that the most appropriate technique to get answers to the research questions asked in this study is via the experts' knowledge of the professionals, which is the rationale or justification for adopting epistemological philosophy (Facilities managers, technicians, builders).

Specifically, the case study area will provide more in-depth research of the functional and environmental aspects of the building lighting systems maintenance and their influence on the building's performance. The information gathered from the case study will be compared with the support provided by using other assumptions, which will be placed side by side. In support of this claim, Saunders and Tosey (2016) point out that an ontological assumption is concerned with the nature of reality and how a researcher perceives reality instead of philosophical assumptions. The position of this study will adopt a pragmatic approach to investigate both the quantitative and qualitative aspects of the research to reach the research's goal and goals. In this perspective, we believe that the epistemological philosophy permits the study to adopt a more appropriate approach to gaining replies to the questions formulated by users of buildings and experts in the built environment.

3.4 Research Approach

Qualitative data collection in assessment is relatively uncommon; yet there is a lack of widespread knowledge of practical and dependable techniques for assessing qualitative data. Several articles and other works of literature are available in support of the fundamental assumptions and techniques associated with assessing qualitative data, including evaluation data. These assumptions are related to specific techniques or traditions, such as grounded theory phenomenology, discourse analysis, and narrative analysis, among others. Inductive and deductive analysis are the two most common methodologies (Fletcher, 2017).

A systematic methodology for assessing qualitative data, inductive analysis, specified assessment goals lead the analysis. Inductive analysis refers to procedures based mainly on a thorough examination of raw data to extract ideas, themes, or a model from the data via clarifications made by the researcher from the source data. It starts with a specific topic of investigation and then lets the hypothesis emerge from the evidence. A typical description of induction involves going from the precise to the broad (Klykken, 2021). One of the critical goals of the inductive technique is to allow research conclusions to emerge from primary data based on the frequent, dominating, or essential themes that emerge, rather than being constrained by the constraints imposed by organized approaches.

On the other hand, deductive analysis is a kind of data analysis that seeks to determine whether the data is consistent with previous assumptions, theories, or hypotheses that have been discovered or produced by a researcher. In deductive analyses, where data acquired is used in an experimental and hypothesis testing study, essential themes are often buried, re-framed, or left unseen due to assumptions imposed by investigators in the data collection and data processing techniques. Beginning with the broad and progressing to the deduction is a process (Saunders et al., 2016).

This research used an inductive method to evaluate the effects of building lighting and heating systems on the performance of the building and the well-being of its residents. The researcher investigated the relationship between the productivity of building inhabitants and the facility's lighting and ventilation systems. Additionally, the degree of risk associated with the lighting performance problems was determined in this research based on their relative levels of influence on the performance objectives and the frequency with which they occur. The use of creative approaches, methods, or techniques to solve the issues and risks related to the structure and performance of lighting in the educational environment. The present socio-economic, technological, and environmental issues encountered by building owners, facilities managers and users concerning their buildings' lighting and heating systems are also discussed. All these investigations were carried out to reach a result that would enhance the lighting and heating systems placed in private and public buildings and determine whether there are disparities in overall productivity.

3.5 Methodological Choice

To expand on the ideas described before, it is critical to select certain research decisions that will aid/assist in obtaining the intended outcome of the study. According to Saunders et al., (2019), three types of study are available: mono-method, multiple-method, and mixed-method. However, Saunders and Tosey (2016) note that the researcher might choose to employ a single data gathering methodology and analysis process or procedure or a combination of data collection methods and analysis procedures to answer a research question in each specific study(s). This procedure will bolster the research's objective approach, which will be accomplished via a mixed technique. This will enable data collecting from interviewers who will be viewed as witnesses to an independent reality. This research objective is accomplished via the use of semi-structured research questionnaires. This allows for a more systematic and uniform survey method with each participant. According to Saunders et al., (2019), this strategy will enable the study to compare respondents' replies to each topic to ascertain the reality underpinning the research's objectives. The study will expand on this assertion by elucidating the primary and secondary data used in the investigation.

3.5.1 Primary Data

Primary data gathering necessitates the use of questionnaires, with both open-ended and closed questions being used. Among the topics covered by the surveys were problems relating to the users' experience and other associated issues, difficulties in maintaining services such as the lighting system, implications for cost and social well-being of users and occupiers, and maintenance challenges in general. A recent study (Yin, 2018) found that this allows the respondents to represent various perspectives adequately. These perspectives may be found in alternative cultural viewpoints, theories, variations among stakeholders or decision makers involved in the case study, or similar contrasts.

3.5.2 Secondary Data

The secondary data includes essential information to the study conducted by other researchers. This data collection aspect requires reviewing the literature in all fields, including articles, books, reports, theses, conference papers, and journals (Creswell & Poth, 2018). Research-area-related journals such as Scopus, online libraries to enable more robust methods of obtaining the much-desired synthetic review and works of literature that might assist shape the flow are all recommended. Considering this, both a qualitative and quantitative methodology was used in this research project. The qualitative method considers the process of observation of the case study concerning the participants' demography, culture, and background. While the quantitative method will be used to analyse and compare research, and the results will be provided in the form of statistics, line charts will illustrate the replies gathered from respondents and case studies will be used.

A random sampling technique is used to distribute the questionnaire to respondents, which is only given to the occupants of the building, based on the selected building samples. The characteristics of the population, closed format questions are used in conjunction with highly structured methods such as questionnaires, surveys, and structured observation to answer questions like how much, how often, how many, and to what extent they believe lighting systems affect building performance.

3.5.3 Scope and Sampling of Study

The sample size focused on the building's owner-occupiers/users, who constituted a significant proportion of the respondents from the case study, allowing for a significant representation of the research data on the one hand, and a sample size small enough to allow for an in-depth analysis of the research data on the other (Creswell & Poth, 2018). It is responsible for the day-to-day administration of the university's physical –plant facilities, comprised of one or more buildings. A range of job titles will be available to management professionals working in the higher education business, including the director of facilities, the director of administrative services, the facilities manager of a particular region or building, and the building supervisor.

However, because the study was carried out at a period when Covid-19 was at rampage, the respondents could not be reached within the university vicinity and data were collected from the respondents while they were at home. To further establish the study findings, the study obtained new data from the students who engaged in the use of workstation after the pandemic was over and the campus was open. This will establish the effect of lighting and heating systems on building performance from students' real experience and their perspective. The study therefore includes a new survey 120 students in the faculty of Art Design and Architecture who came to use the buildings.

3.5.4 The University Overview and Building Samples

According to the University of Huddersfield (2021). The University was established in 1825 as the Huddersfield Scientific and Mechanical Institute, a school with a long history of vocational teaching. It is housed on a single campus in the north of England, just outside the city. Queensgate's main campus is located southeast of Huddersfield's town centre. Huddersfield is a historic market town in West Yorkshire, located 310 kilometres north of London and 16.6 kilometres south of the closest metropolis, Bradford.

Due to the increasing demand for student enrolment and academic quality, the university continually invests in new creative buildings that include dramatic architecture, dynamic form, and critical environmental characteristics, resulting in world-class facilities for students and faculty. Several of these facilities and structures are employed as samples to collect data necessary to accomplish the study goal and objectives.

The University of Huddersfield's contribution to the environment and sustainability agenda cannot be overstated through a variety of initiatives, including investments in new buildings that meet the sustainability standard. The purchase of low-energy computers and equipment and good energy and water management practises, where the university has consistently ranked in the top ten of all United Kingdom universities in terms of carbon emissions. This environment qualifies the structures for the investigation. The buildings to be used will be chosen for their unique qualities to provide a representative sample of responders (University of Huddersfield, 2021).

As a result, this research employs a case study approach. Firstly, the study establishes the university buildings as case studies. Second, the research employs two University buildings as an embedded case study. The Oastler and Percy Shaw buildings are inclusive in this group. This option was made due to the physical peculiarities of the buildings, which vary in terms of the forms and sizes of the rooms and offices. These buildings enable a more accurate description and interpretation of the phenomena based on the data provided by respondents and participants. A more detailed description of the buildings chosen for the research will be conducted later in the thesis. See below Google earth area view of the University’s main campus at Queensgate, Huddersfield.

Figure 3.3 University of Huddersfield Area View, Source Google Earth 2021.

3.6 Research Strategies

A research strategy is essential to any examination of research phenomena because it assists the researcher in making decisions about the organisation of data collecting and the location of respondents throughout the inquiry (Bernard & Bell, 2015). According to Saunders & Tosey (2016), a research strategy is a plan for the researcher to follow to obtain answers to the research interest by the researcher. To achieve the aims and objectives, researchers use eight commonly used research techniques listed below. Experiment, survey, grounded theory, ethnography, narrative inquiry, archival research, action research, and case study are some of the available methodologies (Creswell & Poth, 2018). These tactics are shown in the fourth layer of the research onion model, a diagram of research onion. According to Saunders & Tosey (2016), the following techniques are briefly discussed.

First and foremost, the experiment technique assists in identifying whether a given choice or activity impacts a result. When a variable is independent and may lead to future outcomes that can be dependent variables, the experiment lives on change. This experiment is achieved by the testing of probabilities in an independent variable. However, the experiment technique does not support qualitative philosophies that rely on subjective realities, but it is effective in research using the quantitative method. As a second point, the survey strategy supports a quantitative approach via description of attitudes; it thrives on the opinion and trend of respondents in a population as investigated in a sample of a population of that population. More specifically, the survey technique employs a deductive approach; this technique often takes account of queries, for example, "what," "who," "where," "how many," and "how much." The survey technique, as a result, considers both longitudinal and cross-sectional data collection, with the use of questionnaires or structured interviews for data collection and generalisation. A third advantage of using an empirical technique is that it enables the researcher to arrive at a generalised theory of an abstract process based on respondent opinions, which may be anchors in a grounded encounter or an action. The ground theory also considers collecting data across some stages or phases and continuously comparing the data created for theory creation and improvement. Fourth, the ethnography approach mainly entails gathering observational and interview data from a research study of an intact cultural group in a natural setting for an extended time, as opposed to other data collection methods. A common technique in quantitative methods, this strategy includes evaluating real-life situations or encounters, and it is most often utilised in quantitative methods. A further advantage of this is that the researcher may become an essential part of the study, which entails a close situation over a lengthy time. In the fifth step, the researcher studies live of individuals based on the research area provides tales about their lives to the participants. This technique makes it possible for the participants in the research study area to tell their memories more chronologically since the process becomes inclusive.

Furthermore, the archival research approach concentrates its investigations on records and papers that pertain to administration; the archival research approach is explicating and characterised via the application of analysis. This technique is subject to utilising current and historical documents as a foundation for analysis, if there is no conflict of interest between the archived document and any other secondary data sources. On the seventh point, the action research approach considers a method of learning that involves acting, planning action, evaluating action, and identifying problems. It is a process that includes doing the action, planning action, evaluating action, and identifying issues. Through this tactic, participants may be encouraged to participate in developing solutions to real-world organisational challenges. In contrast to theoretical-based research, this is a practice-based research project. As a result, action research, experimentation, storytelling, and all other research methodologies defined and addressed above are inappropriate for this research topic.

Because it is an inquiry into a current issue in more detail and within its real-world context, the eighth technique, the case study, is a more appropriate method for this research study than the other seven strategies. The technique uses a significant number of sources of evidence, which is advantageous to the earlier formulation of theoretical hypotheses, which serve as a guide for data gathering and analysis. As a result, the case study technique will assist this research study is investigating the building's lighting and heating systems and their influence on the residents and their ability to be productive at work. According to Yin (2018), the case study approach considers the utilisation of a framework, particularly if the available relevant literature does not give a theoretical statement, in which case an exploratory case study must direct the research study. The knowledge of the tenants' experience in the usage of the building's lighting and heating system performance, together with the research's goal and goals, makes the case study technique and phenomenology more suited for the research study objectives. As a result, alternative research methodologies are deemed less relevant for this research topic. Furthermore, the discussion will provide further information on the sections of the case study design and the unit of analysis for the research that will be covered. All of them are discussed in further detail below.

3.6.1 Case Study Design

According to Yin (2018), a case study is an in-depth examination of a subject or event in its natural surroundings. Additionally, Yin (2018) adds that empirical investigations delve deeply into a current phenomenon inside its real-world setting. Considering the theoretical approach or idea to building performance as mentioned in the studies or theories, it is critical to compare and verify the different concepts or models as stated in the studies or theories via a case study.

Research questions need answers, and the answers are addressed in the study by addressing the how and why. For instance, who is liable for the building's lighting system replacement? Where did the lighting components come from? Why is this sort of illumination utilised in this space? These factors contribute to the research design used in this study, which considers the study propositions, unit(s) of analysis, the logic connecting the data to the propositions, and the criteria for interpreting the results (Yin 2018).

Case study design strategies may be categorised as single or many case studies, holistic or embedded case studies. (Yin, 2009). The following figure 3 demonstrates the various sorts of case studies as defined by (Yin, 2009).

Table 3.1: Types of Case Study Designs (Yin, 2009)

	Single Cases	Multiple Cases
Single, Unit of Analysis	Single, Holistic Case-Study	Multiple, Holistic Case-Studies
Multiple Unit of Analysis	Single Embedded Case-Study	Multiple Embedded Case – Studies

3.6.2 Single VS Multiple Case Study Design

Where evaluating a well-formulated theory, the depiction of the crucial case may be justified via the use of a single case study technique, when the single case represents a unique or extreme example, or when the single case is illuminating (Yin, 2009). On the other hand, instance study research is not limited to investigating a particular case. Several disadvantages of a single-case method, particularly when examined from a theoretical viewpoint, have been recognised, including general theory limitations and biases inherent in information processing stages (Eisenhardt ,1989). Moreover, according to Bernard & Bell (2015), the quality of the well-formulated theory reasoning in which the case study researcher engages, along with additional concerns about how well data support the theoretical arguments are generated, determines whether the theoretical analysis is incisive. However, using multiple designs as an extension for the case study design has become more prevalent in research since many case studies are primarily adopted to compare the included examples.

The desire to use a mixed research technique to verify the evidence gathered from a building inspired the logical choice to employ a case study to analyse the persuasive argument for the acceptability of the outcome or feedback received from the building. This study will also enable the research to concentrate on the processes that shape reality and the social interactions between users and building owners and occupiers, referred to as ethnomethodology in this context. On the other hand, case studies will be conducted using a phenomenology method, which focuses on the actual world and abstract mental phenomena significantly influenced by psychology. Instead of relying on a single case study, several case studies aid the researcher in producing a convincing result (Yin, 2018). Several case studies have previously received criticisms as an effort by qualitative researchers to try statistical generalisation rather than analytical generalisation, and this has now been shown to be incorrect (John & Easton,1995). Yin (2019) responded to this critique with a better argument, claiming that several case studies can show a more substantial basis for structures based on theory than a single case study, which is supported by evidence. Bernard & Bell (2015) supported the multiple case study, who states that doing so would enable the researcher to compare the results derived from each of the instances under consideration. In turn, this will push the researcher to analyse what is unique to the study against what is typical among instances in the study, and it will often prompt theoretically thought on the results.

The researcher intends to use a multiple case study technique in this research study, which he or she intends to undertake. According to Bernard & Bell (2015), a single case study is designed to generate an intensive examination of a single case, concerning which they then engage in a theoretical analysis; however, the researcher is not aiming to test a single theory but is testing two different theories to develop and build a new theory. Following the identification of the research gap, there is a need to develop a model or framework that will help reduce the gap between predicted and actual lighting performance in buildings. Consequently, the researcher must first investigate the region and discover the procedure, obstacles, and issues associated with enhancing lighting performance over time.

Multiple case studies provide the researcher with a substantial case study that will be better than utilising a single-case design. More crucially, the analytic advantages from having two or more instances may be considerable and strengthen the validity of a theory (Yin 2018). Saunders and Tosey (2016) further argue that a single case refers to the investigation of a single event or phenomena (a single case), while numerous cases refer to the investigation of several instances (multiple cases). The motivation for selecting case studies is to provide more representation since no two structures are alike because buildings are complex. Important information from respondents will be compared to determine desired and high-quality outcomes. This rationale allows for correct representation without sacrificing the high quality of input that the researcher is considering. Consequently, due to the underpinning benefits that the researcher will obtain from using multiple case studies, it is only appropriate to use a dual case study strategy for this research project when the nature of the 'unit of analysis is also considered, as will be discussed in greater detail in the following section.

This university plays a vital role in the environment and the sustainability agenda through a variety of initiatives, including investments in new buildings that pass the sustainability test, the purchase of low-energy computers and equipment, and good energy and water management practices, where the university has consistently been ranked in the top ten of all United Kingdom universities in terms of carbon emissions since 2007. As a result, the structures are ideal for the research. The buildings that will be utilised will be chosen based on their unique qualities to ensure that all responders will get a fair representation.

As a result, the holistic and embedded case study approaches are used in this work. In the first instance, the study establishes the University buildings as a collection of numerous case studies. Second, the research uses two buildings within the University as case studies, with each structure serving as an embedded case study. The Oastler and Percy Shaw buildings are the two structures under question. Since the physical qualities of the buildings vary, the various forms and sizes of the rooms and offices, this option was chosen. Because of the information provided by the respondents, it was possible to create a more accurate depiction of the phenomena and understand it better.

3.6.3 Unit of Analysis

According to Pathak, (2016), the amount of data aggregation obtained during the following data analysis stage relates to the level of aggregation of the data collected. Yin (2018) distinguishes between two types of case studies: the comprehensive case study and the embedded case study, both viewed as units of analysis. An embedded case study can have numerous subunits of analysis inside a single case and consist of several holistic cases containing just one unit of analysis. The research study seeks to evaluate the performance of the lighting and heating systems in the buildings; a researcher does not seek to evaluate the performance of subunits in the same case. The only item that will be evaluated in both circumstances will be the performance of the lighting and heating systems in the respective buildings. This research study may be classified as a comprehensive case study research study due to this.

3.7 Time Horizon

In research, it is critical to consider time horizons. This information is essential for the study design intended to be used, which must be independent of the research technique that will be used. Longitudinal and cross-sectional time frames are the two kinds of time horizons. Studies repeated over a prolonged time are known as longitudinal studies (Saunders & Tosey, 2016). On the other hand, cross-sectional studies are limited to a single period. Therefore, this research was cross-sectional because of the limited time for completion.

3.8 Research Techniques and Procedures

According to the research methodology framework used in this study (see Section 3.2), "research procedures" are in the model's innermost ring and are impacted by the research philosophy and strategy chosen. In this context, the term "research techniques" refers to the methods used to gather and analyse data. The literature review and synthesis, interviews (both during the case study stage and the validation stage), observation (during the case study stage), and document review were all employed to gather data in this research (case study stage). Statistical analysis and presentation methods were used to analyse and show the data. According to Saunders & Tosey (2016), research procedures gather data to answer questions related to the research topic. According to Creswell & Poth (2018), data collecting may include conducting a reconnaissance survey at the study location and observing persons' behaviour without asking pre-planned questions. Additionally, Townsend et al., (2017) add that it may include conducting interviews with people.

As a result, semi-structured and structured questionnaires were used to gather data for this study. A prototype survey instrument was created to verify the dependability of the research study questions. The research questions were directed at the organization's core, which includes the functional units and directly impacts the workforce. It will also target building inhabitants and users.

These questions were sent and gathered using the Qualtrics web-based survey tool. Qualtrics is a major provider of web-based survey instruments that assists researchers in resolving survey instrument issues. This tool, along with others, provided and distributed the survey instruments required to gather data for this study.

3.9 Data Analysis

This section discusses the data gathering methods employed in this study. The literature review and synthesis methodology were utilised as a standard data gathering strategy in this study, where the collection and synthesis of secondary data were suitable. However, when investigating the primary data for the two instances, the researcher had to utilise unique data gathering approaches in each case while using similar data collection techniques due to the nature of the situations. Additionally, the literature review and synthesis were employed as a data collecting approach where secondary data collection and synthesis were acceptable. During the first phases of the study, the researchers focused on the general subjects of lighting and building performance and difficulties related to sustainable building design. The literature search and evaluation were narrowed as the study focused on topic areas within the existing scope of lighting performance and its influence on the building and its inhabitants. They began the literature search and evaluation of the topic mentioned above without a particular reference to the phases of lighting and heating performance maintenance and operation. These first surveys and syntheses of the literature offered context for the topic under investigation and aided in establishing research needs. After identifying the research gap, the researcher recognised the importance of assessing lighting and heating performance over time and reviewed the literature on the lighting and heating design process to utilise the idea as the foundation for the study. The researcher used the literature synthesis to develop critical elements for a sustainable building design process, then triangulated using primary data. Chapter two contains the study literature review.

The data analysis procedure was carried out following data collection, which included the accurate interpretation and representation of the raw data gathered from the case studies using a mixed-method approach and computer-assisted tools. Computer-aided procedures and pre-packaged software such as SPSS or Ethnography are all examples of computer-assisted qualitative data analysis software (Yin, 2018). This software has become broader and more valuable in recent years, encompassing both text-based and video-based data while also improving and becoming simpler to follow coding skills and procedures instructions.

The research study used statistical tools (univariate and bivariate) to analyse the structured questionnaires to examine the case study data comprehensively. This form of analysis is necessary because the researcher wants to use it to organise the data obtained according to the emerging findings from the case study to offer the structures necessary to answer the research questions.

3.10 Validity and Reliability

Validity refers to the degree to which an instrument accurately measures what it claims to measure (Zohrabi, 2013). It can be seen as the foundation for reliable and accurate evaluation. Additionally, it relates to the extent to which experience pieces of evidence and theoretical justifications support the appropriateness and relevance of instrument-based interpretations and actions. The following sections discuss the many forms of validity:

3.10.1 Construct Validity

Construct validity is how an idea, concept, or behaviour that is a construct is deciphered or transformed into operational and functional reality (Helmes, 2015). This construct validity happens specifically if the connection has its cause and effect; hence the construct validity justifies the existence of the relationship (Green et al., 2019).

3.10.2 Face Validity

An instrument seems to be a valid measure of its underlying construct on the surface. It demonstrates that the instrument evaluates the target construct under investigation. Lecturers often use face validity to assess the validity of research instruments created by their students (Royal, 2016).

3.10.3 Content Validity

Content validity is an assessment of how closely items on an instrument corresponding to the relevant content domain of the construct are being measured (Zohrabi, 2013). The term "content validity" refers to a qualitative sort of validity in which the model's domain is defined, and the analyst determines if the measurements accurately reflect the domain.

3.10.4 Convergent and Discriminant Validity

They are evaluated concurrently or jointly on a set of measures. Convergent validity refers to how closely a measure connects to the construct it attempts to assess or how closely the measure converges with the concept (Zohrabi, 2013). Discriminant validity is a term that relates to the extent to which a measure does not measure or discriminates against a construct that it is not intended to measure. To achieve a successful convergent validity, the observation values of one indicator of one construct are compared to another observed value of other indicators of the same construct.

3.10.5 Criterion-related Validity

Correlation measures the degree of connection between a test measure and one or more external referents (criteria) (Raykov, 2011). Correlations between their observed scores and their instructors' total scores may be seen. Concurrent or predictive validity is strongly connected to criterion-related validity. Concurrent validity refers to the relationship between one measure, and other criteria assumed to occur concurrently. This relationship occurs when criteria and a measure coexist.

Face and concept valid assess this researcher open-ended and structured questionnaires. On the other side, dependability refers to the degree to which measures are reproducible, whether performed by various individuals on different occasions, under different conditions and ostensibly using different devices to measure the construct or skill. Additionally, it may refer to the degree to which a construct's measure is constant or predictable (Mohajan, 2017). Reliability is classified into the following categories:

3.10.6 Test-retest Reliability

It is a metric that indicates the consistency of measurements of the same construct provided to the same sample at two distinct moments in time (Mohajan, 2017). If the correlation between the two sets of tests is considerable, this indicates that the observations have not changed much, indicating that time is a major factor in this form of dependability.

3.10.7 Split-half Reliability

Split-half dependability measures the consistency of a construct measure's two parts. It is assumed that the number of items required to measure a construct is accessible and all measured simultaneously, hence minimising random error. Correlation between the two parts must be determined to get the reliability coefficient (Heale & Twycross, 2015). A practical benefit of this approach is that it is less expensive and easier to achieve than test-retest reliability, which requires the researcher to develop a new set of questions for every administration.

3.10.8 Internal Consistency Reliability

It is a metric for the degree of consistency between objects belonging to the same concept. It assesses the instrument's consistency and the extent to which a collection of items accurately reflects a certain quality of the test. Correlations between individual items within a test evaluate the reliability coefficient. The alpha coefficient of Cronbach's is used to assess items' internal consistency (Quansah, 2017). A single item on a test may have a weak association with actual results; however, a test with several items may have a stronger correlation. Internal consistency reliability was used to determine the reliability of structured and unstructured instruments in this research.

3.11 Summary and Links

Scientists, authors, and philosophers have verified that research is a systematic approach to knowledge discovery. The methodologies used to perform this empirical investigation are detailed in this chapter. The chapter explains the philosophical attitude and rationale for the methodologies described in Section 3.3 and then details the research approaches with further arguments for why each strategy is appropriate for the present investigation. Additionally, the chapter discussed the methodological choices, research methods, periods, and research tools used to perform the study. The chapter discusses the strategies for data collecting, the analytical stages, validation, and dependability as critical components of research and results. The next chapter discusses the conceptual framework that underpins this thesis.

CHAPTER 4: CONCEPTUAL FRAMEWORK

4.1 Introduction

This chapter discusses the research conceptual framework while stressing the essential principles identified in the relevant literature that serve as the research study basis. The chapter outlines the conceptual framework by delving into the underlying concepts and arguing for the empirical research needs.

4.2 Importance of Conceptual Framework

The term "conceptual framework" refers to the organization of ideas and concepts derived from theories, research findings, reports on policies, and other expert opinions that support the study thesis. This concept implies the collection of many related impressions to give a complete knowledge and comprehension of the phenomena that are the subject of the research study (Imenda, 2014). Additionally, this implies that a conceptual framework summarizes many findings from the relevant literature that have been applied to the study, outlining the research agenda to facilitate comprehension of the research aims. It is necessary to have a structural design that incorporates modern thinking and focuses and direction for an investigation (Tabibian & Movahed, 2016). In summary, it introduces the study critical principles and establishes the study emphasis and direction. The vital ideas are derived from the subjects covered that are pertinent to current literature knowledge and from the findings of Literature theories. A conceptual framework emerges from extensive reading of relevant literature and projects to ongoing conversations in the researcher's field by establishing the following parameters: first, it directs the researcher's attention away from distractions, thereby focusing on the critical components of the research area; second, it provides proper direction for the formulation of research questions, with the review of research design and methodology (Bergold et al., 2013).

Additionally, conceptual frameworks circulate structures that duplicate a whole research topic's thought process. Significantly, charts are often created to effectively portray the factors associated with the study subject area, and these variables are related and discussed via arrows (Coppedge et al., 2019). However, the methodology must be consistent with the variables and their relationships and context (Latham et al., 2017). Researchers have the autonomy to adapt existing frameworks but must alter them to fit the unique characteristics of their research setting and the unique characteristics of their research questions (Fisher & Fisher-Yoshida, 2017). A good conceptual framework should demonstrate clarity and comprehension. This framework means that after a researcher has represented the vital variables of the research study graphically, an explanation should be provided regarding the relationships between the variables in terms of how they complement one another to address the primary research problems defined.

Additionally, a conceptual framework lends consistency to the researcher's thoughts, making it simple to communicate how and why the researcher's ideas matter concerning pre-existing bodies of knowledge in the research area, as well as to the writings and experiences of other researchers in the discipline (Koro-Ljungberg, 2010). The following highlights the relevance of conceptual frameworks in doing educational research:

a) tell their research's theoretical components.
b) develop mathematical models of the links between theories and variables.
c) simplify theoretical facts by converting them to assertions or models.
d) provide a theoretical foundation for the design, analysis, and interpretation of research; and

e) aid researchers in visualizing and explaining the subject of their investigation (Ngulube et al., 2015).

The following basics demonstrate the conceptual frameworks' strategic role in the execution of research projects by defining the shape of research projects as various components and outlines. Thus, academics must have a balanced grasp of conceptual frameworks to create and employ them in their research efforts properly. The following section discusses a conceptual framework for reinforced understanding from a narrative and schematic perspective.

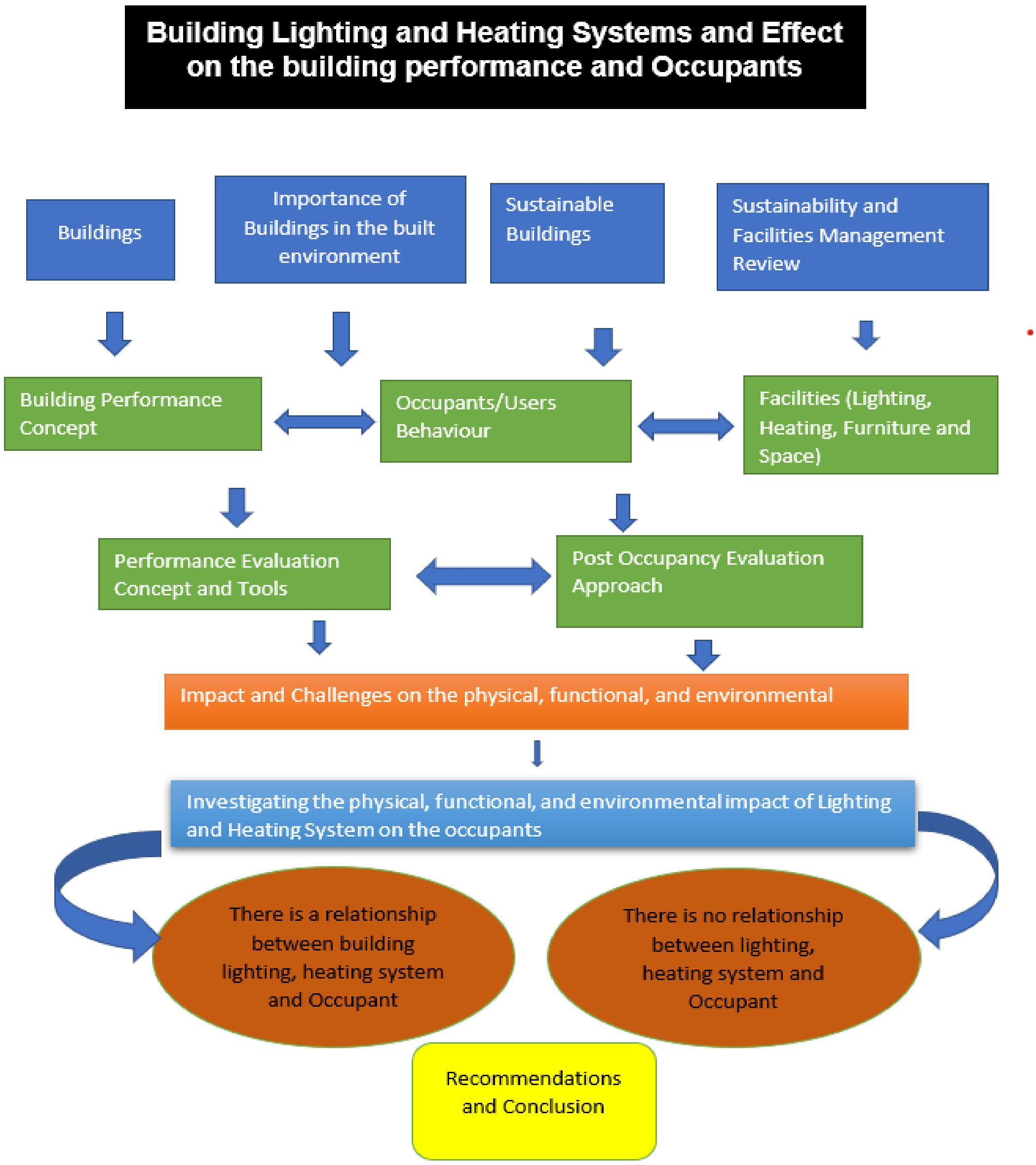


Figure 4.1: Conceptual Framework for Building Lighting and Heating Systems and Effect on Occupants

4.3 Explanation of the Framework

This framework starts with describing the term "building," the significance of buildings in the built environment, the relevance of sustainable construction, and a study of sustainability and facility management. Before any work on this research can begin, it is critical that the notion be well defined and articulated. Buildings take on various shapes and styles depending on their intended use. The significance of the structure was also discussed, researcher moved on to explore building sustainability and facility management within it. The first phase is interconnected since completing one section leads to the next.

Following that, the researcher needed to emphasise the link between building performance, occupant behaviour, building amenities, building performance, and the post-occupancy approach assessment. At this stage, the researcher identified the individual attributes of building performance, occupant behaviour, facilities within the building, building performance, and evaluation of the post-occupancy approach, after which the researcher identified the relationship and impact of each concept (building performance, occupant behaviour, facilities within the building, building performance, and evaluation of post-occupancy approach). The researcher next examined the effect that lighting and heating have on the functional and environmental impacts. These impacts would be capable of forecasting building occupants' productivity levels. Then, establish a correlation between building performance and occupant productivity. After the framework, the researcher determined plausible and workable options for the case study building lighting and heating performance.

Earlier before this study, studies in the past have explored the relations between different forms of buildings and the fitting systems. One of such studies include Veken, Peeters & Hen (2005) compared the heating systems in a residential building, and the result found that LT-radiators surpass the floor heating option. The only floor heating systems capable of competing with these radiators are those powered by a condensing boiler, designed to uphold a steady temperature matching the operative temperature generated by the LT-radiators. Another notable study by Faranda, Guzzetti & Leva (2014) examined the design and technology for efficient lighting system. The study found out that there were existing valuable technologies that can bring about significant energy conservation while simultaneously enhancing user comfort. Additionally, numerous other devices are currently in the process of being developed. In addition, Kumar & Kumar (2017) examined the design of workstations for computer users. The study showed that to address the progress of computer technology and mitigate health risks stemming from non-ergonomic designs in computer workstations, it is essential to make modifications to the current model. Considering the studies above and more, it is noticed that most studies in the past have limited their explorations to residential properties. Deviating from the studies above, this study intends to examine the effects of lighting and heating systems on workstation building using Huddersfield. The study therefore intends to contribute to the existing body of knowledge by establishing the effects of heating and lighting systems on building performance and occupants. The result of this study will therefore be useful to students and staff who engage in the use of workstations at University of Huddersfield. It will as well enhance effective managerial decision in the university building maintenance department. To this end, the established framework for this research can as well be validated and extended to studies that intend to examine the effects of lighting and heating systems on building performance in other universities.

4.4 Summary and Links

Concisely, a "conceptual framework" organizes ideas from theories, research, and expert opinions to underpin a study thesis. It provides a theoretical base for research design and aids in analysis and interpretation. It helps researchers understand and explain their subject.

The researcher identified attributes like building performance, occupant behavior, and facilities. Relationships and impacts were examined, and lighting/heating effects were studied. Plausible options for lighting/heating were determined using this framework, culminating in a research analysis in the next chapter.

CHAPTER 5: ANALYSIS OF CASE STUDY

5.1 Introduction

This chapter discusses the investigation in connection to the case study outcomes. As so, this chapter is structured as follows.

- To begin, background information about the University of Huddersfield as a case study, the rationale for selecting the case study, the process used (observation, document review, and survey) to achieve and to build performance based on investigating the lighting and heating performance, as well as how this is expected to affect the occupants in the university environment, are presented, along with a description of the data collection from the case study.
- Subsequently, prior to giving and presenting the primary analysis, the method and characteristics of building performance and the predicted performance of lighting and heating will be discussed.
- Thirdly, principal analysis was carried out, identifying the primary variables that emerged from the case study.
- Finally, the case study major elements were further analysed to provide suggestions.

5.2 Background to the Case Study- University of Huddersfield

The research examined the building Lighting and heating systems at the University of Huddersfield as a case study, as described in the research methodology. As such, this chapter will analyse the lighting and heating systems in buildings about the research topic, in relation to the lighting and heating performance. By conducting this case study, the researcher hoped to ascertain the nature of the lighting and heating performance process, specifically what the nature of lighting and heating performance was prior to and after improvement, and how these performances contribute to the formulation of critical factors and components of a sustainable building performance framework within the University of Huddersfield environment or community.

According to the University of Huddersfield (2021), the University of Huddersfield's, previously known as Huddersfield University, is a public university situated in the English town of Huddersfield. It has been a university since 1992, and its operations are centred on teaching to maintain its Teaching Excellence Framework (TEF) Gold Award, last gotten in 2017. The university has continued to make significant investments in enhancing its facilities. Notably, it is teaching, non-teaching, and school environments. Queensgate, the university's main campus, is located south of Huddersfield town centre. Almost the bulk of the university's teaching occurs on the main Queensgate campus. The main campus comprises a combination of repurposed mill buildings and purpose-built structures.

This campus qualifies the structures for the investigation. The buildings to be utilised were chosen for their unusual traits to provide a representative sample of responses. As a result, this research employs a comprehensive and integrated case study approach. The research establishes the University buildings as a case study, with an integrated case study of two university buildings. These are the Oastler and Percy Shaw structures. This option was made since no two structures are identical. Buildings are distinct and unusual since their physical qualities vary, including the forms and sizes of the rooms, amenities, utilities, and offices.

Additionally, continuous improvement is performed periodically when adjustments or renovations are made to the existing structure and built environment to satisfy users' and occupiers' required standards and expectations. This adjustment enables a more accurate description and interpretation of the phenomena based on the data provided by respondents and participants. The campus map below highlights many of the buildings selected for the case study portion of the research thesis.

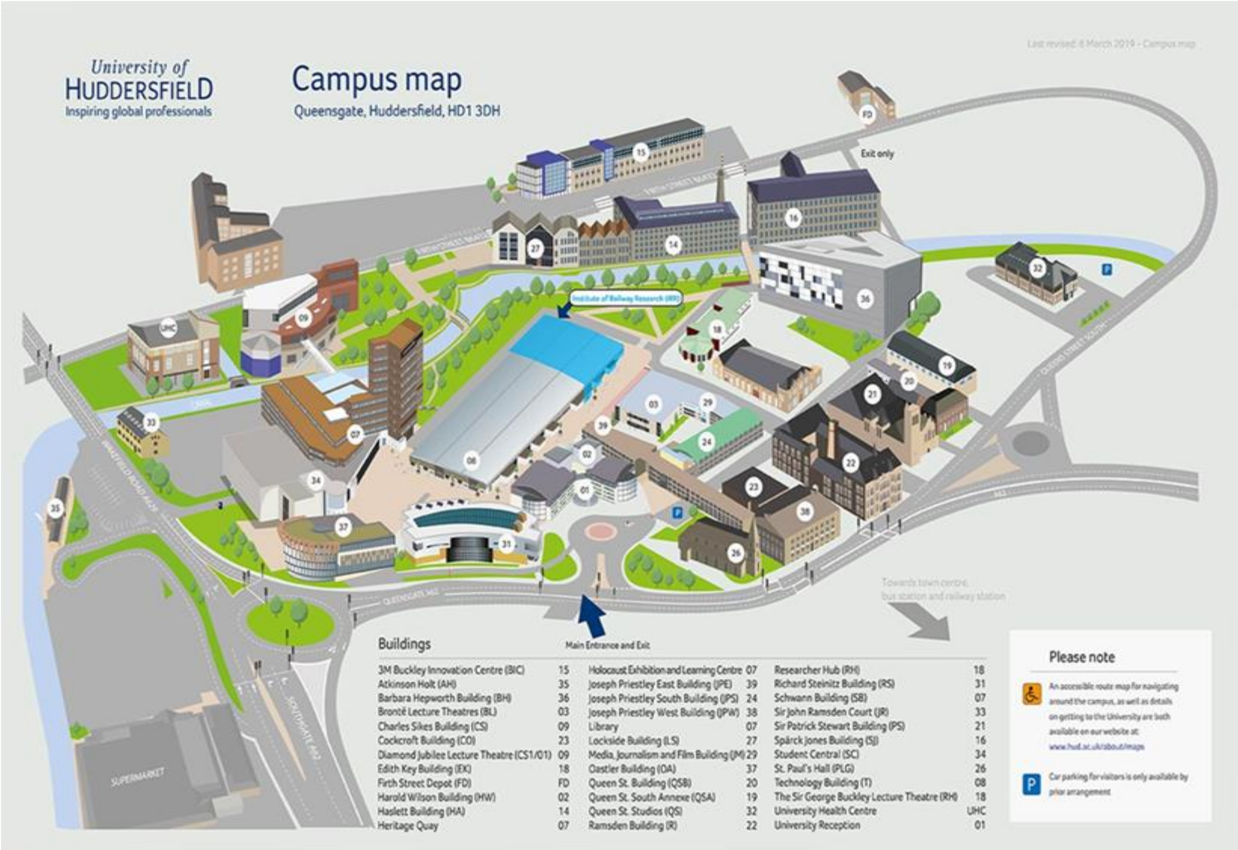


Figure 5.1. The University of Huddersfield Map, Source University of Huddersfield website 2021.

5.2.1The Oastler Building

The Oastler building is one of the newly constructed facilities on campus. It was meant to complement other existing structures on campus, especially the Student Central Building and the Richard Steinitz Building. The building's attributes set it apart from other university buildings; it has collaborative learning spaces that enable students and staff to bring their gadgets and plug them in to share or work with others. These facilities enable extensive group work and debate, which is especially beneficial when lecture rooms are unavailable.

Linguistics and Modern Language students have access to state-of-the-art facilities in the Oastler building, including an Experimental Laboratory, a Linguistics Laboratory, and Language Laboratories equipped with worldwide multimedia viewing and recording capabilities. Several additional facilities include the Language Research Centre, which has four high-quality sound booths connected to a conference room, offering students the opportunity to practise translating and interpreting in real-world situations. Additionally, the centre is equipped with the necessary equipment for recording, interpreting, and analysing language work.

The Oastler building provides break out places for work and leisure time for employees and students, notably for catching up on work at the PC stations located throughout the prow of the building or socialising with friends in various locations of the building's many sitting areas. The expansive postgraduate area has 52 networked PCs, workstations, photocopying capabilities, comfortable seats, and even a kitchen for late-night coffee demands. Academic personnel, subject area professional teams, and technological services have all relocated to the building's new offices, enabling and facilitating access to a variety of on-site support services. Additionally, the Oastler building has academic offices, conference rooms, a 300-seat lecture theatre, a 180-seat practice-based learning area, and event space. These facilities have a variety of lighting fixtures and heating qualities or systems that serve the University's workers who work almost every year.

Figure 5.2: External View of the Oastler Building

Figure 5.3: 300-Seater Lecture Theatre with the Surface IP66 Led Dali Dimmable Linear Luminaire Lighting Fixtures and Central Heating System (Oastler Building).

Figure 5.4: Controls for the Lighting and Heating System (Oastler Building)

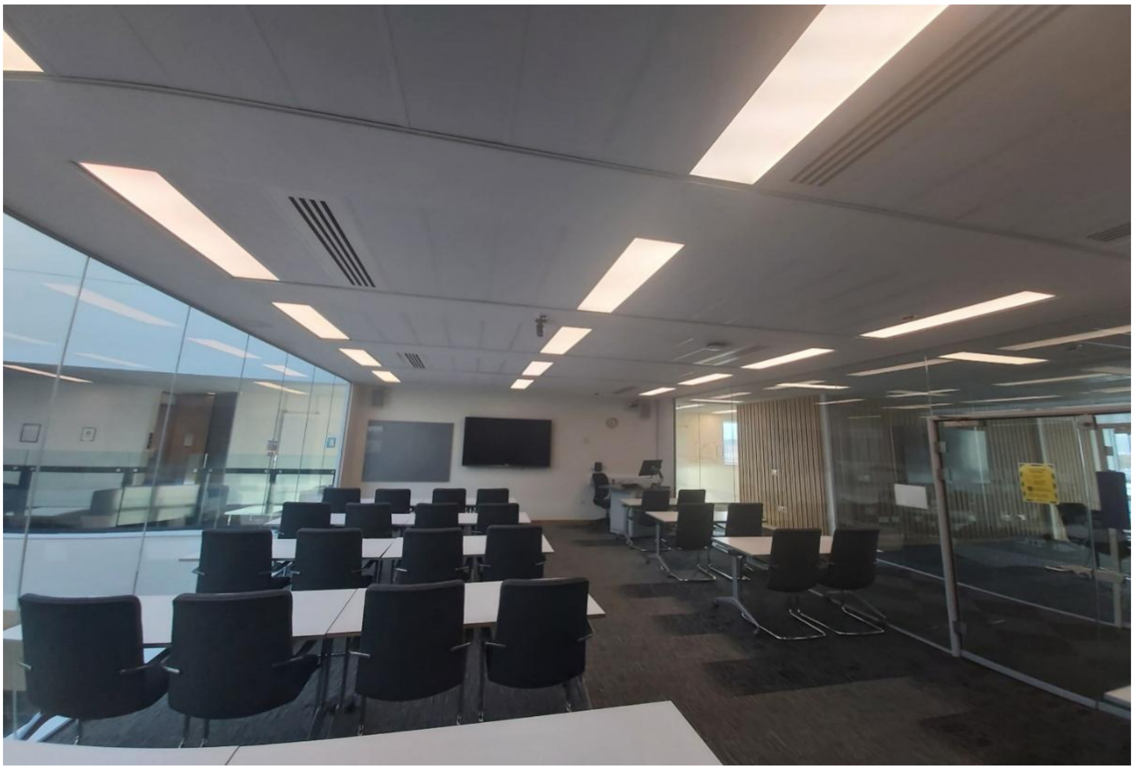


Figure 5.5: Meeting room with Recessed Led Dali Dimmable Luminaire C/W Polycarbonate Diffuser Lighting fixtures in the ceiling and central heating in (Oastler Building)

It is however noticed that one of the challenges in Oastler meeting room as indicated in Fig. 9 is the existing glare in the lighting system. A glare is a common form of image degradation which arises when performing computer activities (Glimne et al., 2013). The presence of glare in lighting system affects reading performance because reading is a sensitive task to image degradation. Therefore, one major criticisms of the Oastler building are the presence of glare in the lighting system which affects readers' eyes and as such affects the reading performance of the users of meeting room in Oastler. The more adverse the lighting quality is, the more the decrease in the in the reading speed.

Comparatively, it could be said that the lighting glare is more presence in Oastler building than the Percy Shaw building due to the nature of the Oastler building. The Oastler building unlike the Percy Shaw is built of glasses all through and as such, it is expected to have loss of visual performance in Oastler building because of the production of light intensity through the glasses which is greater than what eyes are adapted to.

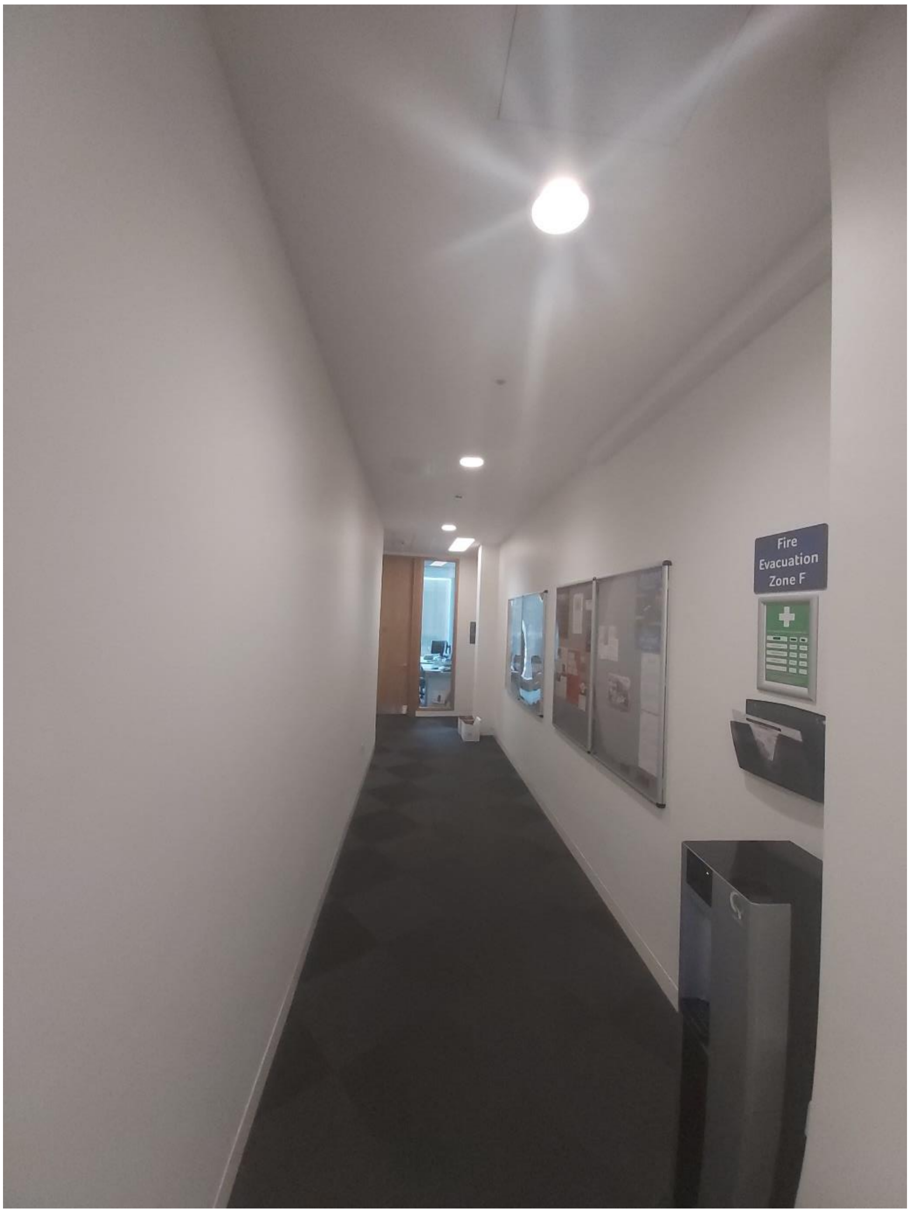


Figure 5.6: Lighting fixtures (SURFACE IP64 LED CIRCULAR DALI DIMMABLE LUMINAIRE C/W POLYCARBONATE DIFFUSER) on the corridor to one of the academic staff rooms (Oastler Building).

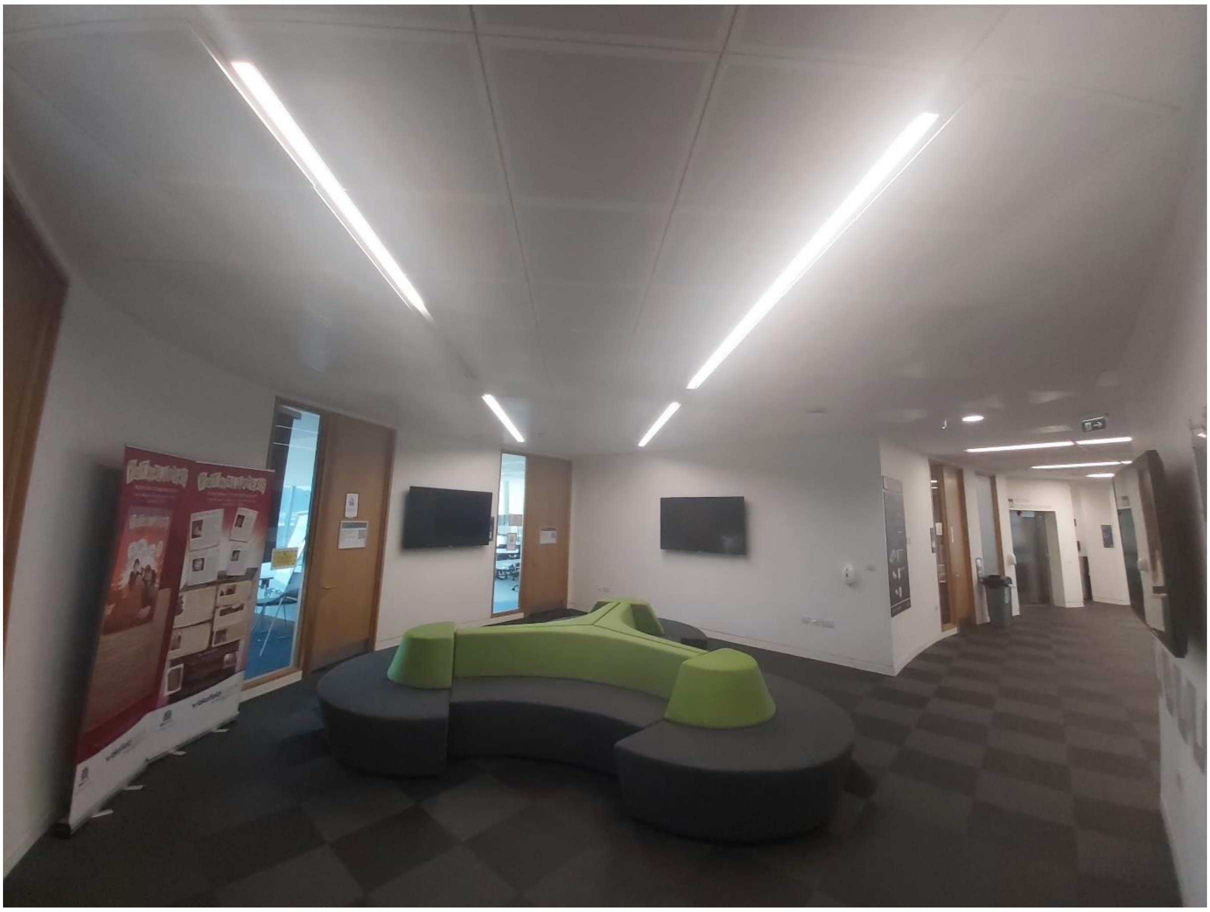


Figure 5.7: Waiting Space at the Classroom area with a Surface IP66 Led Dimmable Linear Luminaire lighting fixtures (Oastler Building).

5.2.2 Percy Shaw Building

In contrast, the Oastler building is relatively modern and has multi-purpose spaces for classrooms, offices, theatre rooms, computer laboratories, and other departmental functions. The Percy Shaw building houses the school of Art, Design, and Architecture's state-of-the-art amenities, including a café, a complete workshop, and other access to the design centre, which has critical industrial and technological resources such as digital measuring and quick photocopying machines. Staff offices and lecture rooms are available to assist the school's teaching. Due to its strategic location for staff and students, this facility is critical to the research area. The significance of these amenities cannot be overstated since the institution recently renovated the facility to increase its facilities.

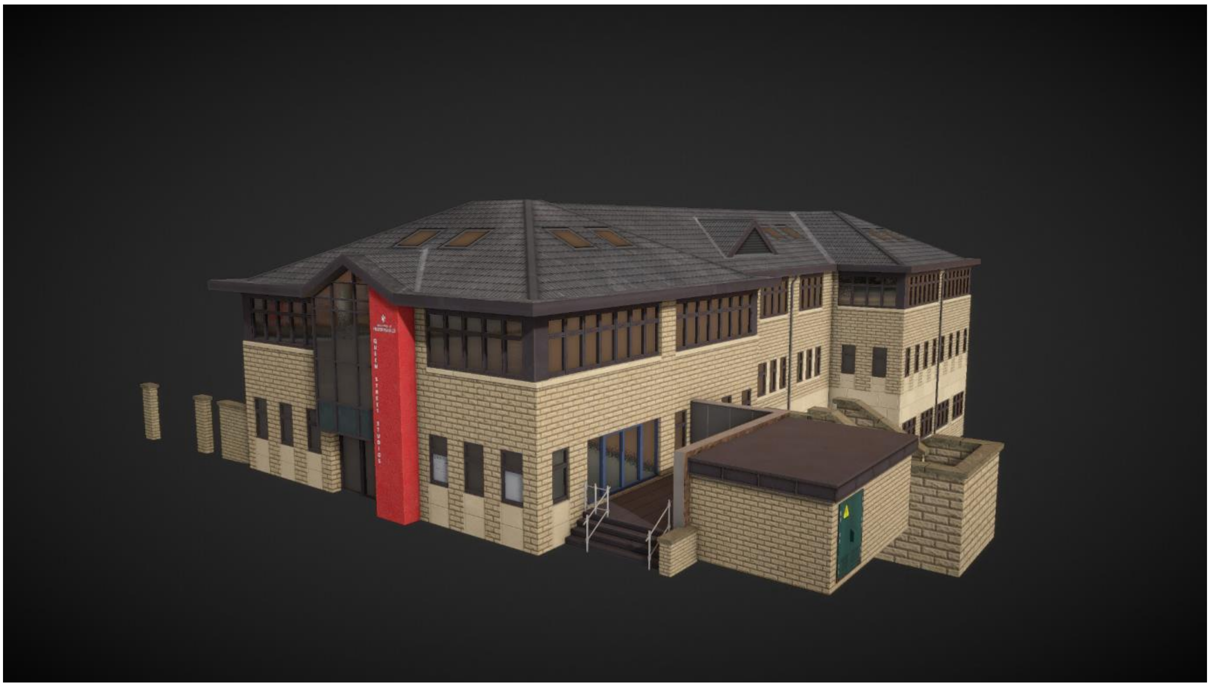


Figure 5.8 Area view of the Percy Shaw House Building. Source from the Art station.

Figure 5.9: Front View of the Percy Shaw House Building.

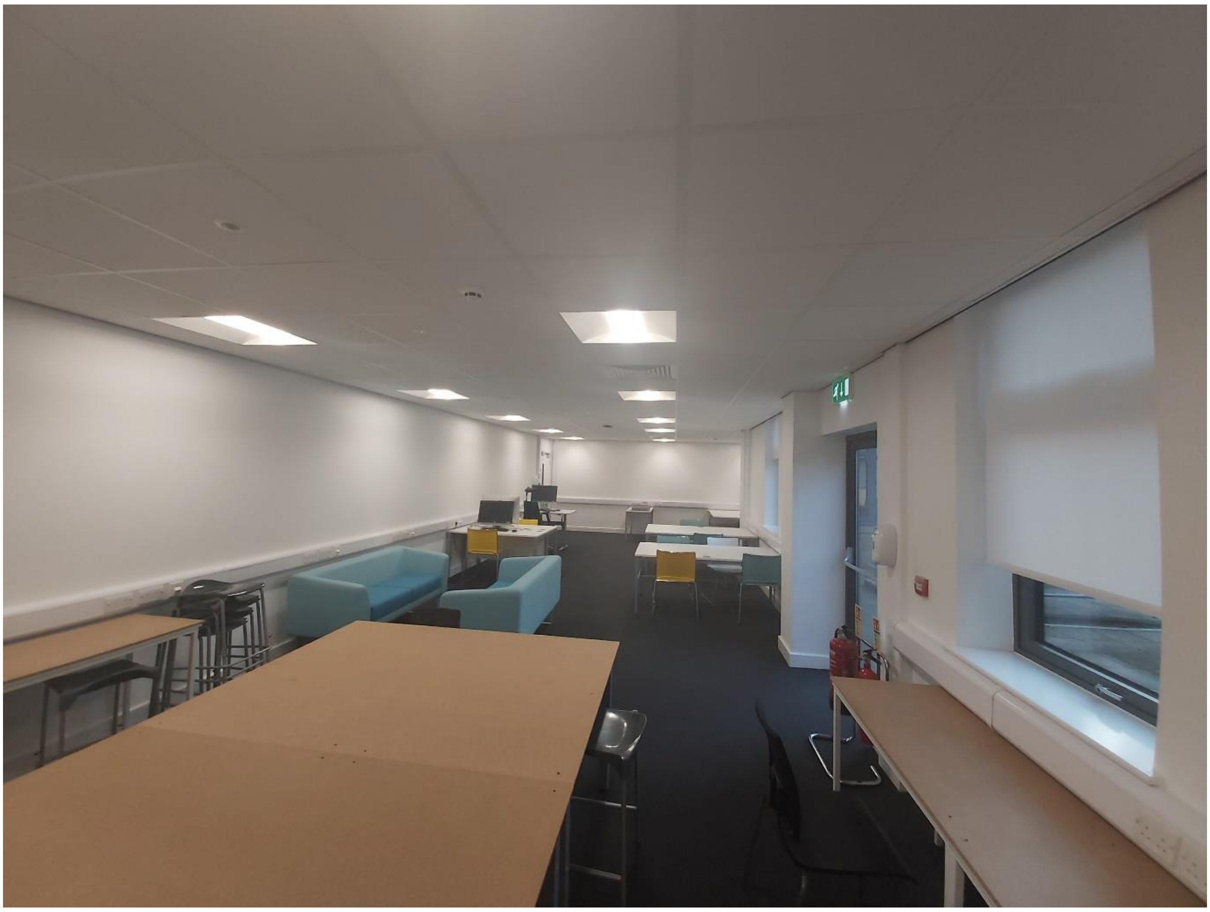


Figure 5.10: Post Graduate Room Recessed Led 600 x 600 Dali Dimmable LG7 Luminaire C/W Ribbed Polycarbonate Refractor Lighting Fixtures furnished with Central Heating Fixtures (Percy Shaw House Building)

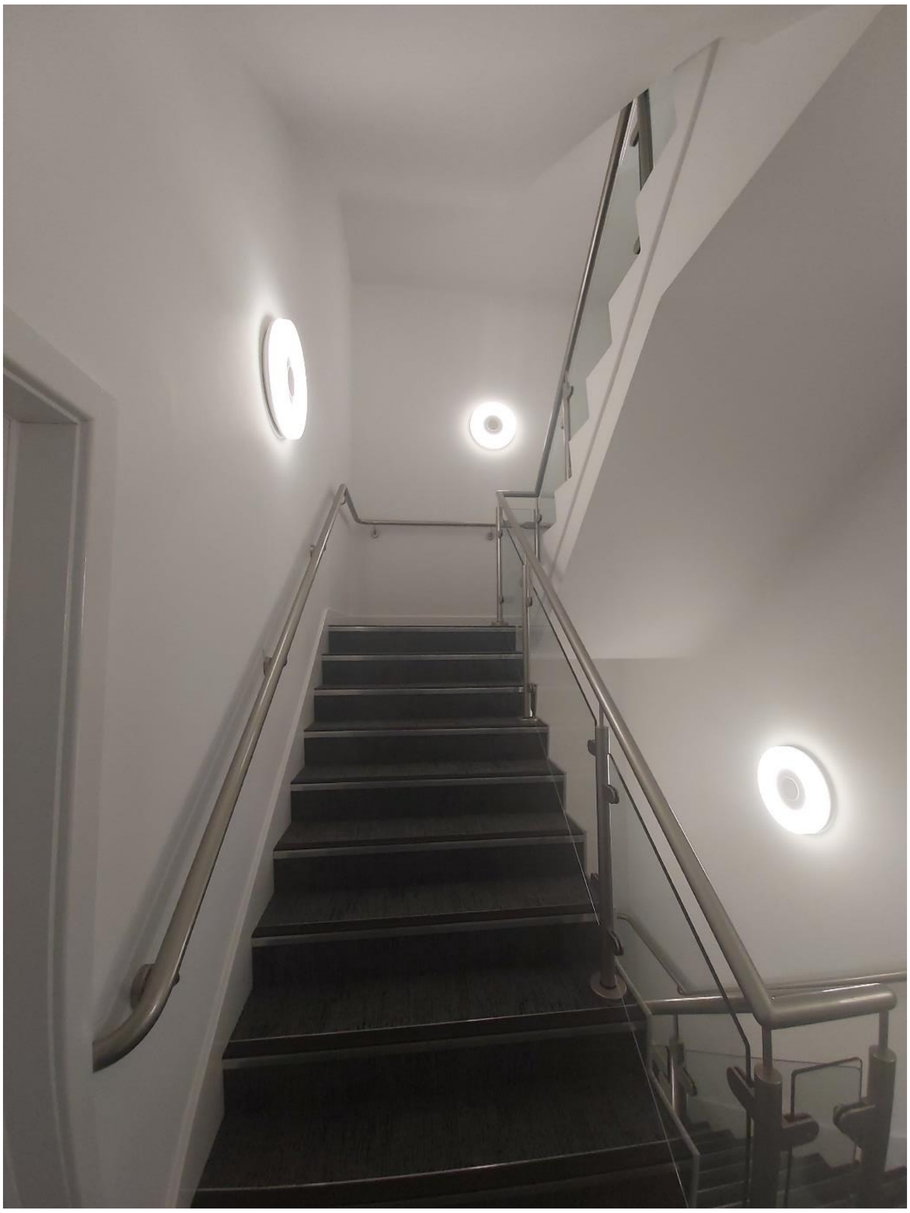


Figure 5.11: Staircase leading to some of the workshop room lit with a Recessed Led Circular Dali Dimmable Downlighter Lighting Fixtures (Percy Shaw House Building).

Figure 5.12: Waiting Space, Academic staff offices with Surface IP64 Led Circular Dimmable Luminaire C/W Polycarbonate Diffuser Lighting fixtures (Percy Shaw House Building).

Figure 5.13: Surface Heating System (Percy Shaw House Building).

Figure 5.14: Control System for the Lighting and Heating System (Percy Shaw House Building)

5.3 Observation

Non-participant observation is critical to the case study data collecting procedures. The researcher often enters the study scene to understand what and why they want to observe in the research region. (Saunders et al., 2019).

Before performing the survey, the researcher met with and observed some top management members of the University's estates department and did an on-site survey of the case study to get first-hand knowledge of the region and speak with several key stakeholders in the buildings.

The meeting enables the researcher, as a non-participant observer, to keep a field notebook in which she records all observational observations and then converts them into a collection of field observational transcripts. Consent was obtained from stakeholders and respondents/participants.

However, the research was carried out at a period Covid-19 virus was at rampage; as such seventy percent of the survey was carried out in the private homes of the respondents, the university staffs. Furthermore, the surveyed staffs were the regular users of the workstations at Percy Shaw and Oastler buildings. Therefore, the respondents' responses are reliable to determine the performance of Percy Shaw and Oastler buildings. To further establish the study result, data were also from students who make use of the workstations at Percy Shaw and Oastler buildings, the surveyed students are students in the Faculty of Art, Design and Architecture.

5.4 Document Review

Before conducting the investigation, the researcher requested structural lighting and heating designs for some buildings to conduct a critical examination. The paper is crucial for the case study since it enables the researcher to analyse the research topic. This review is to allow a reconnaissance scan of the research region based on what the researcher noticed early in the investigation. As a result, the researcher evaluated documents relevant to this case study lighting performance inquiry. Some of the reviewed documents provided by the Estate Department Team are presented below.

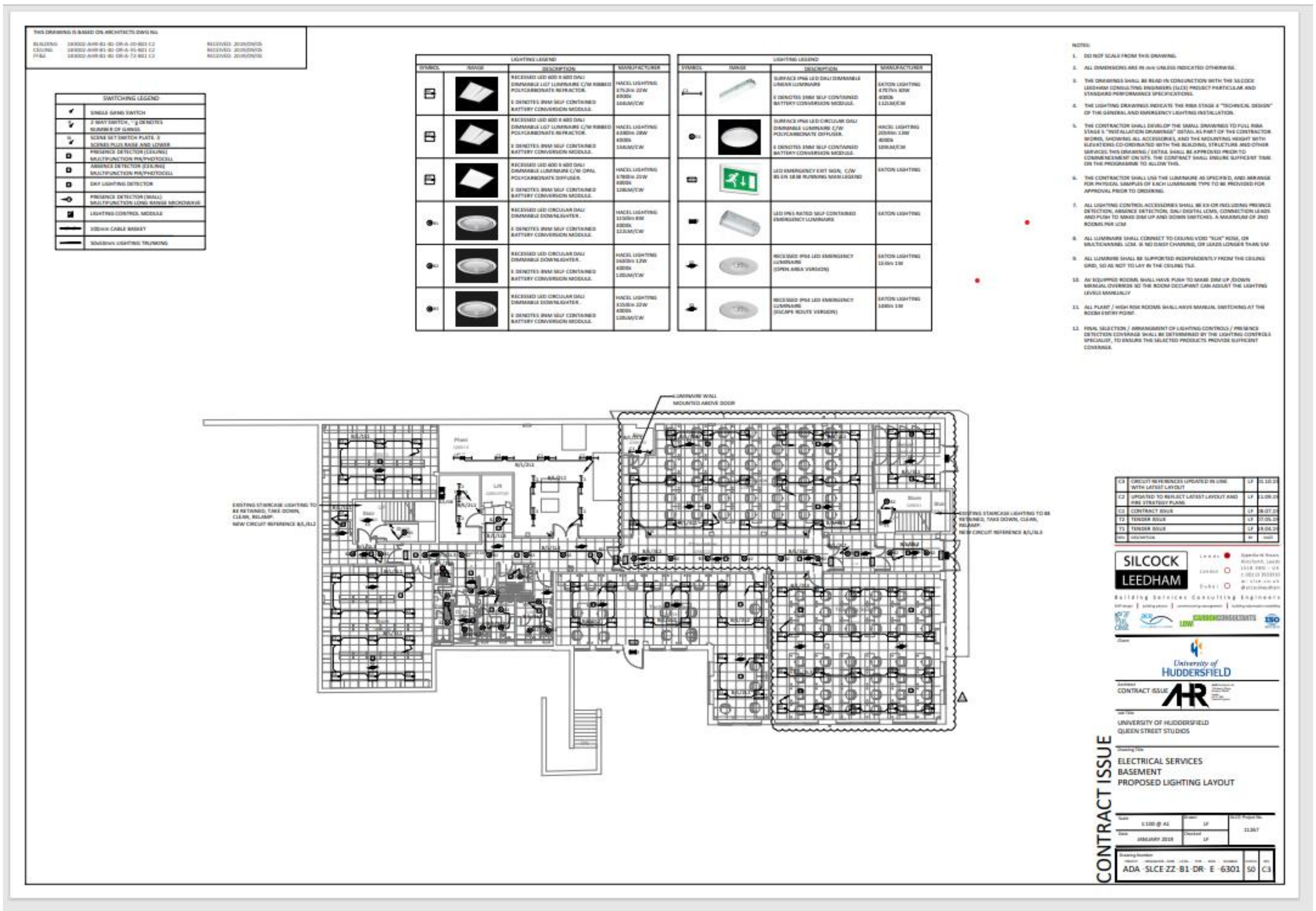


Figure 5.15: Electrical Services Basement Proposed Lighting Layout (Percy Shaw House Building).

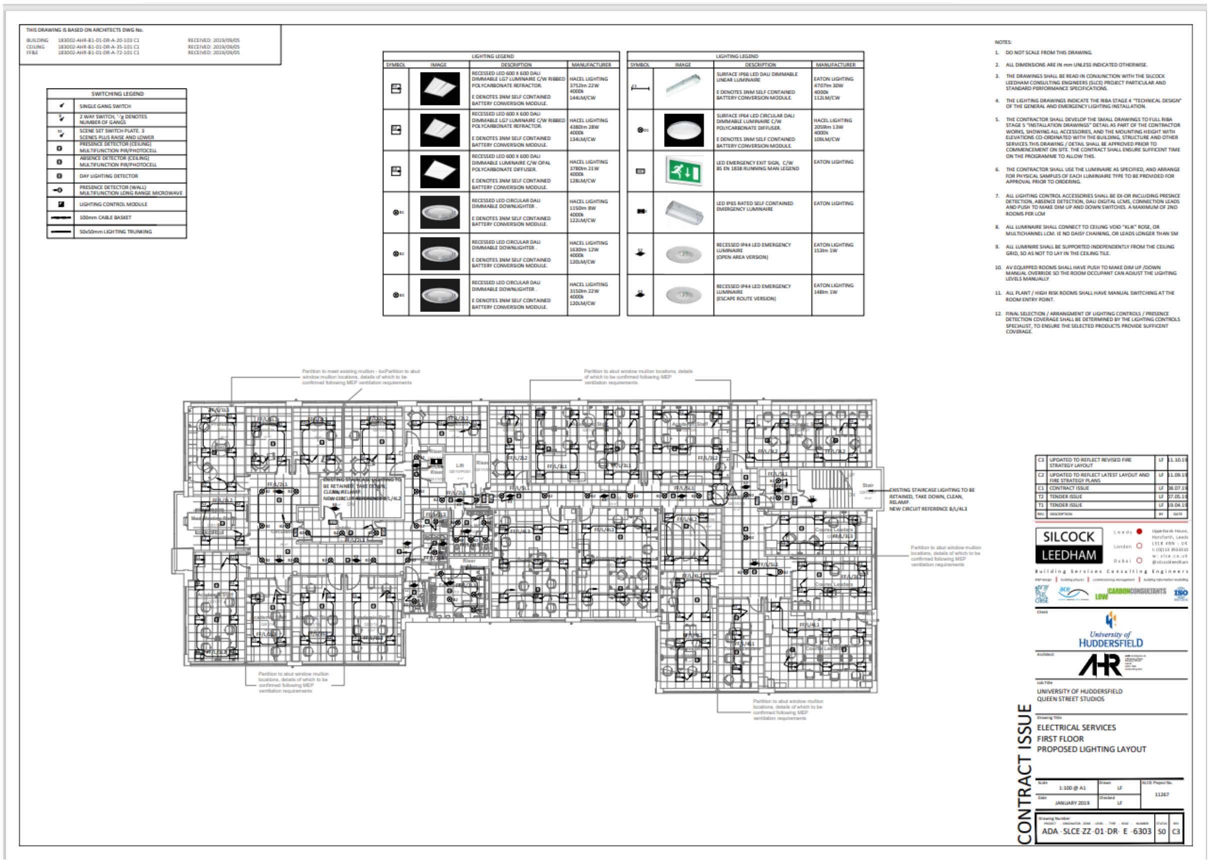


Figure 5.16: Electrical Services First Floor Proposed Lighting Layout (Percy Shaw House Building).

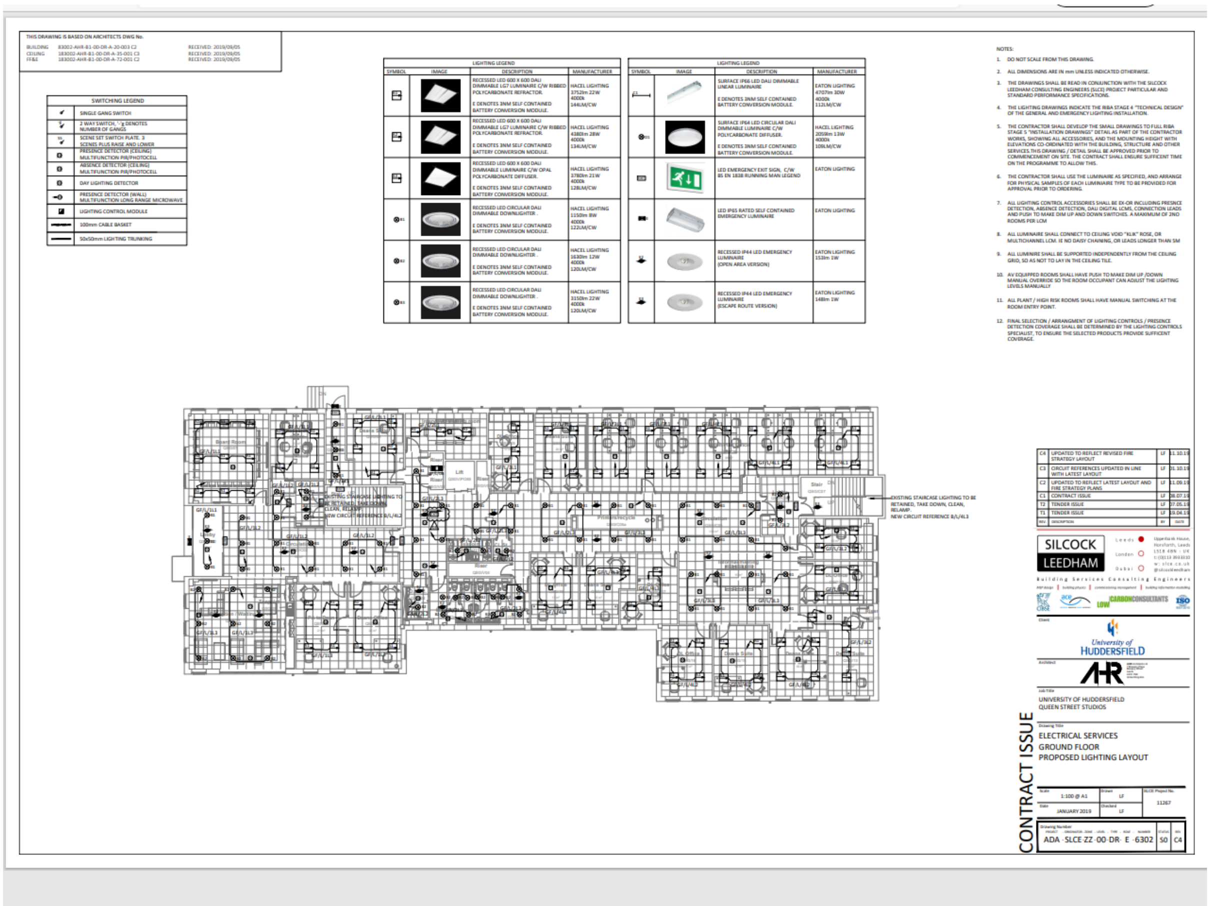


Figure 5.17: Electrical Services Ground Floor Proposed Lighting Layout (Percy Shaw House Building).

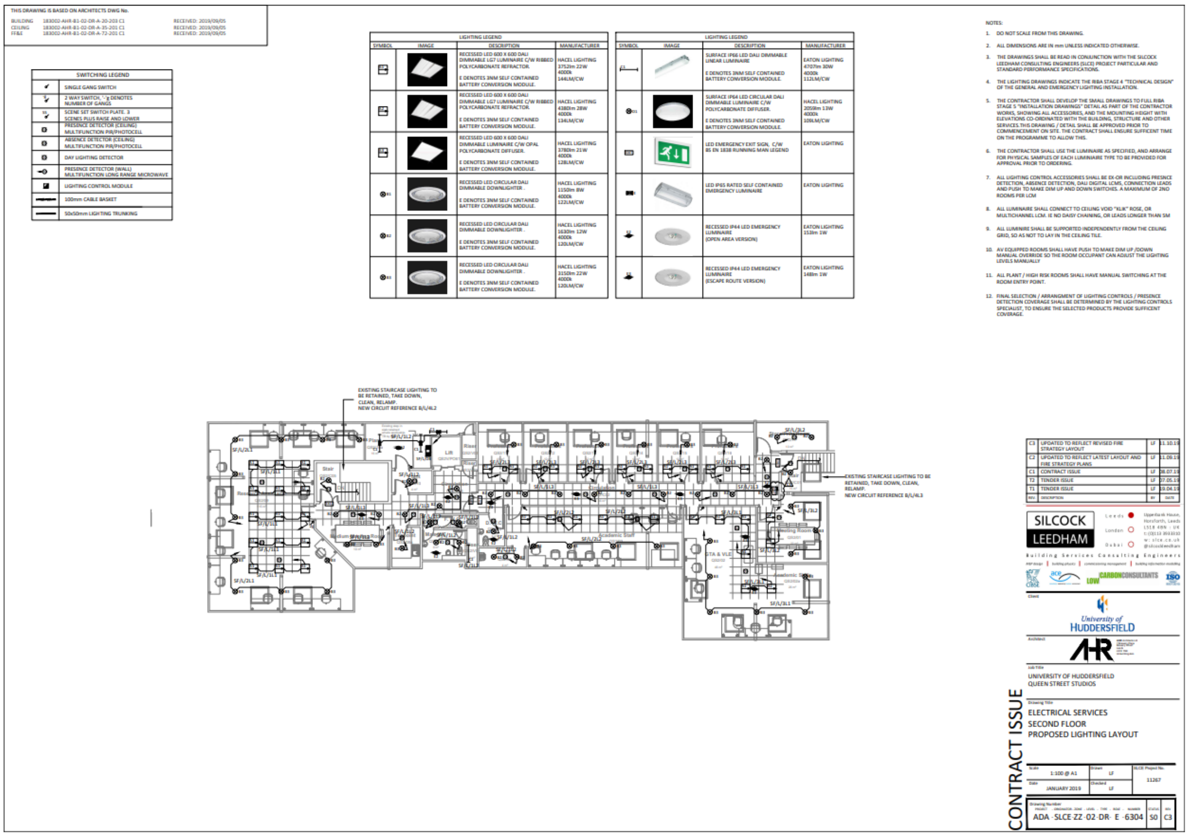


Figure 5.18: Electrical services Second Floor Proposed Light Layout (Percy Shaw House Building).

5.4.1 Surveys

The surveys provide an excellent chance for the researcher to explore how the building's lighting systems and performance impact employee productivity. In this case study, questionnaires were conducted to obtain more perspectives on the lighting performance inquiry. As a result, observation as a study approach was chosen. The study might document the whole process and consider specialists and professionals' perspectives in the built environment. However, it is critical to highlight that the observation findings were based on the researcher's perception of the lighting performance and its processes.

Meanwhile, the document review offered a helpful balance and assessment of how the investigation's primary project and other components were seen. A few structured surveys were done with case study specialists. Additionally, respondents were deliberately chosen throughout the research region, given that the study's objective is to determine the influence of building illumination performance on the occupant's or user's productivity. Thus, the research is focused on the substance of the data, regardless of its source. However, taking the department or area of expertise into account, surveys were performed among the University's estate facilities and support staff.

5.5 Summary and Links

The study investigated lighting and heating systems at the University of Huddersfield, focusing on the Oastler and Percy Shaw buildings. This research aimed to understand their performance, both before and after improvements, and how these performances contribute to a sustainable building performance framework. The main campus includes repurposed mill buildings and purpose-built structures. The research utilized a case study approach to analyze these systems and their impact within the University community.

CHAPTER 6: ANALYSIS AND DISCUSSION OF FINDINGS

6.1 Introduction

This chapter provides an in-depth analysis of the data acquired through survey questionnaires sent to respondents mainly from the University of Huddersfield's School of Art, Design and Architecture. The respondents include teaching and non-teaching personnel as well as students at the University of Huddersfield and representatives from the built environment sector who work in the University's estate facilities.

The analysis conducted in this chapter's facet or session has been divided into three components. The first part discusses the study's respondent profiles. The second component examines the effectiveness and efficiency of the building's lighting and heating systems compared to how satisfying they are to the responder, while the third piece examines the interaction between the building's heating, cooling, and environmental systems. These analyses were conducted to address the research's purpose and goals. Extensive conversations are held about the use of statistical analysis through tables and graphs and other presentations and summary levels for each variable, research topic, or target.

6.2 Preliminary Data and Analysis

The data acquired to answer the research questions were necessary to accomplish the research objectives. Due to the period circumstances, the evaluation was undertaken to gather input at various times and locations within the institution and those working from home. The objective for conducting a second poll at a different time and place was to account for the effects of the COVID-19 epidemic, which restricted staff to travel and forced them to work from home. On the other hand, this enabled the study to adopt a new approach since several staff members worked from home before the pandemic owing to their unique circumstances. This study increased its inclusiveness in terms of sample population and size.

Additionally, this survey provides an additional method for data gathering within the research field of investigation. These results from the data sets will enable the researcher to compare information obtained from the survey, resulting in a more rigorous study.

Data were collected between April and November 2019 and in May 2020. Also, survey was carried out among students in May and was retrieved in June 2022. This survey was done at different times of the year and months to allow for more representations and comparisons between case studies. The administration of the questionnaire and retrieval was obtained through the aid of an online survey (Qualtrics). The various responses were subsequently coded and analysed using a Statistical Package for Social Scientists (SPSS version 10) and Microsoft Excel Spreadsheet. Table 6.1. Below is a summary of the questionnaires administered and retrieved. See Appendix 1 for the study questionnaire.

Table 6.1: Administered and Gathered Questionnaires

Questionnaire Type	Description	Expected Responses	Retrieved Responses	Response Rate (%)
Online Survey (University)	University Staff	60	46	s77
Online Survey (Home)	University Staff	60	33	55
Online Survey	University Estate Department	15	7	47
Online Survey (University)	The University Students in the School of Art Design and Architecture	120	98	82

The first survey was created and conducted in March 2019, the second was conducted in April 2020 and the last survey was conducted in May 2022. The researcher received 77% and 55% responses from the university staff and managers in their offices during the survey and university staff working from home due to the pandemic. The study further received a total of 120 responses from the students, however, 98 of these responses were valid which represents 82% of the surveyed population and gives a true representation of the surveyed students. Going by these results, it can therefore be said that a large percentage of the respondents were the students and the reason for this is because they constitute the participants who used the workstation most. Next to the students were the staff working in their offices as at the time of gathering data, this implies that a higher number of staff were working in school as at the time of collecting the datasets.

The motive for the different times and locations is to allow for a fair representation of the experiences of the staff and managers working from the office or home. The response rate for the staff of the University Estate Department who were selected for the interviews was low at 47%, as the staff are quite mobile, and it was not easy to track them down during the survey period. It is worthy to note that some challenges were faced concerning the questionnaire administration and area of concentration. Due to the COVID-19 pandemic, the questionnaire could not be administered within the University premises. However, the research took advantage to add a different perspective to the research study, considering the potential differences in the lighting and heating performance at an alternative workstation (i.e., those working from the comfort of their homes). The results in Table 6.1 are further presented in Figure 6.1

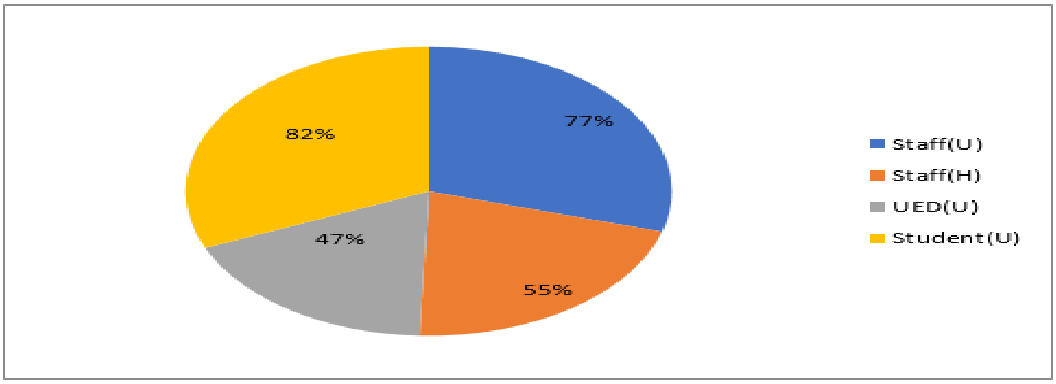


Figure 6.1: A Pie Chart Representation of the Administered and Retrieved Questionnaire Staff (U) – Staff at the University, Staff (H) – Staff at Home, UED - (University Estate Department), Students (U) Students at the University

The result above shows that 77% of the respondents were surveyed staffs who were surveyed at the university while 55% were staffs surveyed at home. Furthermore, 47% of the respondents were staffs at the University Estate Department. Also 82% of the students constituted the study survey.

6.3 Analytical Methods

Univariate and bivariate analyses were employed to depict the sample characteristics and variations in the outcomes using descriptive statistics and cross tabulation-Chi square tests, respectively. The statistical significance for the Chi-square test was set at 5%, i.e., within a 95% confidence interval. The descriptive statistics involved two socio demographic characteristics (SDCs) categories, and their frequencies and proportion, averages and t-tests are shown in the results in the Tables below.

Table 6.2: Univariate Analysis of Personal Characteristics among University Staff and Students

Variables	Full sample (n = 177)*		Work from home (n = 33)		Work from Office (n = 46)		Student n=98	
	N	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Gender								
Male	63	(35.59)	11	(33.33)	10	(21.74)	42(42.85)	
Female	144	(81.36)	22	(66.67)	36	(78.26)	56(57.14)	
Age								
20-29	54	(30.51)	2	(6.06)	9	(19.57)	43(43.88)	
30-39	62	(35.02)	10	(30.30)	14	(30.43)	38(38.78)	
40-49	26	(14.69)	4	(12.12)	5	(10.87)	17(17.35)	
50-59	27	(15.25)	12	(36.36)	15	(32.61)	-	
60 years or more	5	(2.82)	3	(9.09)	2	(4.35)	-	
Prefer not to say	2	(1.13)	2	(6.06)	0	(0.00)	-	
Job Role								
Administrator	16	(20.25)	6	(18.18)	10	(21.74)		
Technical	10	(12.66)	4	(12.12)	6	(13.04)		
Teaching &Research	28	(35.44)	16	(48.48)	12	(26.09)		
Teaching/Research only	9	(11.39)	5	(15.15)	4	(8.70)		
Missing	4	(5.06)	0	(0.00)	4	(8.70)		
Time Spent at the Workstation								
Up to 1 year	57	(32.20)	8	(24.24)	13	(28.26)	36 (36.73)	
2-5 years	70	(39.55)	7	(21.21)	16	(34.78)	47(48.0)	
6-10 years	23	(12.99)	5	(15.15)	3	(6.52)	15(15.31)	
More than 10 Years	26	(14.69)	3	(39.39)	13	(28.26)	-	
Missing	1	(0.56)	0	(0.00)	1	(2.17)	-	

Tables 6.2 shows the univariate analyses of the covariates, which are categorised into personal and workstation characteristics. According to the analysis, many of the respondents were females (69.57%). The difference between the number of females and males was vast (39.14%), therefore, there were more female respondents than male. The differences are even more expansive when comparing those who responded to the home questionnaire (33.34%) and the office questionnaire (56.52%). A significant number of the respondents were within the 50-59 age bracket (34.18%), followed closely by those within the 30-39 age bracket (29.95%). The least age group captured within the survey was the 18-20 age bracket (1.27%). These representations are quantitatively similar when comparing those who responded from home and the office, respectively. It can therefore be deduced that a higher number of the respondents fell within the age bracket of 50-59 followed by those within the age bracket of 30-39. These age groups perfectly represent the status of the respondents being sampled which comprised staff and post graduate students. These two sets of individuals can be categorized as the set of people that mostly make use of the workstation. Moreover, 35.44% of the respondents work as teaching and research staff, while 20.25% and 12.66% work as administrators or technical staff, respectively. When the sample is split by location, teaching and research staff also formed the most significant respondents (48.48% - home questionnaire; 26.09% - office questionnaire).

Furthermore, results from the job roles of the respondents, 18.18% of those who work from home were administrators while 21.74% of the staff who work in the office were administrators. This is a clear indication that a larger percentage of the administrators as at the time of the survey were working from the office. By implication, a larger percentage of the administrators as at the period of COVID-19 still work at the workstation. Therefore, data obtained from such respondents are reliable. Similarly, more staff who were technical staff also work from office as at the time of collecting the data at a percentage of 13.04% as against those who work from home whose percentage was 12.12%. It could therefore be said that the staff who were administrators and those who were technicians both had larger percentage working from the office. This also applies to other staff whose duties were not stated but a larger percentage of them at 21.74% work from office. It is however important to note that the need for surveying the staff working is with a view to examining their post occupancy examination perceptions prior to the COVID-19 lockdown.

In general, one-third of the respondents had spent more than ten years at their residence or workstation. When split by location, 39.39% of the work-from-home respondents had spent more than ten years in their residence. However, most of the office respondents had spent 2 to 5 years at their workstations. Furthermore, some of the students had spent 2 to 5 years with a percentage of 48.0%.

The personal characteristics among the university staff and students are further presented in the pie charts below.

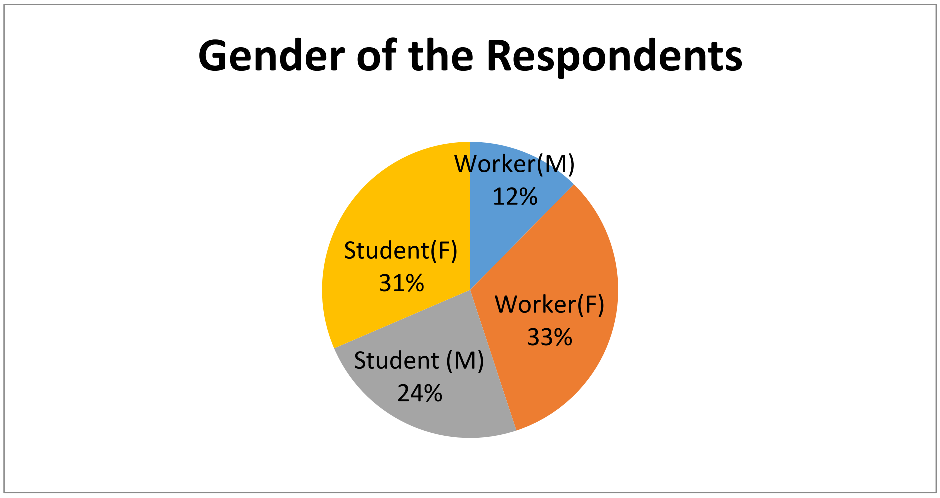


Figure 6.2: Pie Chart Representing Gender of the Respondents

Workers (M)- Male Workers, Workers(F)- Female Workers, Students (M)-Male Students, Students(F)- Female Students

The Figure 6.2 above is a representation of the respondents' gender. The pie chart reveals that the highest numbers of respondents are the female workers representing 33% of the population. This percentage is an expression of the addition of the number of female workers from home and office. The lowest numbers of respondents are the male workers at 12% which represents the expression of number of male workers from home and office.

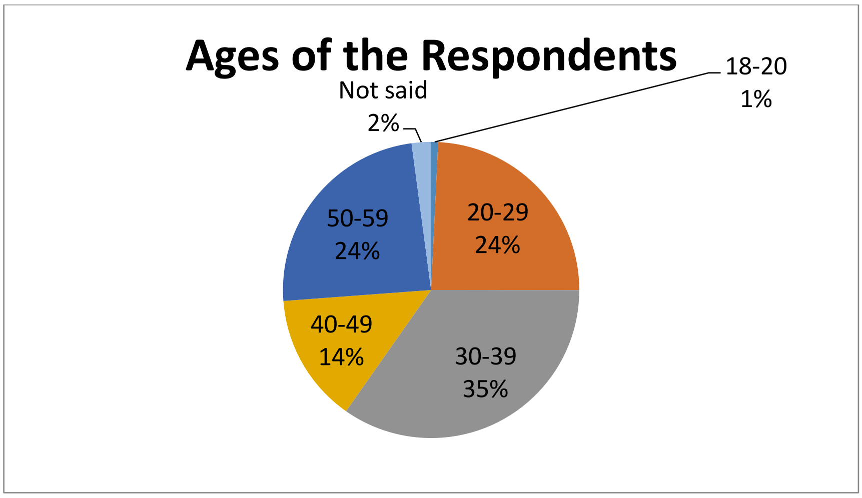


Figure 6.3: Pie Chart Representing Ages of the Respondents

The Figure 6.3 above is a representation of the respondents' ages. The pie chart reveals that the respondents within the ages of 30-39 years constitute the highest number of respondents representing 35% of the total respondents. This percentage represents the addition of the numbers of the surveyed workers from home, office and students. The lowest respondents' age group were those within the age bracket of 18-20years with a percentage of 1%.

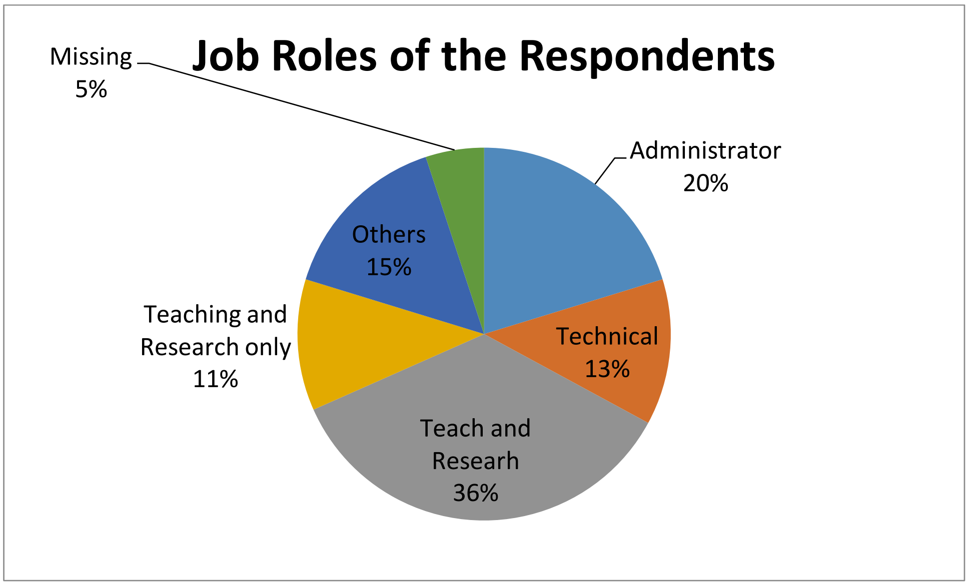


Figure 6.4: Pie Chart Representing Job Roles of the Respondents

The Figure 6.4 above is a representation of the respondents' job roles. The pie chart shows that the respondents who engage in teaching and research role have the highest number of respondents with a percentage of 36% of the total respondents. This percentage is obtained from the addition of the surveyed workers from home and office. While the lowest number of respondents are those that engage in teaching and research only at 11%.

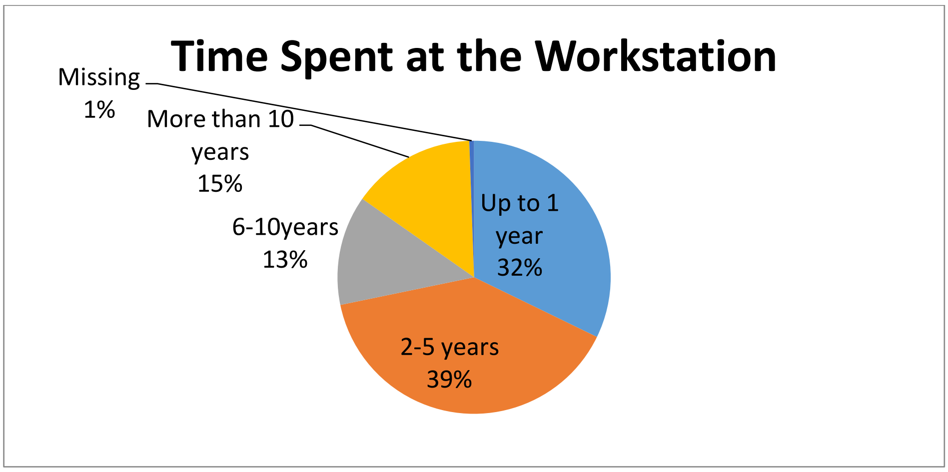


Figure 6.5: Pie Chart Representing the Time Spent at the Workstation

The Figure 6.5 above is a representation of the time spent at the workstation. The pie chart shows that the respondents who have spent 2-5 years at the workstation have the highest percentage representing 39% of the total respondents while the lowest percentage is 13% representing those who spent 6-10 years. To this end, those who have spent 2-5 years constitute the highest number of the study respondents. However, those who have spent 6-10 years constitute the lowest number of the respondents.

Table 6.3: Univariate Analysis of Workstation Characteristics among University Staff and Students

	Full sample (n = 177)		**Work from home (n = 33)**		**Work from Office (n = 46)**		**Students (n = 98)**
Variables	**N**	**(%)**	**N**	**%**	**N**	**%**	**N %**
Window in the room or workstation							
No	21	(11.86)	1	(3.03)	7	(15.22)	13 (13.27)
Yes	156	(88.13)	2	(96.97)	39	(84.78)	85 (86.73)
Important to have a window in the room or immediate work area							
Not at all important	16	(9.04)	2	(6.06)	2	(4.35)	12 (12.24)
Moderately important	30	(16.95)	3	(9.09)	4	(8.70)	23 (23.47)
Very important	131	(74.01)	28	(84.85)	40	(86.96)	63 (64.29)
Lighting control at the workstation							
Wall switch with room sensor	94	(53.11)	23	(24.47)	39	(41.50)	32(32.65)
Others such as desk lamp, table lamp, side lamp	83	(46.89)	20	(60.61)	20	(43.48)	43(51.81)

In terms of the workstation characteristics as shown in Table 6.3, the results revealed that just 1(3.03%) of the respondents from home claimed there was no window at the workstation which represent the least perception. This was followed by those who work from office with 7(15.22%) claiming there was no window in the workstation while the highest respondents recorded were the students, 13(13.27%). In total, just 11.86% of the respondents claimed there no window at their workstation which was far below those that claimed there was window at their workstation, 156 (88.13%). Breaking down the responses of those who claimed there was window at the workstation, it was found that 2(96.97%) of the respondents worked from home, 39(84.78%) and 85(86.73%) worked from office and were students respectively.

Also, the respondents unanimously (86.08%) agreed that it is very important to have a window in your room or immediate work area, and the share is slightly higher (84.85%) for those who worked from the office. Also, a larger percentage of the students (64.29%) believed that it is important to have windows in the room or immediate work area. Furthermore, a higher number of students representing 23.47% believed that the window in the room or immediate work area was moderately important while 3(9.09%) and 4(8.70%) those who worked from office and home respectively believed it was moderately important.

This aspect of the building design is usually accorded with the highest premium for effective functioning and productivity, especially with educational or institutional buildings, facilities and their environment (Nielsen et al., 2016). The post-occupancy evaluation tool is critical to identifying and evaluating design and behaviour. This design and behaviour are essential for facility managers, architects, designers, and decision-makers to provide design guidance for future facilities and improvement (Mohamed et al., 2017).

The survey participants were also asked how lighting is controlled at their workstation, as lighting control systems are essential in achieving a comfortable and suitable working environment and minimising energy consumption. This question is important to this research as the design of the light systems is vital because poorly designed and commissioned control systems can lead to uncomfortable levels of internal air temperature and unsuitable lighting conditions. According to the responses from the survey, 53.11% have wall switches combined with room sensors to control lighting at their workstation. When split by location, the univariate analysis suggests that more than half (56.52%) represents staff in the office who preferred wall switch with sensor system. 32.65% present students had wall switches with room sensors as their preferences. The other respondents representing 60.61%, 43.48% and 67.55% for those staff who work from home, staff who work from office and students respectively indicated that lighting is controlled centrally by the building management or other methods (standard wall switch, room sensor only, or dimmer switch).

Furthermore, results from the lighting control system reveals that majority of the respondents used wall switch with room sensor which represents 53%. The 53% is a percentile representation of the total number of respondents who preferred wall switch with room sensor which includes 13 staff working from home, 26 staff working from office and 32 students. This infers that a larger number of students preferred wall switch with room sensor followed by the staff working from office. However, a higher number of staff, combination of both working from home and office preferred wall switch with room sensor than students. This might be a reflection that the staff spend more time at the workstation building than students. This use of wall switches combined with room sensors has been corroborated by the recommendation of (Langford & Haynes, 2015; Lange et al., 2021) that in most workspaces, classrooms and residential accommodation, even if a sensor lighting switch is provided, switching on should be done manually. As Li et al., (2020) opined, the freedom or autonomy of occupants to adjust the lighting of their workplaces according to their preferences has a positive effect on their work satisfaction, motivation, vigilance and visual comfort. More so, the lighting conditions and controls with the design vary from place to place, but the lighting environment should directly impact the mood, circadian rhythms, attention, vision, circadian rhythms, and cognition (McArthur & Powell, 2020).

Furthermore, 47% of the respondents preferred other forms of lighting control systems such as side lamp, head lamp, table lamp among others. Constituting this 47% was 20 staff working from home, 20 working from office and 66 students. The result indicates that while higher number of staff preferred wall switch with room sensor, higher number of students preferred other forms of a forementioned lighting systems.

To further explain the characteristics of the workstation, data on the lighting control system were further represented in the pie charts below.

Table 6.4: Univariate Analysis of Workstation Characteristics among University Staff and Students (Contd.)

Variables	Full sample (n = 177) N	(%)	Work from home (n = 33) N	%	Work from Office (n = 46) N	%	Students (n = 98) N %
Glare problems at the workstation							
No	121	(68.36)	21	(63.64)	31	(67.39)	69 (70.41)
Yes	50	(28.25)	12	(36.36)	11	(23.91)	27 (27.55)
Missing	6	(3.39)	0	(0.00)	4	(8.70)	2(2.04)
Main heating/cooling system at the current workstation							
Hot water radiator	126	(71.19)	26	(78.79)	23	(50.00)	77(78.57)
Storage heaters	11	(6.21)	2	(6.06)	3	(6.52)	6(6.12)
Warm air systems	10	(5.65)	2	(6.06)	4	(8.70)	4(4.08)
Air conditioning	20	(11.30)	2	(6.06)	10	(21.74)	8(8.16)
Others	10	(5.65)	1	(3.03)	6	(13.04)	3(3.06)
Access to temperature controls at the workstation							
Time switch	34	(19.21)	6	(18.18)	5	(10.87)	23 (23.47)
Thermostatic radiator valves	69	(38.98)	13	(39.39)	19	(41.30)	37 (37.76)
Storage dials	17	(9.60)	1	(3.03)	2	(4.35)	14 (14.29)
Multiple	17	(9.60))	9	(27.27)	0	(0.00)	8 (8.16)
Others	40	(22.60)	4	(12.12)	20	(43.48)	16(16.32

When asked whether they had glare problems at their workstation, less than 30% responded that they had glare problems due to the sun. Specifically, 28.25% of the respondents claimed there was glare problem at the workstation. This was far below the respondents who claimed there was no glare problems at the workstation who were 121(68.36%) in number and a very low missing value of 6 representing 3.39%.

In terms of location, 36.36%, 23.91% and 27.55% of those who responded to the home, office and students survey, respectively, reported that they had glare issues due to the sun. The lower proportion of 'office survey' participants responding to glare issues may be linked to the orientation of the buildings. One of the reasons for this could be the availability and use of shading devices to reduce the glare problems in the rooms, which could help improve indoor visual comfort, make the day lighting uniformity, and reduce artificial lighting demands (Mao and Fotios, 2021).

In addition to the lighting systems, the survey inquired about the source of heating/cooling and the temperature controls at the workstation. The data suggests that more than 70% of the respondents have hot water radiators as their main heating/cooling system, whilst 11.30% use air conditioning, 5.65% use warm air systems, 6.21% use electric storage heaters, and 5.65% use other sources for heating or cooling at their current workstation When split by their location, a large proportion (78.79%) of those who worked from home use hot water radiators. One in every two respondents (50%) use hot water radiators for those who responded from their office. A larger percentage of students used Heater Water Radiator at 78.57%. Regarding the temperature controls, 38.98% of the respondents use thermostatic radiator valves to control the temperature at the workstation. When split by the work area, radiator valves remain the most common heating control for those who responded from home (39.39%). Similarly for students, the thermostatic radiator valves remain the most common heating control with a percentage of 37.76%. For those who responded from the office, 41.30% also used thermostatic radiator valves, and 43.48% used other means.

In terms of accessing temperature controls at the workstation, the result showed that Thermostatic had the highest access with 69 respondents representing 38.98%. This was followed by Time switch with 34 (19.21%), 17(9.60%) respondents claimed they had access to storage dials and multiple respectively. To this end, it could be said thermostatic radiator valves was the highest accessed temperature control system at the workstation.

To further explain the characteristics of the workstation, data on the heating control system were further represented in the pie charts below.

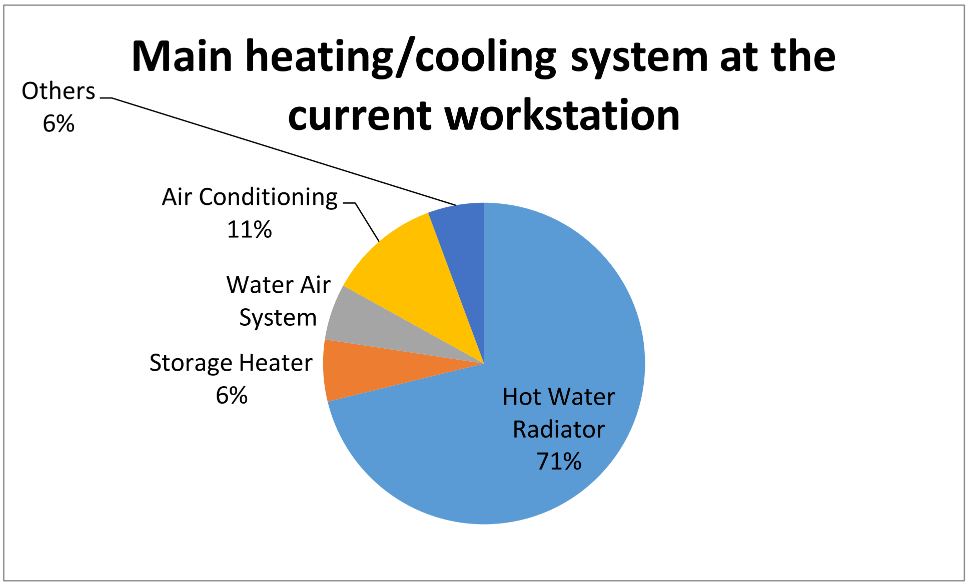


Figure 6.6: Pie Chart Representing the Main Heating System at Workstation

The Figure 6.6 above represents the common heating/cooling system being adopted at the workstation. The result indicates that 71% of the respondents experienced hot water radiator as their main heating system. The 71% comprises 26 respondents working from home, 23 respondents from office and 77 students. This implies that a larger proportion of students prefer hot water as heating/cooling system than staff working at home and office combined.

The warm air system and storage heater represent the lowest preferred heating system being adopted by the respondents representing 6% each. The 6% for the warm air system comprised the addition of 2 staff working from home, 4 working from office and 4 students while 6% for storage heaters comprises 2 workers from home, 3 workers from office and 6 students. It could be inferred from the result that equal number of students and workers from office preferred warm air system. The number of staff who work from home when combined with those who work from office are higher than the students who prefer warm air water. In other words, a higher number of staff preferred warm air system than students. Contrarily, a higher number of students preferred storage heater than staff working at home and office when combined.

Furthermore, 11% of the respondents preferred air conditioning as the main heating system which were made up of 2 and 10 staff from home and office respectively and 8 students. This implies that more staff preferred air conditioning as their main heating/cooling system than students.

Conclusively, the result further re-establishes the result in Table 6.4 that the main heating control system being used is Hot Water Radiator. This result is synonymous to the result of Østergaard et al. (2018) and Benakopoulos et al. (2019) whose study found out that the hot water radiator system was sufficient for the considered building and as such was the most used control system.

6.4 Data Analysis Objective by Objective

This section presents the analyses of the study objectives using different statistical tools based on the nature of the study objectives.

6.4.1 Objective One: Commonly used Heating Systems at the Workstation Building

To achieve this objective, the study made use of one-sample T-test by comparing the means of the usage of different heating systems. The results obtained are further shown in Table 6.5

Table 6.5: One-Sample T-test Results showing the commonly used Heating Systems at the Workstation

Variables	Mean	Std. Dev.	Std. Error	Sig.
Hot-Water Radiator	42.00	2.34	.052	.0132
Storage Heater	3.67	2.06	.062	.024
Warm air System	6.67	4.16	.072	.065
Air Condition	6.89	4.23	.013	.042

Results from Table 6.5 reveals the most used heating system at the workstation by considering the heating systems at the workstation as at the time of the survey. The results revealed that the hot-water radiator was the most used heating system with a mean of 42.00 while storage heater had a mean usage of 3.67, warm air system had a mean of 6.67 and Air Condition had a mean of 6.89. The result implies that a higher number of the respondents preferred to use hot-water radiator as a form of heating system when using the workstation. The choice of using hot-water radiator can be attributed to effectiveness when compared with its contemporaries. This result corroborates the result of Østergaard et al. (2018) and Mao and Fotios (2021).

In addition, it was also found from the result that the mean of hot-water radiation was significant at $P< 0.05$. This implies that the hot-water radiation was not only the commonly used heating, but its usage is also significant. However, the hot-water radiation had a standard deviation of 2.34, which signifies the risk of using hot-water radiation is low. Contrarily, the use of air condition had the highest risk of usage with a standard deviation of 4.23. In addition, the air condition had an average usage of 6.89 which was significant at P< 0.05. In other words, the use of air condition though small but was significant, that is it usage was important.

This was followed using warm air system with a mean usage of 6.89 and a standard deviation of 4.16. This implies that the use of warm air system had a risk of 4.16 which was not significant at P<0.05. This implies that the use of warm air system as at the period of the research was inconsequential.

Lastly, the storage heater had an average usage of 3.67 and a risk 2.06 which was not significant at P<0.05. Therefore, the use of storage heater as a form of heating system though poses risk but the risk is not consequential.

6.4.2 Objective One: Commonly used Lighting Systems at the Workstation Building

To achieve objective one, the study made use of One-way T-test. With the use of T-test, the study established the mean difference between the wall switch with room sensor and other forms of lighting systems. Table 6.6 below shows the details of the result.

Table 6.6: One-Way T-test Results showing the commonly used Lighting Systems at the Workstation

Variable	Mean	Std, Dev.	Std. Error Mean	Sig,
Wall Switch	31.33	8.02	4.63081	.021
Desk Switch	27.67	13.28	7.66667	.015

Results from Table 6.6 above shows the mean values which describe the commonly used lighting systems. The result reveals that the most commonly used lighting system at the workstation was the wall switch with room sensor with an average usage of 31.33 which was higher than the mean of desk switch which has a mean of 27.67. Furthermore, the mean of the wall switch and other lighting systems were found to be significant at $p<0.05$. In addition, the wall switch had a standard deviation of 8.02 which signifies that the use of wall switch room sensor had a high level of risk with its usage. Contrarily, the use of desk switch had a higher risk of 13.28 for its usage.

This implies that the usage of the two lighting systems significantly contributed to whatsoever use the respondents were using them for. This result corroborates the result of Østergaard et al. (2018) and Benakopoulos et al. (2019).

6.5 The Level of Users' Satisfaction in the use of Heating and lighting Systems at the Workstations Buildings

To determine the level of user's satisfaction in the use of heating and lighting systems at the workstation buildings, the study made use of binary logistic regression. The analyses employed two independent variables as predictors. The regression model encompassed only those predictors with value below 0.05. Occupants' satisfaction was coded numerically as 1, 2, and 3 corresponding to very dissatisfied, neutral and very satisfied respectively.

Basically, logistic regression function is as follow:

$Z = β0 + β\ 1X1 + β\ 2X2 + ... + β\ kXk + ε$

Where,

Z = latent variable

X1, X2, ..., Xk = independent variables β0 = constant

β1, β2, ..., βk = change in Y for a change of one unit in X1, X2, ..., Xk respectively

ε = error term

The results are further presented in Table 6.7 below.

Table 6.7: Binary Logistic Regression

		B	Sig, Error	Wald	Sig.	Exp (B)
Step 1a	Lighting system	3.532	.249	36.762	.000	5.032
	Constant	-5.137	.934	30.752	.023	.003
Step 2b	Heating system	3.261	.283	.326	.0023	3.211
	Lighting system	2.563	.351	.276	.000	.376
	Constant	-8.313	.271	.142	.031	.000

Variable(s) entered on step 1: Lighting system.

b. Variable(s) entered on step 2: Heating system.

By using forward stepwise method, SPSS generated a series of two stages (refer to Table 6.7) for incorporating the predictors that held notable significance in contributing to the logistic regression model. The initial step, step 1, uncovered a noteworthy connection among the lighting systems and the likelihood of occupants expressing satisfaction, with a chi-square value (X^2) of 63.00 and a p-value (P< 0.05). Moving on to Step 2, the analysis revealed a similar trend with lighting and heating systems, resulting to (X^2) of 21.93 and a p-value (P< 0.05) 0.05 for both lighting and heating systems.

Furthermore, considering the beta value (B), the result showed that 35.32% of the variation in the occupants' satisfaction was predicted by the lighting system. However, when combined with the heating system in step 2, the lighting system explained 25.63% of the variation in the occupants' satisfaction while heating system explained the 32.61%. It is quite important to note that these variations explained by the independent variables were both significant at $p<0.05$.

Consequently, it can be inferred that the model suitably fits the available data. This led to the derivation of the logistic regression equation as depicted in Table 6.7:

$Z = - 8.313 + 3.261\ HS + 2.563LS + .031$

Considering these results, since the lighting and the heating systems defined a considering few percentages of the occupants' satisfactions, therefore, it could be said that the respondents were fairly satisfied with the lighting and the heating systems at the workstation. The reason behind the fair satisfaction is because the lighting and the heating systems did not explain half (50%) of the variation in the occupants' satisfaction. This further informs the next objective that is the challenges attributed to the heating system.

Furthermore, the results of the study are presented in the pie chart in Figures 6.7 and 6.8

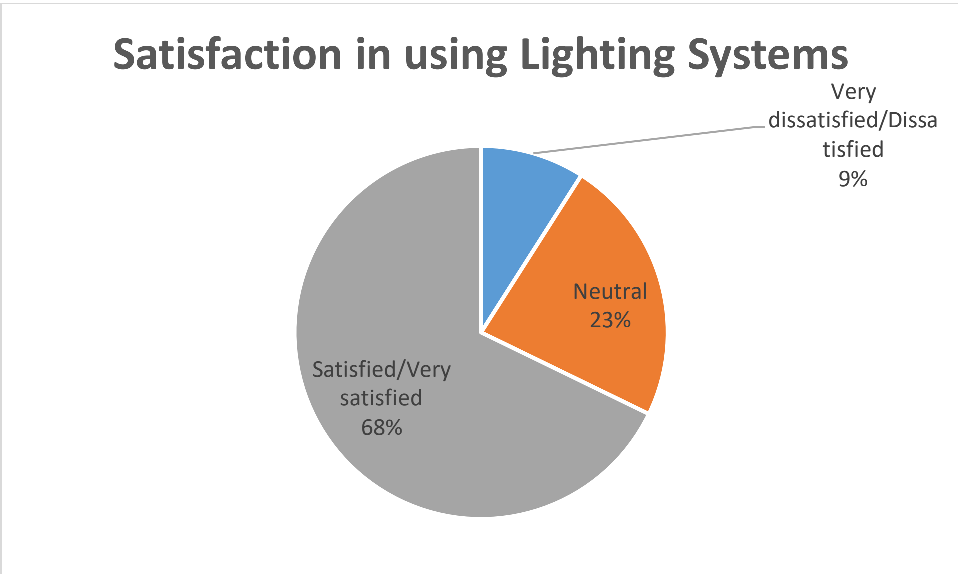


Figure 6.7: Pie Chart Representing Light Control at the Workstation

Results from Figure 6.7 indicate that a larger percentage of the respondents were satisfied with the with the lighting systems at the workstation with a significant percentage of 68% formed from 25 staff from home, 22 staff from office and 73 students. This means that more students are very satisfied with the lighting system than the staff and this could be evidence that the students make use of the lighting systems often than the staff for activities such as reading, writing among others. A lower percentage of 23% of the respondents were indifferent about satisfaction of the lighting system. This means they were neither positive nor negative with the satisfactory level of the lighting system at the workstation. Furthermore, an insignificant percentage of 9% were dissatisfied with the lighting system at the workstation.

Conclusively, it can be inferred from the results that a higher percentage of the respondents were satisfied with the lighting system at the workstation. This result is synonymous with the, p [

study of Veitch et al. (2005) whose study examined the satisfaction with lighting in open-plan office and found out that the respondents were satisfied with the lighting system. Also, somewhat like the study is a study by Duijnhoven et al. (2013), the study established that satisfaction in relation to office light system were not always statistically significant throughout the study period.

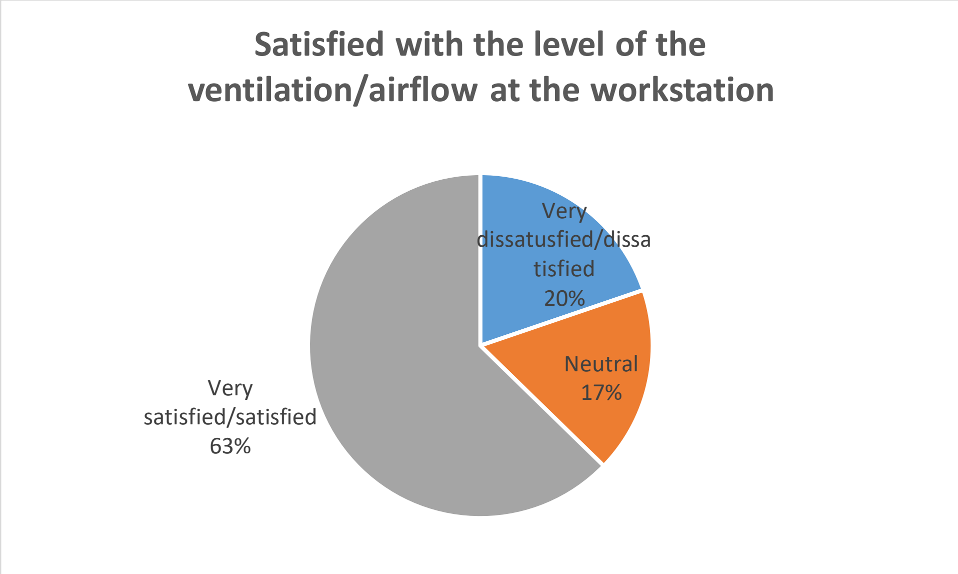


Figure 6.8: Pie Chart Representing Heating Control System at the Workstation

The above Pie Chart in Figure 6.8 reflects the satisfaction of the respondents on the heating control system at the workstations. Like the result obtained in the light control system, a larger percentage of the respondents at 63% were satisfied with the heating control system and this percentage was made up of 4 workers from home, 19 workers in the office and 8 students. This is an indication that workers in the office were more satisfied with the heating control system than every other respondent. Furthermore, the study revealed that 17% of the respondents were neutral and indifference about the heating control system which was made up of 6 workers from home, 11 from office and 14 students. This result implies that students were more neutral in regard the heating control system followed by 11 workers from office. However, a slightly higher percentage of 20% were dissatisfied with the heating system at the workstation. The 20% comprised 4 workers from home, 19 workers from office and 8 students. The result indicates that a higher number of workers from office were dissatisfied with the heating system. Conclusively, it can be inferred from the results that a higher percentage of the respondents were satisfied with the heating system at the workstation.

6.6 Challenges Associated with the Lighting and Heating System at the Workstation Buildings

To achieve this objective, the study made use of one-sample T-test by comparing the means of the usage of different heating systems. The results obtained are further shown in Table 6.8

Table 6.8: One-Sample T-test Showing the Lighting and Heating System at the Workstation

Variables	Mean	Std. Dev.	Std. Error	Sig.
No	40.33	25.32	.043	.000
Yes	16.67	8.96	.056	.004
Missing	2.00	2.32	.014	.065

Results from Table 6.8 revealed that an average of 40.33 of the respondents expressed their opinions that there was no glaring problem at the workstation and the perception of these respondents were found to be significant at P< 0.05. Furthermore, an average of 16.67 of the respondents identified that there was glare problem at workstation and like those who claimed there was no glare problem, their view was also found to be significant at P< 0.05. Those whose response were missing had an average of 2.00, however, there response was not significant.

It could therefore be said that a higher number of the respondents were of the view that the there was no glare problem at the workstation and with their view being significant, it implies that their views are relevant. However, the views of the respondents who claimed that there was glare problem at the workstation cannot be overruled because their views were significant as well. Thus, this result further informs the next objective that is the effects of the lighting and heating systems at the workstation. This result is synonymous to the studies of Šeduikyte & Paukštys (2008); Nemethova et al. (2016) whose studies established that glare problem was one of the serious challenges affecting the lighting system in buildings especially the residential building.

Below is the pie chart showing the percentages of the respondents as regards the glare problem at the workstation.

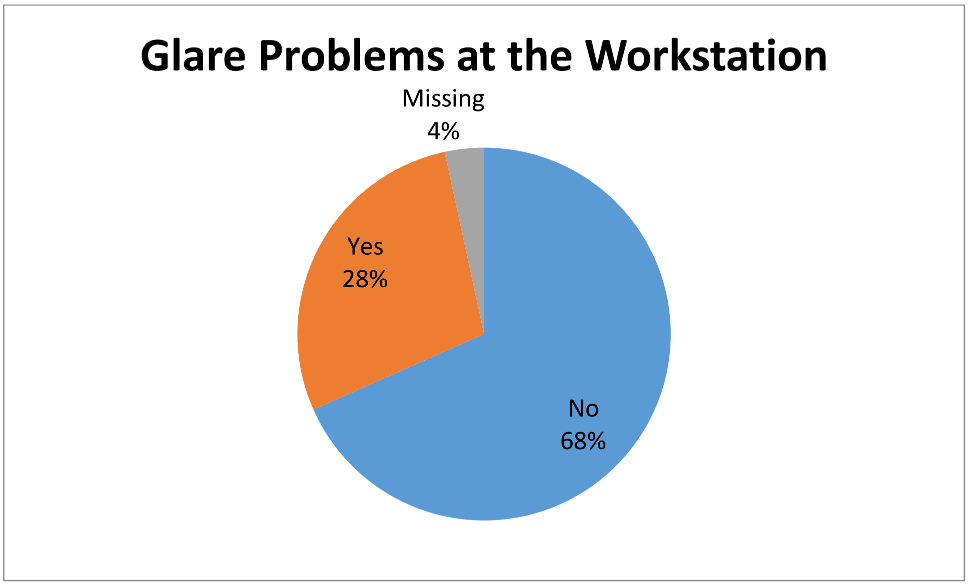


Figure 6.9: Pie Chart Representing the Glare Problems at the Workstation

The Figure 6.9 above re-establishes the result in Table 5 above by indicating that 68% of the respondents did not identify glare problem at the workstation. Numerically, this 68% are made up of 21 staff working from home, 31 staff working from office and 69 students. This implies higher number of students do not experience glare problems compared to the staff. Contrarily, 28% found out that there was glare problem at the workstation. The 28% represent the percentage of the added number of respondents which were, 12 staff working from office, 11 staff working from home and 27 students. Comparing the results, it is an indication that the glare problems are not predominant at the surveyed workstations. Therefore, the glare problem though is part of the challenges affecting the lighting and heating system, it is not the major challenge affecting the lighting and heating systems.

6.7 Effects of Lighting and heating Systems on the Performance of the Workstation Buildings

To achieve this objective, the study will make use of bivariate regression analysis. To use the bivariate regression analysis, the heating and lighting systems will be used as independent variables while data on the performance of the workstation buildings is used as dependent variable. The regression equation is given below:

$\Upsilon = \alpha + \beta_1 X_1 + \beta_2 X_2 + \varepsilon$………………. (3.1)

Where:

Υ = Dependent variables (Performance of the workstation)

α = Intercept

$\beta_1 X_1$ = Coefficient and independent variable – lighting system

$\beta_2 X_2$ = Coefficient and independent variable – heating system

ε = Error terms

The result of the studies is further presented in Table 6.9 below:

Table 6.9: Regression Analysis showing the Effects of Lighting and Systems on the Performance of the Workstation Buildings

Model	Unstandardized Coefficient		Standardized Coefficient	T	Sig.	R-Square
	B	Std. Error	Beta			
Constant	.005	.013		1.054	.039	.438
Lighting System	.036	.010	.528	4.459	.000	
Heating System	.016	.018	-.402	-1.542	.047	

Dependent variable: Workstation Building

From Table 6.9, the unstandardized coefficient elucidates the impact of a one-unit change in the independent variables (Lighting and Heating Systems) on the dependent variable (Performance of Workstation building).

In this context, the findings from Table 6.9 divulge that the unstandardized coefficient maintains a constant value of 0.005, which holds significance at a level of $P < 0.05$. This suggests that the value of the dependent variable (Performance of the workstation) remains at 0.005 when the independent variables (lighting and heating systems) are held constant. Furthermore, one of the principal predictive factors, also referred to as the independent variable (lighting system), had a positive unstandardized coefficient of 0.036, and significant at $P < 0.05$. This outcome signifies that a single unit alteration in lighting system had a substantial 3.6% influence on the workstation building performance. The positive unstandardized coefficient of lighting system implies a direct relationship with the performance of workstation building, suggesting that an increase in lighting system effectiveness leads to a corresponding increase in workstation building performance. Conversely, a decrease in lighting system results in a decrease in the performance workstation building.

Similarly, akin to the observations concerning heating system, had a negative unstandardized coefficient of 0.016 (1.6%). However, this coefficient was statistical significance at the $P<0.05$. This suggests that a unit change in heating system leads to consequential positive impact of 1.6% on digital payment. In simpler terms, the connection between heating system and the performance of workstation building was positively significant.

Moreover, the coefficient of determination (R square) indicates that 43.8% of the variance in the dependent variable (workstation building performance) can be accounted for by changes in the independent variable (lighting and heating systems).

Contrary to this result, a relatable study by Boyce (2010) while examining the impact of lighting system on human health, the study found out that lighting system negatively affect human health. The study further classified the negative effects into three which are, light as a radiation, lighting operating through virtual which all causes discomfort to the eyes. Similarly, a study by Katabaro and Yan (2019), the study examined the effects of lighting quality on workers efficiency in offices in Tanzania, the study revealed that majority of the were less satisfied with the lighting quality and as such, the workers complained that the lighting system affected their working efficiency.

6.8 Commonly Applied Temperature Controls among the Users at the Workstation Buildings

To achieve this objective, the study made use of One-Sample T-test and the results are presented in Table 6.9 below.

Table 6.10: One-Sample Statistics of the Commonly Applied Temperature Controls

Variables	Mean	Std. Deviation	Standard Error	Sig,
Time Switch	11.3333	10.11599	5.84047	.012
Thermostatic	15.6667	18.90326	10.91380	.008
Storage Dial	5.6667	7.23418	4.17665	.308
Multiple	5.6667	4.93288	2.84800	.185
Others	13.3333	8.32666	4.80740	.013

Results from Table 6.10 revealed the commonly applied temperature controls at the workstation using the one-sample statistics. The result revealed that most applied temperature control at the workstation was the thermostatic with a mean of usage of 15.67 which was higher than other temperature control at the workstation. In addition, the result further established that the usage of thermostatic was significant at $P<0.05$. This implies that the usage of thermostatic as a form of temperature control played a significant role in the usage of the workstation by the respondents. Next to the thermostatic was the time switch which had a mean usage of time switch with a mean usage of 11.33, and it is significant at $P<0.05$. However, the usage of multiple and storage dial was not significant $p>0.05$. This implies that the usage of the multiple and storage dial at the workstation were not as important as thermostatic and time switch. The result obtained corroborated the study Carmody et al. (2014)

The results are further reflected in the pie chart in Figure 6.11 below.

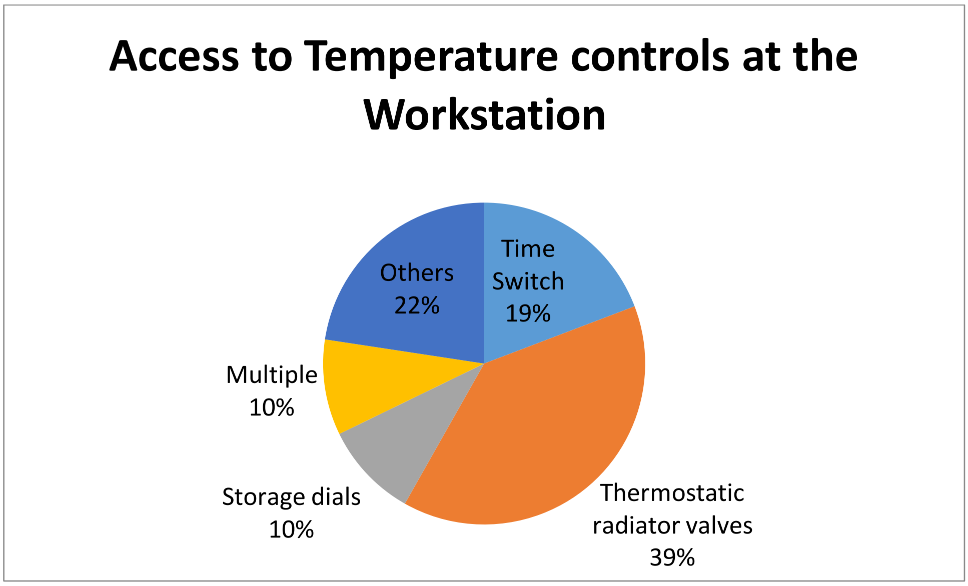


Figure 6.10: Pie Chart of Access to temperature controls at the workstation

The Figure 6.10 above is a representation of the respondents' responses on the access to temperature controls at the workstation. The result shows that 39% of the respondents have access to thermostatic radiator valves as a form of temperature control at the workstation. This 39% represents the percentage of the sum of values of the respondents, 13 staff at home, 19 in the office and 37 students. This is an indication that higher number of students had access to thermostatic radiator valves as a form of temperature control at the workstations than the staff even when combined.

However, the lowest form of temperature control at the workstations was the storage dials which represents 10% of the total respondents and was made up of 1 staff working from home, 2 working from office and 14 students. Like the previous result, a higher number of students accessed storage dials than the staff.

6.9 Effectiveness of the applied temperature controls at the workstation buildings.

The interpretations of this objective can be determined from the pie-chart onward.

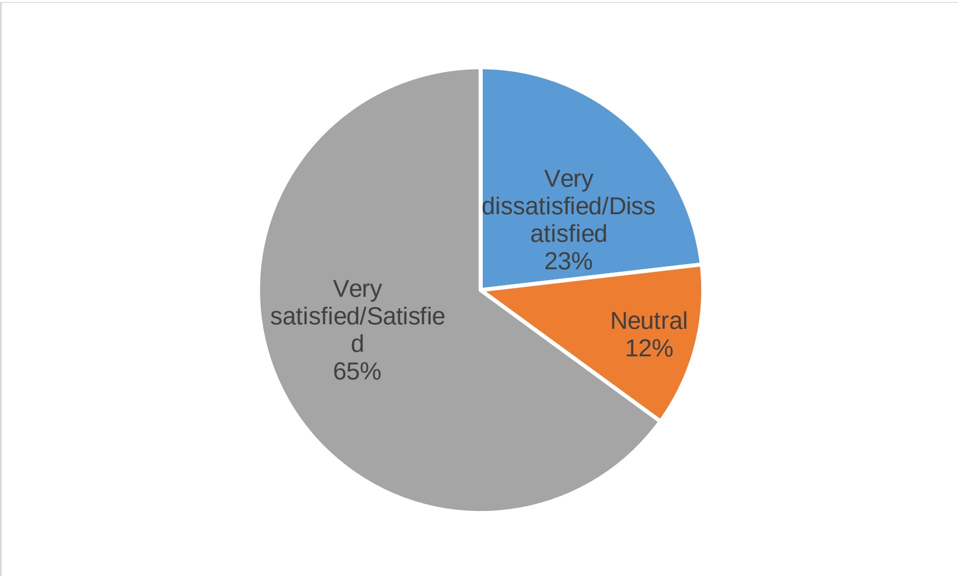


Figure 6.11: Pie Chart of Effectiveness of the Temperature Controls at the Workstations

Result for this objective will be inferentially deduced from Table 6.11 under the heading, satisfaction with the temperature control system at the workstation. The level of satisfaction will help to infer if the temperature controls at the workstations are effective or not.

It can therefore be inferred from Figure 6.11 above that a larger percentage of the respondents were very satisfied with temperature control system with a percentage of 65% which was made up of 21 and 16 staff working from home and office respectively while 78 were students. This infers that a higher number of students believed that the temperature control system was effective than the staff. A lower percentage of 12% was neutral about the effectiveness of the temperature control system comprising equal number of staff (6) working from home and offices and 9 students. In addition, 23% of the respondents were dissatisfied with the temperature control system comprising 6 and 24 workers from home and office respectively and 11 students. This is an indication that workers from home were more dissatisfied with temperature control system than other respondents. The result corroborated with the studies such as Nolan et al. (2013) and Lubock et al. (2017) in a study that examined the effectiveness of temperature control of thermocyclers in offices and the study found out that the temperature control system was effective.

Table 6.11: Univariate Analysis of Satisfaction with the lighting at the workstation among University Staff

	Full sample (n = 177)		Work from home (n = 33)		Work from Office (n =46)		No and % of students. (98)
Variables	**N**	**(%)**	**N**	**%**	**N**	**%**	**N %**
Satisfaction with the existing artificial electric lighting at the workstation							
Very dissatisfied/Dissatisfied	16	(5.65)	2	(6.06)	8	(17.39)	6(6.12)
Neutral	41	(23.16)	6	(18.18)	16	(34.78)	19(19.39)
Satisfied/Very satisfied	120	(67.80)	25	(75.76)	22	(47.83)	73(74.49)
Satisfied with the position of light fittings at the workstation							
Very dissatisfied/Dissatisfied	16	(9.03)	4	(12.12)	6	(13.04)	6(6.12)
Neutral	35	(19.77)	7	(21.21)	17	(36.96)	11 (11.22)
Satisfied/Very satisfied	127	(17.75)	22	(66.67)	23	(50.00)	82(66.33)
Rating of lighting control measures at the current the workstation							
Very dissatisfied/Dissatisfied	21	(16.46)	2	(6.06)	11	(23.91)	8(8.16)
Neutral	37	(20.90)	9	(27.27)	11	(23.91)	17(17.35)
Satisfied/Very satisfied	119	(67.23)	22	(66.67)	24	(52.17)	73(74.49)
Rating of natural lighting at the current the workstation							
Very dissatisfied/Dissatisfied	24	(13.56)	2	(6.06)	11	(23.91)	11(11.22)
Neutral	27	(15.21)	4	(12.12)	6	(13.04)	17(9.60)
Satisfied/Very satisfied	126	(71.19)	27	(81.82)	29	(63.04)	70(7.0)

N= Sample size; % = Sample percentage

Table 6.11 describes the outcome variables, that is, the satisfaction of lighting among University Staff. First, the respondents were asked about their satisfaction with their workstation's existing artificial (electric) lighting. More than half (67.80%) of the respondents were satisfied with the existing artificial lighting, and this was driven by those who responded from home, office and students (75.76%, 47.83% and 74.49%) respectively. Among the latter (i.e., work from home), 18.18% were neutral. 34.78% and 19.39% represented respondents in the office and students who were neutral respectively. Furthermore, 6.06%, 17.39% and 6.12% represented workers at home, workers in the office and students respectively who were dissatisfied with their lighting.

Second, the respondents were asked about their satisfaction with light fittings at the workstation. The results show that 71.75% of the respondents were satisfied or very satisfied with the position of light fittings at the workstation. Among the rest of the respondents, 19.77% were neutral, and 9.03% were very dissatisfied or dissatisfied with the position of the light fittings. Moreover, 66.67%, 50% and 66.33% were satisfied/very satisfied with the position of light fittings working from home or the office, respectively.

Concerning the rating of lighting control measures at the current workstation, as shown in Table 6, generally, more than half of the respondents are satisfied/very satisfied with the lighting control measures. Moreover, two-thirds of the respondents who worked from home were satisfied/very satisfied, 52.17% and 74.49% of those who worked from the office and students respectively were satisfied/very satisfied with the lighting control measures at the current workstation. Furthermore, more participants who responded from the office were more likely to report dissatisfaction with the lighting control measures at their current workstation.

Again, a large proportion of the respondents (71.19%) were satisfied with the natural lighting at the current workstation, 15.21% were neutral, and 13.56% were dissatisfied or very dissatisfied. In terms of their area of work, approximately four out of five respondents who were working from home at the time of the survey were satisfied or very satisfied with the natural lighting at the current workstation. For those whose workstation was at the office, 63.04% were satisfied/very satisfied, 13.04% were neutral, and 23.91% were dissatisfied or very dissatisfied. While for students, 70% were satisfied, 9.60% were neutral and 11.22%

were dissatisfied or very dissatisfied. Using an open-ended question, the respondents were asked the following question ‘if they could change the lighting in their work area, what would they do?’. 34.62% of the respondents said they would not change anything, whereas 65.38% said they would change things. Among the 51 respondents who opted for a change, 21.57% said they would need to be able to control the brightness or light output of the overhead lighting fixtures, and 19.61% said they would need to get access to a window view and daylight, the remainder had a range of suggestions for the lighting system within their workstation.

Table 6.12: Univariate Analysis of Satisfaction with the heating/cooling at the workstation

	Full sample (n = 177)		Work from home (n = 33)		Work from Office (n = 46)		Students (98)
Variables	**N**	**(%)**	**N**	**%**	**N**	**%**	**N %**
Satisfaction with the level of control over ventilation/air flow at the workstation							
Very dissatisfied/Dissatisfied	51	(28.81)	4	(12.12)	23	(50.00)	24(24.49)
Neutral	32	(18.07)	7	(21.21)	10	(21.74)	15(15.31)
Very satisfied/Satisfied	94	(53.11)	22	(66.67)	13	(28.26)	59(60.20)
Satisfied with the level of the ventilation/airflow at the workstation							
Very dissatisfied/Dissatisfied	31	(17,51)	4	(12.12)	19	(41.30)	8(8.16)
Neutral	31	(17.51)	6	(18.18)	11	(23.91)	14(14.29)
Very satisfied/Satisfied	115	(64.97)	23	(69.70)	16	(34.78)	76(77.55)
Satisfaction with the temperature at the current workstation							
Very dissatisfied/Dissatisfied	32	(40.51)	6	(18.18)	26	(56.52)	23(23.47)
Neutral	13	(16.46)	6	(18.18)	7	(15.22)	16(16.33)
Very satisfied/Satisfied	34	(43.04)	21	(63.64)	13	(28.26)	59(60.20)
Satisfaction with the level of comfort at the current workstation							
Very dissatisfied/Dissatisfied	39	(22.03)	7	(21.21)	15	(32.61)	17(17.35)
Neutral	25	(14.12)	6	(18.18)	10	(21.74)	9(9.18)
Very satisfied/Satisfied	113	(63.84)	20	(60.61)	21	(45.65)	72(73.47)
Satisfaction with the temperature control system at the workstation							
Very dissatisfied/Dissatisfied	51	(28.81)	6	(18.18)	24	(52.17)	21(21.42)
Neutral	24	(13.56)	6	(18.18)	6	(13.04)	12(12.24)
Very satisfied/Satisfied	102	(57.63)	21	(63.64)	16	(34.78)	65(66.33)

N= Sample size; % = Sample percentage

Table 6.12 describes the satisfaction of ventilation/airflow, temperature, and comfort among the University Staff. First, the respondents were asked about their satisfaction with the level of control over ventilation/airflow at their workstations. On average, 53.11% of the respondents were satisfied/very satisfied, 18.07% were neutral, and 28.81% were very dissatisfied or dissatisfied. When split by the work area, the results suggest that more than two-thirds of the respondents who reported from their room were very satisfied/satisfied compared to 28.26% from the office. Furthermore, half of the respondents who work from the office were very dissatisfied or dissatisfied with the level of control over ventilation/airflow at the workstation compared to 12.12% of those who work from home. Also, more than half of the students at 60.20% were satisfied with the control over ventilation/airflow which was higher than those staff in the office at 28.26%.

In general, slightly under half of the respondents (64.97%) were very satisfied or satisfied, 17.57% were neutral, and 17.51% were very dissatisfied/dissatisfied with the level of the ventilation/airflow at the workstation. When split by location, more respondents who work from home are very satisfied or satisfied with the ventilation/air flow level at the workstation (69.70%) compared to 34.78% of those who worked from the office and 77.55%. Moreover, 41.30%, 12.12% and 8.16% of those working from home, office and students, respectively, were very dissatisfied with the ventilation or airflow level at the workstation.

Concerning the satisfaction with the temperature at the current workstation, on average, 31.07%, 16.38% and 52.54% of the respondents were very dissatisfied/dissatisfied, neutral and very satisfied/satisfied with it. When split by location, a large proportion of the respondents (63.64%) who work from home are very satisfied/satisfied with the temperature at the current workstation compared to 18.18% were neutral and 18.18% were very dissatisfied. On the other hand, for those working from the office, more than half of the respondents (56.52%) were very dissatisfied/dissatisfied, 15.22% were neutral, and 28.26% reported that they are very satisfied/satisfied with the temperature at the current workstation. For the students, a larger percentage of them at 60.20% were satisfied with the temperature at the current workstation, 16.33% were neutral and 23.47% were dissatisfied/very dissatisfied.

For their comfort level at their workstation, 63.84% of the respondents were very satisfied/satisfied, 14.12% were neutral, and 22.03% were very dissatisfied/dissatisfied. When split by location, more respondents working from home than those working from the office as well as students were very satisfied/satisfied with the comfort level at the current workstation. Finally, for the satisfaction with the temperature adjustment at the workstation, the results suggest that 57.63% were very satisfied/satisfied, 13.56% were neutral, and 28.81% were very dissatisfied/dissatisfied. When split by work area, more students (66.33%) were very satisfied/satisfied compared to those working from the office (34.78%) and home (63.64%). Moreover, more than half of the respondents (52.17%) working from the office was very dissatisfied/dissatisfied.

Table 6.13: Univariate Analysis of Satisfaction with the general impression and hours spent at the workstation among the University Staff

	Full sample (n = 177)		Work from home (n = 33)		Work from Office (n = 46)		Students (98)
Variables	**N**	**(%)**	**N**	**%**	**N**	**%**	**N %**
The general impression of the current workstation							
Dark/unevenly lit/Other	53	(29.94)	8	(24.24)	12	(26.09)	35(35.71)
Good/Even lighting	88	(49.72)	17	(51.52)	19	(41.30)	52(53.06)
Bright	34	(19.21)	8	(24.24)	15	(32.61)	11(11.22)
Satisfaction with the current workstation							
Low	32	(18.08)	3	(9.09)	14	(30.43)	15(15.31)
Average	87	(49.15)	15	(45.45)	27	(58.70)	43(43.88)
High	60	(33.90)	15	(45.45)	5	(10.87)	40(40.82)
Number of hours spent at the workstation							
Less than 4 hours	27	(15.25)	2	(6.06)	12	(26.09)	13(13.27)
4 hours or more	150	(84.75)	31	(93.94)	34	(73.91)	85(86.74)

N= Sample size; % = Sample percentage

Table 6.13 describes the satisfaction with the workstation. First, when the respondents were asked about the general impression of their workstation, a significant proportion reported that they have good or even lighting (49.72%), 19.21% reported that their workstation was bright, and 29.94% reported that their workstation was not bright or evenly lit. For those who reported from the office, 41.30% reported that their workstation has good or even lighting, 32.61% reported that their workstation is bright, and 26.09% were neither evenly lit nor bright. For the overall satisfaction with the current workstation, the satisfaction with the current workstation was reported to be average. In general, 49.15% reported average satisfaction, 33.90% reported high satisfaction, and 18.08% reported low satisfaction with the current workstation.

Again, the respondents were asked about the number of hours spent at the workstation, which measures their productivity. A large proportion of the respondents spend at least 4 hours or more at their workstation (84.75%). When split by the work area, 93.94% of those who worked from home reported spending four or more hours compared to 73.91% and 86.74% of those who worked from the office and students respectively.

6.10 Summary from the Univariate Analysis

To address the research objectives, the study collected essential data, including input from staff both on-site and remote due to COVID-19. A second survey was conducted to consider pandemic-related impacts and variations among staff working remotely, offering a fresh perspective. This dataset will enhance the study's rigor through comparative analysis.

The datasets were analysed towards achieving the study objectives. For objective one, the study found out that the most used lighting system at the workstation was the wall switch with an average usage of 31.33. Also, the study found that the most commonly used heating system was the Hot Water Radiator with a mean usage of 42. For objective two, the study found that though the users of the workstation were satisfied with the lighting and the system, however their level of satisfaction was not at maximum because neither the heating nor lighting systems explained 50% of the users' satisfactions. For objective three, the result revealed that a larger number of the respondents representing an average of 40.33 claimed there was no glare problem at the workstation. However, an average of 16.67 claimed that there was glare problem at the workstation. For objective four, result showed that the lighting and the heating had significant effects on the performance of the building and the users. For objective five, the result revealed that that most used temperature control system is thermostatic with an average usage of 15.67.

From the above results, the Post Occupancy evaluation can be deduced. It can be concluded that there was existence of glare problem at the workstation though not substantial. Also, some of the users were satisfied with the lighting and heating systems though the satisfaction was not substantial enough.

CHAPTER 7: STAFF CHARACTERISTICS AND SATISFACTION WITH WORKSTATION

7.1 Introduction

Chapter 7 presents the findings and discussion from the school (office) and home survey. The statistical method and measures will be explained, the analytical methods and the empirical results will be presented using descriptive statistics. The approach adopted for this chapter is to present the feedback and discussion from the survey first, then compare the survey conducted from school(office) and home. Lastly, present and discuss the structured questionnaires conducted from the university's estate facilities and sustainability department.

7.2 Statistical Methods

7.2.1 Measures

Four dimensions of the participants' perceptions of their workstation will be investigated (lighting, ventilation/airflow, temperature, and the workstation itself). Four indicators were employed for the lighting (existing artificial electric lighting, the position of light fittings, lighting control measures and the natural lighting), five indicators for the ventilation and temperature (level of control over ventilation/air flow, level of the ventilation/air flow, temperature, level of comfort, temperature adjustment), and three indicators for the workstation itself (general impression, satisfaction and the number of hours spent working).

7.2.2 Analytical Methods

This analytical method seeks to investigate the factors associated with the user's satisfaction with their workstation and productivity (measured by the number of hours they spend at their workstation). The bivariate analysis using cross tabulation-Chi-Square analysis and

Spearman rank correlation test were carried out in Stata version 14. Separate bivariate analyses were done between the independent variables and the workstation outcomes (satisfaction with lighting performance, satisfaction with the heating/cooling performance, and time spent at the workstation used as a measure of productivity). The results are shown in Table 8.

The spearman rank correlation was also conducted to determine the direction of relationship among the outcomes of interest i.e., the user satisfaction with their lighting, ventilation and temperature, and the number of hours spent at their workstation (see Table 8). The analyses helped identify any significant confounding variables in the relationship between workstation characteristics/performance and the average user's satisfaction.

Referring to Table 6.6, Columns 1 & 2 (Chapter 6), indicates that a significant number of the respondent reported high satisfaction with the existing artificial electric lighting at the workstation (67.80%), position of light fittings (71.75%), lighting control measures (67.23%) and natural lighting (71.19%).

7.3 Empirical Results

7.3.1 Socio-Demographic Characteristics and lighting at the workstation

7.3.1.1 Descriptive Analysis

Referring to Table 6, Columns 1 & 2 (Chapter 6), indicates that many of the participants reported high satisfaction with the existing artificial electric lighting at the workstation (67.80%), position of light fittings (71.75%), lighting control measures (67.23%) and natural lighting (71.19%).

7.3.1.2 Bivariate Results

As mentioned above, the Cross Tabulation Chi-Square test was conducted to ascertain the relationship between the Socio Demographic Characteristics (SDC) and the respondents' satisfaction with the performance of their workstation shown.

- **Satisfaction with existing artificial electric lighting at the workstation**

From the Chi-Square analyses in Table 7.1, the result indicates that there are significant variations concerning the area of work and the presence of glare problems with those working from home and those without glare problems being highly satisfied with the existing artificial electric lighting at the workstation (location [$\chi 2$ (2, N=177) = 5.233, $p<0.05$] and glare problems [$\chi 2$ (2, N=177) = 9.183, $p<0.05$] (see Table 7.1). The results indicate that location of the workstation played a significant role in the satisfaction with the existing artificial electric lighting at the workstation. Similarly, the glare problems played a significant role in the satisfaction with the existing artificial electric lighting at the workstation. Moreover, the results did not find significant gender or age differences in the respondents' self-reported satisfaction with the existing artificial electric lighting at the workstation. Therefore, the gender and age of the respondents were found insignificant because P-value was greater than 0.05 and this implies that the gender and age of the respondents did not contribute to their satisfaction to the artificial lighting.

Table 7.1: Bivariate Results of Satisfaction with lighting and Sociodemographic characteristics using Cross Tabulation-Chi-Square Test.

Variable	Satisfaction with the existing artificial electric lighting at the workstation							
	Low		Neutral		High			
	N	(%)	N	(%)	N	(%)	χ2	*p*-value
Personal Characteristics								
Gender								
Male	8	(12.70)	18	(28.57)	37	(58.73)	0.217	0.897
Female	17	(14.91)	30	(26.32)	67	(58.77)		
Total	25	(14.12)	48	(27.12)	104	(58.76)		
Age (years)								
18-29	10	(18.18)	11	(20.00)	34	(61.82)	7.058	0.798
30-49	13	(14.44)	22	(24.44)	55	(61.11)		
50 years or more	5	(15.63)	10	(31.25)	17	(53.13)		
Total	28	(15.82)	43	(24.29)	106	(59.89)		
Job Role								
Administrator	1	(6.25)	3	(18.75)	12	(75.00)	11.76	0.162
Technical	0	(0.00)	4	(40.00)	6	(60.00)		
Teaching and Research	8	(29.63)	6	(21.43)	14	(50.00)		
Teaching/Research only	0	(0.00)	4	(44.44)	5	(55.56)		
Other	1	(8.33)	4	(33.33)	7	(58.33)		
Total	10	(13.70)	21	(28.00)	44	(58.67)		
Workstation characteristics								
Location								
Home	2	(6.06)	6	(18.18)	25	(75.76)	5.233	0.073
Office	8	(17.39)	16	(34.78)	22	(47.83)		
University Students	18	(18.37)	33	(33.67)	47	(47.96)		
Total	28	(12.66)	55	(27.85)	94	(59.49)		
Time spent at residence or workstation								
Up to 1 year	6	(10.53)	9	(15.79)	42	(73.68)	2.289	0.515
2-5 years	11	(15.71)	20	(28.57)	39	(55.71)		

6-10 years	4	(16.67)	7	(29.17)	13	(54.17)		
10+ years	4	(15.38)	6	(23.08)	16	(61.54)		
Total	25	(14.12)	42	(23.73)	110	(62.15)		
Window in the room or workstation								
No	5	(23.81)	6	(28.57)	10	(47.62)	2.582	0.108
Yes	17	(10.89)	31	(19.87)	108	(69.23)		
Total	22	(12.42)	37	(20.90)	118	(66.67)		
Important to have a window in the room or immediate work area								
Not at all important	0	(0.00)	2	(50.00)	14	(50.00)	5.417	0.067
Moderately important	1	(0.00)	11	(28.57)	18	(71.43)		
Very important	13	(14.71)	23	(26.47)	95	(58.82)		
Total	14	(12.66)	36	(27.85)	127	(59.49)		
Lighting control at the workstation								
Wall switch with room sensor	14	(14.89)	24	(25.53)	56	(59.57)	0.262	0.608
Other	13	(15.66)	16	(19.28)	54	(65.06)		
Total	27	(15.25)	40	(22.60)	110	(62.15)		
Glare problems at the workstation								
No	21	(17.36)	26	(21.49)	74	(61.16)	9.183	0.024**
Yes	6	(50.00)	24	(48.00)	20	(40.00)		
Total	27	(15.79)	50	(29.24)	94	(54.97)		
Main heating/cooling system at current workstation								
Hot water radiator	18	(14.29)	41	(32.54)	67	(53.17)	0.820	0.936
Storage heaters	2	(18.18)	3	(27.27)	6	(54.54)		
Warm air systems	1	(10.00)	3	(27.27)	6	(54.54)		
Air conditioning	2	(10.00)	4	(20.00)	14	(70.00)		
Others	2	(20.00)	2	(20.00)	6	(6.00)		
Total	25	(14.12)	53	(29.94)	99	(55.93)		
Access to temperature controls at the workstation								
Time switch	4	(11.76)	6	(17.65)	24	(70.59)	1.988	0.738
Radiator valves	5	(7.25)	15	(21.74)	49	(71.01)		

Storage dials	2	(11.76)	4	(23.53)	11	(64.71)
Multiple	2	(12.50)	4	(25.00)	11	(68.75)
Others	7	(17.50)	12	(30.00)	21	(52.50)
Total	20	(11.30)	41	(23.16)	116	(65.54)

****p < 0.01, ** p < 0.05, N = sample size, % = percentage*

- **Satisfaction with the position of light fittings at the workstation**

Referring to Table 7.2, the results generally did not find any significant associations (at a 5% level of significance) between the independent variables and the user's satisfaction with the position of light fittings at the workstation. The user's response to whether they had a window in the workstation was statistically significantly associated with the position of light fittings, albeit at the 10% level of significance. Moreover, those who have a window were more likely to report high satisfaction with the position of the light fittings at the workstation (location [$\chi 2$ (2, N=177) = 2.038, $p<0.1$] (see Table 10). Again, the results did not find any significant gender or age differences in the respondents' self-reported satisfaction with the position of light fittings at the workstation.

Elaboratively, the results indicate that age had significantly described the satisfaction the respondents had with the position of light fittings at the workstation. To this end, the study found that age of the respondents was very important in the position of lighting fittings at the workstation. However, other variables were found to be insignificant and as such, they did not have significant contributions to the position of light fittings at the workstation.

Table 7.2: Bivariate Results of Satisfaction with the position of light fittings at the workstation and Sociodemographic characteristics using Cross Tabulation-Chi-Square Test.

Variable	**Satisfaction with the position of light fittings at the workstation**							
	Low		**Neutral**		**High**		**χ2**	***p*-value**
	N	**(%)**	**N**	**(%)**	**N**	**(%)**		
Personal Characteristics								
Gender								
Male	8	(12.70)	13	(20.63)	42	(66.67))	0.061	0.970
Female	14	(12.28)	22	(19.29)	78	(54.54)		
Total	22	(12.43)	35	(19.77)	120	(67.80)		
Age (years)								
18-29	0	(0.00)	5	(41.67)	7	(58.33)	6.217	0.045
30-49	15	(12.93)	23	(19.83)	78	(67.24)		
50 years or more	9	(18.37)	17	(34.69)	23	(46.94)		
Total	24	(13.56)	45	(25.42)	108	(61.02)		
Job Role								
Administrator	1	(6.25)	2	(12.50)	13	(81.25)	11.011	0.201
Technical	0	(0.00)	4	(40.00)	6	(60.00)		
Teaching and Research	7	(25.00)	10	(35.71)	11	(39.29)		
Teaching/Research only	1	(11.11)	3	(33.33)	5	(55.56)		
Other	1	(8.33)	5	(41.67)	6	(50.00)		
Total	10	(13.33)	24	(32.00)	41	(54.67)		
Workstation characteristics								
Location								
Home	4	(12.90)	7	(21.21)	22	(66.67)	3.281	0.194
Office	6	(13.16)	17	(36.96)	23	(50.00)		
Student	23	(23.47)	27	(27.55)	48	48.98		
Total	33	(18.64)	51	(28.81)	93	(52.54)		
Time spent at residence or workstation								
Up to 1 year	9	(21.43)	11	(26.18)	22	(52.38)	5.334	0.149
2-5 years	5	(7.14)	20	(28.57)	45	(64.29)		

6-10 years	5	(13.51)	14	(37.84)	18	(48.65)		
10+ years	3	(11.54)	8	(30.77)	15	(57.69)		
Total	22	(13.50)	48	(29.45)	93	(57.06)		
Window in the room or workstation								
No	0	(0.00)	7	(33.33)	14	(66.67)	1.860	0.173
Yes	20	(12.82)	36	(23.08)	100	(64.10)		
Total	20	(11.30))	43	(24.29)	114	(64.41)		
Important to have a window in the room or immediate work area								
Not at all important	1	(6.25)	5	(31.25)	10	(62.5)	2.038	0.153
Moderately important	3	(10.00)	10	(33.33)	17	(56.67)		
Very important	18	(13.74)	33	(25.19)	80	(61.07)		
Total	22	(12.43)	48	(27.12)	107	(60.45)		
Lighting control at the workstation								
Wall switch with room sensor	14	(15.05)	24	(25.81)	55	(59.14)	0.076	0.9303
Other	12	(14.29)	20	(23.81)	52	(61.90)		
Total	26	(12.66)	44	(30.38)	107	(56.96)		
Glare problems at the workstation								
No	15	(11.54)	29	(25.00)	73	(63.46)	0.740	0.390
Yes	10	(13.04)	19	(39.13)	31	(47.83)		
Total	25	(12.00)	48	(29.33)	104	(58.67)		
Main heating/cooling system at current workstation								
Hot water radiator	13	(12.24)	35	(28.57)	78	(59.18)	3.361	0.499
Storage heaters	1	(20.00)	3	(20.00)	7	(60.00)		
Warm air systems	0	(0.00)	4	(50.00)	6	(50.00)		
Air conditioning	2	(0.00)	5	(33.33)	13	(66.67)		
Others	3	(42.86)	3	(28.57)	4	(28.57)		
Total	19	(12.66)	50	(30.38)	108	(56.96)		
Access to temperature controls at the workstation								
Time switch	7	(20.00)	8	(10.00)	19	(70.00)	0.5	0.973

Radiator valves	12	(10.71)	24	(42.86)	33	(46.43)
Storage dials	3	(33.33)	6	(33.33)	10	(33.33)
Multiple	3	(22.22)	4	(22.22)	10	(55.56)
Others	5	(5.26)	12	(21.05)	19	(73.68)
Total	30	(13.04)	54	(28.99)	91	(57.97)

****p < 0.01, ** p < 0.05, N = sample size, % = percentage*

- **Rating of lighting control measures at the current workstation**

Referring to Table 7.3 the results show that many of the independent variables are not significantly associated (at a 5% level of significance) with the user's satisfaction with the lighting control measures at the workstation. However, the results suggest that gender and glare problems are significantly associated with satisfaction with the lighting control measures. Moreover, females are slightly more likely to report high satisfaction ([$\chi 2$ (2, N=177) = 8.189, p<0.05] and those who report no glare problems are also likely to report high satisfaction with the lighting controls at the workstation ([$\chi 2$ (2, N=177) = 6.125, p<0.05] (see Table 11). Therefore, it can be deduced from the results that only the age of the respondents as well as perception about the glare problem were the major variables that affect the rating of the lighting control at the workstation. However, the results did not find any significant age differences or variations related to the job role in the respondents' self-reported satisfaction with the position of light fittings at the workstation.

Table 7.3: Bivariate Results of Satisfaction with lighting control measures at the current workstation and Sociodemographic characteristics using Cross Tabulation-Chi-Square Test.

Variable	Satisfaction with the lighting control measures at the current workstation						χ2	*p*-value
	Low		Neutral		High			
	N	(%)	N	(%)	N	(%)		
Personal Characteristics								
Gender								
Male	3	(0.00)	25	(42.86)	35	(57.14)	8.189	0.017**
Female	8	(22.41)	22	(18.97)	71	(58.62)		
Total	11	(16.46)	47	(25.32)	106	(58.23)		
Age (years)								
18-29	6	(8.33	17	(41.67)	30	(50.00)	5.251	0.263
30-49	17	(21.21)	19	(12.22)	56	(66.67)		
50 years or more	5	(15.63)	9	(28.13)	18	(56.25)		
Total	28	(16.88)	45	(23.38)	104	(59.74)		
Job Role								
Administrator	2	(7.14)	1	(7.14)	13	(85.71)	9.344	0.314
Technical	0	(0.00)	5	(44.44)	5	(55.56)		
Teaching and Research	6	(22.22)	7	(22.22)	15	(55.56)		
Teaching/Research only	2	(28.57)	3	(14.29)	4	(57.14)		
Other	2	(16.67)	3	(25.00)	7	(58.33)		
Total	12	(15.94)	19	(21.74)	44	(62.32)		
Workstation characteristics								
Location								
Home	2	(6.06)	9	(27.27)	22	(66.67)	4.500	0.105
Office	11	(23.91)	11	(23.91)	24	(52.17)		
Student	19		24		55			
Total	32	(16.46)	44	(25.32)	101	(58.23)		
Time spent at residence or workstation								
Up to 1 year	9	(19.05)	11	(14.29)	38	(66.67)	9.324	0.156
2-5 years	9	(13.04)	19	(30.43)	42	(56.52)		

6-10 years	6	(37.50)	8	(50.00)	9	(12.50)		
10+ years	3	(11.54)	6	(23.08)	17	(65.38)		
Total	27	(16.67)	44	(25.64)	106	(57.69)		
Window in the room or workstation								
No	5	(37.50)	6	(25.00)	10	(37.50)	3.053	0.217
Yes	17	(14.08)	41	(25.35)	98	(60.56)		
Total	22	(16.48)	47	(25.32)	108	(58.23)		
Important to have a window in the room or immediate work area								
Not at all important	1	(0.00)	6	(50.00)	9	(50.00)	3.446	0.486
Moderately important	4	(0.00)	10	(20.00)	16	(71.43)		
Very important	21	(18.33)	31	(20.00)	79	(57.35)		
Total	26	(15.94)	47	(21.74)	104	(58.23)		
Lighting control at the workstation								
Wall switch with room sensor	12	(23.22)	22	(28.21)	60	(58.97)	0.880	0.644
Other	15	(20.00)	22	(22.50)	46	(57.50)		
Total	27	(16.46)	44	(25.32)	106	(58.23)		
Glare problems at the workstation								
No	11	(11.54)	21	(19.23)	89	(69.23)	6.125	0.047**
Yes	8	(26.09)	17	(34.78)	27	(39.13)		
Total	19	(16.00)	38	(24.00)	74	(60.00)		
Main heating/cooling system at current workstation								
Hot water radiator	24	(12.24)	39	(28.57)	63	(59.18)	9.741	0.284
Storage heaters	0	(0.00)	2	(20.00)	9	(80.00)		
Warm air systems	2	(16.67)	4	(50.00)	4	(33.33)		
Air conditioning	5	(25.00)	2	(8.33)	13	(66.67)		
Others	3	(42.86)	0	(14.29)	9	(42.86)		
Total	34	(16.46)	45	(25.32)	98	(58.23)		
Access to temperature controls at the workstation								
Time switch	4	(20.	4	(0.00)	26	(81.82)	4.628	0.797
Radiator valves	13	(10.71)	19	(28.13)	37	(53.13)		

Storage dials	2	(33.33)	4	(33.33)	11	(66.67)
Multiple	3	(22.22)	4	(22.22)	10	(66.67)
Others	6	(5.26)	12	(33.33)	24	(50.00)
Total	26	(13.04)	43	(25.32)	108	(58.23)

****p < 0.01, ** p < 0.05, N = sample size, % = percentage*

● Rating of natural lighting at the current staff workstation

Referring to Table 7.3, the results show significant associations between the respondents' report of their rating of the natural lighting at their current workstation and five of the independent variables. First, location is significantly associated with satisfaction with natural lighting, although the chi-square statistic is only significant at the 10% level. Like the above results, those working from home are more likely to be satisfied with the natural lighting compared to those working from the office [$\chi 2$ (2, N=177) = 5.531, p<0.1]. Second, the result suggests a strong and statistically significant relationship between having a window in the workstation and the satisfaction with the natural lighting, and those who say that they have a window are more likely to be satisfied. [$\chi 2$ (2, N=177) = 12.079, p<0.05]. Third, those who report that they have no glare problems are also more likely to be satisfied with their workstation [$\chi 2$ (2, N=177) = 4.026, p<0.05]. Fourth, a significant association was noted between the main heating/cooling system and satisfaction with the natural lighting. The results suggest that respondents' who use hot water radiators as their main heating/cooling system are more likely to be satisfied with the natural lighting at their workstation [$\chi 2$ (2, N=177) = 17.201, p < 0.05]. Finally, the results suggest a significant association between the access to temperature controls in the workplace and the rating of the natural lighting at the workstation. Moreover, a large proportion of the respondents use storage dials and three out of every four of these respondents report that they are satisfied with the natural lighting at their workstation [$\chi 2$ (8, N=177) = 18.371, p<0.1]. The results did not find any significant gender or age differences or variations related to the job role in the respondents' self-reported satisfaction with the position of light fittings at the workstation.

Table 7.4 Bivariate Results of Satisfaction with the natural lighting and Sociodemographic characteristics using Cross Tabulation-Chi-Square Test

Variable	Satisfaction with the natural lighting at the current workstation						χ2	*p*-value
	Low		Neutral		High			
	N	(%)	N	(%)	N	(%)		
Personal Characteristics								
Gender								
Male	8	(12.70)	14	(22.22)	41	(65.08)	2.371	0.124
Female	28	(24.56)	17	(14.91)	69	(60.52)		
Total	36	(20.33)	31	(17.51)	110	(62.15)		
Age (years)								
18-29	12	(21.05)	8	(14.04)	37	(64.91)	0.146	0.929
30-49	20	(22.73)	14	(15.91)	54	(61.36)		
50 years or more	5	(15.63)	5	(15.63)	22	(68.75)		
Total	37	(20.90)	27	(15.25)	113	(63.84)		
Job Role								
Administrator	1	(6.25)	1	(6.25)	14	(87.50)	9.105	0.334
Technical	3	(30.00)	1	(10.00)	6	(60.00)		
Teaching and Research	6	(21.43)	3	(10.71)	19	(67.86)		
Teaching/Research only	3	(33.33)	1	(11.11)	5	(55.56)		
Other	0	(0.00)	3	(25.00)	9	(75.00)		
Total	13	(17.33)	9	(12.00)	53	(70.67)		
Workstation characteristics								
Location								
Home	2	(6.06)	4	(12.12)	27	(81.82)	5.531	0.063*
Office	11	(23.91)	6	(13.04)	29	(63.04)		
Student	12	(12.24)	23	(23.47)	63	(64.29)		
Total	25	(14.12)	33	(18.64)	119	(67.23)		
Time spent at residence or workstation								
Up to 1 year	8	(14.03)	13	(22.81)	36	(63.16)	0.496	0.919

2-5 years	13	(18.31)	12	(16.90)	46	(64.79)		
6-10 years	5	(21.74)	3	(13.04)	15	(65.22)		
10+ years	4	(15.38)	4	(15.38)	18	(69.23)		
Total	30	(16.95)	32	(18.08)	115	(64.97)		
Window in the room or workstation								
No	10	(47.62)	2	(9.52)	9	(42.85)	12.079	0.001***
Yes	21	(13.46)	35	(22.43)	100	(64.10)		
Total	31	(17.51)	37	(20.90)	109	(61.58)		
Important to have a window in the room or immediate work area								
Not at all important	5	(31.25)	2	(12.5)	9	(56.25)	1.483	0.476
Moderately important	10	(33.33)	6	(20.00)	14	(46.67)		
Very important	27	(20.61)	22	(16.79)	82	(62.60)		
Total	42	(23.73)	30	(16.95)	105	(59.32)		
Lighting control at the workstation								
Wall switch with room sensor	22	(23.40)	14	(14.89)	58	(61.70)	0.201	0.653
Other	16	(19.28)	16	(19.28)	51	(61.44)		
Total	38	(21.47)	30	(16.95)	109	(61.58)		
Glare problems at the workstation								
No	31	(24.41)	17	(13.38)	79	(62.20)	4.026	0.045**
Yes	5	(10.00)	12	(24.00)	33	(66.00)		
Total	36	(20.33)	29	(16.38)	112	(63.28)		
Main heating/cooling system at current workstation								
Hot water radiator	13	(10.32)	22	(17.46)	91	(72.22)	17.201	0.001***
Storage heaters	0	(0.00)	0	(0.00)	11	(100.00)		
Warm air systems	4	(40.00)	2	(20.00)	4	(40.00)		
Air conditioning	3	(15.00)	5	(25.00)	12	(60.00)		
Others	4	(57.14)	1	(14.29)	2	(28.57)		
Total	24	(13.79)	30	(17.24)	120	(68.97)		
Access to temperature controls at the workstation								
Time switch	4	(11.76)	8	(23.53)	22	(64.71)	18.371	0.001*
Radiator valves	10	(14.49)	15	(21.74)	44	(63.77)		

Storage dials	0	(0.00)	0	(0.00)	18	(100.00)
Multiple	0	(0.00)	3	(17.65)	14	(82.35)
Others	13	(33.33)	2	(5.13)	24	(61.54)
Total	27	(16.46)	28	(12.66)	121	(70.89)

****p < 0.01, ** p < 0.05, ** p < 0.1, N = sample size, % = percentage*

7.4 Sociodemographic Characteristics and ventilation/ temperature at the workstation

7.4.1 Descriptive Statistics

Referring to Table 6.12, Columns 1 & 2 indicates that 53.11% of the respondents were very satisfied/satisfied with the level of control over ventilation/airflow at their workstation, level of the ventilation/airflow at the workstation (64.97%), the temperature at the current workstation (43.04%), level of comfort at the current workstation (63.84%), and natural lighting (46.84%). The proportion of respondents who were very dissatisfied/dissatisfied ranges from 22.03% (level of comfort at current workstation) to 40.51% (the temperature at current workstation).

7.4.2 Bivariate Results

- **Satisfaction with the level of control over ventilation/airflow at the workstation**

Referring to Table 7.5, the results show significant associations between the respondents' report of their satisfaction with the level of control over ventilation/airflow at the current workstation and six of the independent variables. First, gender is significantly associated with satisfaction with control over ventilation/airflow, although the chi-square statistic is only significant at 10%. Moreover, female respondents are slightly more likely to report high satisfaction with control over ventilation/airflow; 60.64% of the women reported high satisfaction compared to 41.27% of the male respondents. Also, the results show that males are more than twice more likely to report neutrality and women twice as more likely to report low satisfaction with the level of control over ventilation/airflow [$\chi2$ (2, N=177) = 3.631, $p<0.1$]. Second, the result suggests a strong and statistically significant relationship between the location and the satisfaction with the level of control over ventilation/airflow, and those who responded from home were more likely to report high satisfaction. Moreover, a similar proportion reported neutrality for this question [$\chi2$ (2, N=177) = 24.917, $p<0.01$]. Third, having a window in the workstation and being satisfied with the level of control over ventilation/airflow, and those who say they have a window are more likely to report high satisfaction. None of the respondents without a window in their room or workstation report high satisfaction, and three out of every four of the respondents reported that they are dissatisfied or very/dissatisfied with the level of control over ventilation/airflow in their workstation [$\chi2$ (2, N=177) = 18.187, $p<0.05$]. Fourth, the type of lighting control is associated with the level of control over ventilation/airflow in their workstation, and those with wall switches with room sensors were more likely to report low satisfaction compared to respondents with other types of lighting control [$\chi2$ (2, N=177) = 1.709, $p<0.1$]. Fifth, the type of heating/cooling system at the current workstation also exhibited strong associations with the level of control over ventilation/airflow. The results show that those who use hot water radiators are most likely to report high satisfaction (60.31%), followed by storage heaters (54.55%). In terms of the reports of low satisfaction (i.e., very dissatisfied/dissatisfied), those who use warm air systems were in the majority (83.33%) followed by those who use air conditioning (66.67%) [$\chi2$ (8, N=177) = 23.361, $p<0.01$]. Finally, the results suggest a significant association between the access to temperature controls in the workplace and the level of control over ventilation/airflow at the workstation. Out of the respondents who reported using multiple temperature controls, 88.89% of them reported high satisfaction with control over the level of control over ventilation/airflow at the workstation. Conversely, a large proportion of respondents with storage dials were more likely to report low satisfaction with the level of control over ventilation/airflow at the workstation [$\chi 2$ (8, N=177) = 12.209, $p<0.1$].

Table 7.5. Bivariate Results of Satisfaction with the level of control over ventilation/airflow at the current workstation and Sociodemographic characteristics using Cross Tabulation-Chi-Square Test.

Variable	**Satisfaction with the level of control over ventilation/airflow at the current workstation**						**χ2**	***p*-value**
	Low		**Neutral**		**High**			
	N	**(%)**	**N**	**(%)**	**N**	**(%)**		
Personal Characteristics								
Gender								
Male	14	(22.22)	23	(36.51)	26	(41.27)	3.631	0.057*****
Female	13	(13.83)	24	(25.53)	57	(60.64)		
Total	27	(17.19)	47	(29.94)	83	(52.87)		
Age (years)								
18-29	20	(36.36)	7	(12.73)	28	(50.91)	0.749	0.687
30-49	28	(31.82)	16	(18.18)	44	(50.00)		
50 years or more	9	(28.13)	8	(25.00)	15	(46.88)		
Total	57	(32.57)	31	(17.71)	87	(49.71)		
Job Role								
Administrator	5	(31.25)	2	(12.50)	9	(56.25)	**9.557**	**0.297**
Technical	4	(40.00)	5	(50.00)	1	(10.00)		
Teaching and Research	8	(28.57)	5	(17.86)	15	(53.57)		
Teaching/Research only	4	(44.44)	1	(11.11)	4	(44.44)		
Other	3	(25.00)	3	(25.00)	6	(50.00)		
Total	24	(32.00)	16	(21.33)	35	(46.67)		
Workstation characteristics								
Location								

Home	4	(12.12)	7	(21.21)	22	(66.67)	24.917	0.0038***
Office	23	(50.00)	10	(21.74)	13	(28.26)		
Student	20	(20.41)	36	(36.73)	42	(42.86)		
Total	47	(26.55)	53	(29.94)	77	(43.50)		
Time spent at residence or workstation								
Up to 1 year	12	(20.69)	15	(25.86)	31	(53.44)	5.423	0.143
2-5 years	21	(30.00)	14	(20.00)	35	(50.00)		
6-10 years	8	(34.78)	0	(0.00)	15	(65.21)		
10+ years	10	(38.46)	5	(19.23)	11	(42.31)		
Total	51	(28.81)	34	(19.21)	92	(51.97)		
Window in the room or workstation								
No	16	(76.19)	5	(23.81)	0	(0.00)	18.187	0.002**
Yes	46	(29.49)	35	(22.43)	75	(48.08)		
Total	62	(35.02)	40	(22.60)	75	(42.37)		
Important to have a window in the room or immediate work area								
Not at all important	8	(50.00)	8	(50.00)	0	(0.00)	11.113	0.004**
Moderately important	7	(24.14)	10	(34.48)	12	(41.38)		
Very important	43	(32.82)	27	(20.61)	61	(46.56)		
Total	58	(34.18)	45	(21.52)	73	(44.30)		
Lighting control at the workstation								
Wall switch with room sensor	30	(35.71)	16	(19.04)	38	(45.24)	1.709	0.0191*
Other	19	(22.89)	19	(22.89)	45	(54.22)		
Total	49	(29.34)	35	(20.96)	83	(49.70)		
Glare problems at the workstation								
No	37	(29.13)	22	(17.32)	68	(53.54)	1.800	0.179

Yes	16	(32.00)	14	(28.00)	20	(40.00)		
Total	53	(29.94)	36	(20.33)	88	(49.72)		
Main heating/cooling system at current workstation								
Hot water radiator	25	(19.84)	25	(19.84)	76	(60.31)	22.098	0.0002***
Storage heaters	4	(36.36)	1	(9.09)	6	(54.55)		
Warm air systems	5	(50.00)	0	(0.00)	5	(50.00)		
Air conditioning	12	(60.00)	2	(10.00)	6	(30.00)		
Others	2	(20.00)	6	(60.00)	2	(20.00)		
Total	48	(27.11)	34	(19.21)	95	(53.67)		
Access to temperature controls at the workstation								
Time switch	12	(35.29)	10	(29.41)	12	(35.29)	12.209	0.016***
Radiator valves	21	(30.43)	14	(20.29)	34	(49.27)		
Storage dials	7	(41.18)	0	(0.00)	10	(58.82)		
Multiple	0	(0.00)	4	(23.53)	13	(76.47)		
Others	18	(45.00)	8	(20.00)	14	(35.00)		
Total	58	(32.77)	36	(20.64)	83	(46.89)		

******p < 0.01, ** p < 0.05, N = sample size, % = percentage***

- **Satisfaction with the level of the ventilation/airflow at the workstation**

About Table 7.6, the results show significant associations between the respondents' reports of their satisfaction with the level of control over ventilation/airflow at the current workstation and five of the independent variables. First, the result suggests a strong and statistically significant relationship between the location and the satisfaction with the ventilation/airflow level, and those who responded from home were more likely to report high satisfaction. For instance, 69.70% of those who responded to the survey from their home reported high satisfaction compared to 34.78% and 42.86% of persons reporting from the office and students respectively [$\chi 2$ (2, N=177) = 7.538, $p<0.05$]. Second, having a window in the workstation and being satisfied with the ventilation/airflow level, and those who say that they have a window are more likely to report high satisfaction. Only 14.28% of the respondents without a window in their room or workstation reported high satisfaction, and 47.62% of these respondents reported that they were dissatisfied or very/dissatisfied with the level of control over ventilation/airflow in their workstation [$\chi 2$ (2, N=79) = 13.623, $p<0.01$]. Third, the type of lighting control is associated with the control over ventilation/airflow in their workstation, although this is only significant at the 10% level of significance.

Moreover, those with wall switches with room sensors were more likely to report low satisfaction compared to respondents with other types of lighting control [$\chi 2$ (2, N=177) = 0.623, $p<0.1$]. Fourth, the type of heating/cooling system at the current workstation also exhibited strong associations with the ventilation/airflow level. The results show that those who use hot water radiators are most likely to report high satisfaction (52.38%), followed by storage heaters (54.55%). In terms of the reports of low satisfaction (i.e., very dissatisfied/dissatisfied), and 60.00% of those who use warm air systems and those who use air conditioning similarly report low satisfaction over the level of ventilation/airflow [$\chi 2$ (8, N=177) = 22.463, $p<0.01$]. Finally, the results suggest a significant association between the access to temperature controls in the workplace and the ventilation/air flow level at the workstation. Out of the nine respondents who reported using multiple temperature controls, 64.71% of them reported high satisfaction with the level of ventilation/airflow at the workstation. Conversely, a large proportion of respondents with storage dials were more likely to report low satisfaction with the level of control over ventilation/airflow at the workstation (52.94%) [χ^2 (8, N=79) = 19.229, $p<0.05$].

Table 7.6. Bivariate Results of Satisfaction with the level of ventilation/airflow at the current workstation and Sociodemographic characteristics using Cross Tabulation-Chi-Square Test.

	Satisfaction with the level of ventilation/airflow at the workstation						χ2	*p*-value
	Low		**Neutral**		**High**			
	N	**(%)**	**N**	**(%)**	**N**	**(%)**		
Personal Characteristics								
Gender								
Male	16	(25.39)	13	(20.63)	34	(53.97)	0.068	0.793
Female	29	(25.44)	19	(16.66)	66	(57.89)		
Total	45	(25.42)	32	(18.07)	100	(56.49)		
Age (years)								
18-29	10	(18.18)	13	(23.64)	32	(58.18)	2.668	0.263
30-49	27	(32.53)	13	(15.66)	43	(51.80)		
50 years or more	8	(25.00)	9	(28.13)	15	(46.88)		
Total	45	(26.47)	35	(20.59)	90	(52.94)		
Job Role								
Administrator	3	(18.75)	3	(18.75)	10	(62.50)	4.781	0.781
Technical	4	(40.00)	3	(30.00)	3	(30.00)		
Teaching and Research	8	(28.57)	4	(14.29)	16	(57.14)		
Teaching/Research only	3	(33.33)	2	(22.22)	4	(44.44)		
Other	3	(25.00)	4	(33.33)	5	(41.67)		
Total	21	(28.00)	16	(21.33)	38	(50.67)		
Workstation characteristics								
Location								

Home	4	(12.12)	6	(18.18)	23	(69.70)	7.538	0.023**
Office	19	(41.30)	11	(23.91)	16	(34.78)		
Student	34	(34.7)	22	(22.45)	42	(42.86)		
Total	57	(32.22)	39	(22.03)	81	(45.76)		
Time spent at residence or workstation								
Up to 1 year	12	(21.05)	16	(28.07)	29	(50.88)	1.423	0.700
2-5 years	19	(27.14)	13	(18.57)	38	(54.29)		
6-10 years	8	(34.78)	5	(21.74)	10	(43.48)		
10+ years	9	(34.62)	6	(23.08)	11	(42.31)		
Total	48	(27.12)	40	(22.60)	88	(49.72)		
Window in the room or workstation								
No	10	(47.62)	8	(38.10)	3	(14.28)	13.623	0.0002***
Yes	32	(20.51)	28	(17.95)	96	(61.54)		
Total	42	(23.73)	36	(20.34)	99	(55.93)		
Important to have a window in room the immediate work area								
Not at all important	6	(54.55)	5	(45.45)	5	(45.45)	3.450	0.178
Moderately important	6	(20.00)	5	(16.67)	19	(63.33)		
Very important	27	(22.31)	21	(17.36)	83	(68.60)		
Total	39	(22.03)	31	(17.51)	107	(60.45)		
Lighting control at the workstation								
Wall switch with room sensor	30	(31.91)	21	(22.34)	43	(45.74)	0.623	0.430
Other	21	(25.30)	16	(20.48)	46	(55.42)		
Total	51	(28.81)	37	(20.90)	89	(50.28)		
Glare problems at the workstation								
No	29	(23.97)	25	(20.66)	67	(55.37)	1.308	0.253

Yes	18	(36.00)	10	(20.00)	22	(44.00)		
Total	47	(27.49)	35	(20.46)	89	(52.05)		
Main heating/cooling system at current workstation								
Hot water radiator	24	(19.05)	36	(28.57)	66	(52.38)	22.463	0.001***
Storage heaters	3	(27.27)	2	(18.18)	6	(54.55)		
Warm air systems	6	(60.00)	1	(10.00)	3	(30.00)		
Air conditioning	14	(70.00)	5	(25.00)	1	(5.00)		
Others	3	(30.00)	3	(30.00)	4	(40.00)		
Total	50	(28.25)	47	(26.55)	80	(45.20)		
Access to temperature controls at the workstation								
Time switch	5	(14.71)	14	(41.17)	15	(44.11)	19.229	0.007**
Radiator valves	16	(23.19)	17	(24.64)	36	(52.17)		
Storage dials	9	(52.94)	2	(11.76)	6	(35.29)		
Multiple	2	(11.76)	4	(23.53)	11	(64.71)		
Others	21	(52.50)	4	(10.00)	15	(37.50)		
Total	53	(29.94)	41	(23.16)	83	(46.89)		

****p < 0.01, ** p < 0.05, ** p < 0.1, N = sample size, % = percentage*

- **Satisfaction with the temperature at the current workstation**

Referring to Table 7.7, the results show significant associations between the respondents' report of their satisfaction with the temperature at the current workstation and three of the independent variables. We find a strong and statistically significant association between the respondent's age and the temperature at the current workstation for the first time. The results suggest that respondents between 30 and 49 years (48.86%) are most likely to report high satisfaction, followed by those who are at least 50 years (43.75%). On the other hand, young respondents (18-29 years) are the most likely to be dissatisfied/very dissatisfied with the temperature at their current workstation (32.72%) [$\chi 2$ (4, N=177) = 7.305, $p<0.05$]. Second, the result suggests a strong and statistically significant relationship between the location and the satisfaction with the level of control over ventilation/airflow, and 63.64% of those who responded from home were more likely to report high satisfaction [$\chi 2$ (2, N=177) = 12.451, $p<0.01$]. Finally, the results suggest a significant association between the access to temperature controls in the workplace and the temperature at the workstation. Out of the nine respondents who reported using multiple temperature controls, 88.24% of them reported high satisfaction with control over the level of control over ventilation/airflow at the workstation. Conversely, a large proportion of respondents with storage dials were more likely to report low satisfaction with the level of control over ventilation/airflow at the workstation (65.63%) [$\chi 2$ (8, N=177) = 16.831, $p<0.05$].

Table 7.7. Bivariate Results of Satisfaction with the temperature at the current workstation and Sociodemographic characteristics using Cross Tabulation-Chi-Square Test.

Variable	Satisfaction with the temperature at the current workstation						χ2	*p*-value
	Low		Neutral		High			
	N	(%)	N	(%)	N	(%)		
Personal Characteristics								
Gender								
Male	16	(25.40)	10	(15.87)	37	(58.73)	3.965	0.046
Female	50	(43.86)	16	(14.04)	48	(42.10)		
Total	66	(37.29)	26	(14.69)	85	(48.02)		
Age (years)								
18-29	18	(32.72)	2	(3.63)	35	(63.64)	7.305	0.026**
30-49	27	(30.68)	18	(20.45)	43	(48.86)		
50 years or more	9	(28.13)	9	(28.13)	14	(43.75)		
Total	54	(30.86)	29	(16.57)	92	(52.57)		
Job Role								
Administrator	6	(37.50)	4	(25.00)	6	(37.50)	2.340	0.969
Technical	5	(50.00)	1	(10.00)	4	(40.00)		
Teaching and Research	9	(32.14)	5	(17.86)	14	(50.00)		
Teaching/Research only	4	(44.44)	1	(11.11)	4	(44.44)		
Other	4	(33.33)	2	(16.67)	6	(50.00)		
Total	28	(37.33)	13	(17.33)	34	(45.33)		
Workstation characteristics								
Location								
Home	6	(18.18)	6	(18.18)	21	(63.64)	12.451	0.002**
Office	26	(56.52)	7	(15.22)	13	(28.26)		
Student	29	(29.60)	25	(25.51)	44	(44.90)		
Total	61	(34.46)	38	(21.47)	78	(44.07)		
Time spent at residence or workstation								
Up to 1 year	21	(36.84)	7	(12.28)	29	(50.88)	2.928	0.403
2-5 years	24	(33.80)	21	(29.58)	26	(36.62)		
6-10 years	8	(34.78)	6	(26.09)	9	(39.13)		
10+ years	8	(30.77)	6	(23.08)	12	(46.15)		

Total	61	(34.46)	40	(22.60)	76	(42.94)		
Window in the room or workstation								
No	8	(36.36)	3	(13.64)	11	(50.00)	0.116	0.734
Yes	54	(34.84)	32	(20.65)	69	(44.51)		
Total	62	(35.03)	35	(19.77)	80	(45.20)		
Important to have a window in the room or immediate work area								
Not at all important	5	(31.25)	4	(25.00)	7	(43.75)	2.806	0.246
Moderately important	8	(25.00)	3	(9.38)	21	(65.62)		
Very important	47	(36.43)	25	(19.38)	57	(44.19)		
Total	60	(33.90)	32	(18.08)	85	(48.02)		
Lighting control at the workstation								
Wall switch with room sensor	37	(39.36)	20	(21.28)	37	(39.36)	0.652	0.419
Other	32	(38.55)	12	(14.46)	39	(46.98)		
Total	69	(38.98)	32	(18.10)	76	(42.94)		
Glare problems at the workstation								
No	40	(33.06)	28	(23.14)	53	(43.80)	1.352	0.245
Yes	18	(36.00)	6	(12.00)	26	(52.00)		
Total	58	(33.92)	34	(19.88)	79	(46.20)		
Main heating/cooling system at current workstation								
Hot water radiator	41	(32.54)	26	(20.63)	59	(46.83)	1.857	0.762
Storage heaters	2	(18.18)	1	(9.09)	8	(72.73)		
Warm air systems	5	(45.45)	2	(18.18)	4	(36.36)		
Air conditioning	7	(35.00)	5	(25.00)	8	(40.00)		
Others	4	(44.44)	2	(22.22)	3	(33.33)		
Total	59	(33.33)	36	(20.34)	82	(46.33)		
Access to temperature controls at the workstation								
Time switch	5	(15.63)	6	(18.75)	21	(65.63)	16.831	0.01**
Radiator valves	21	(29.58)	17	(23.94)	33	(46.48)		
Storage dials	8	(47.06)	3	(17.65)	6	(35.29)		
Multiple	1	(5.88)	1	(5.88)	15	(88.24)		
Others	20	(50.00)	4	(10.00)	16	(40.00)		
Total	55	(31.07)	31	(17.51)	91	(51.41)		

****p < 0.01, ** p < 0.05, N = sample size, % = percentage*

Satisfaction with the level of comfort at current workstation

Referring to Table 7.8, the results only show a significant association between glare issues and the comfort level at the current workstation. This implies that that glare problem $p<0.05$, as a consequential association with the satisfaction with the level of comfort at the workstation. Therefore, glare problem at the workstation significantly affected the comfort of the respondents at the current workstation and this was very much expected. Furthermore, we find that those without glare problems at their current workstation (47.93%) have high satisfaction than those with glare problems (40%). Also, we find that the latter are more likely to report neutrality when it concerns their level of comfort and glare problems at workstation [$\chi 2$ (2, N=177) = 0.516, $p<0.05$].

Table 7.8 Bivariate Results of Satisfaction with the level of comfort at the current workstation and Sociodemographic characteristics using Cross Tabulation-Chi-Square Test.

Variable	Satisfaction with the level of comfort at current workstation						χ2	*p*-value
	Low		Neutral		High			
	N	(%)	N	(%)	N	(%)		
Personal Characteristics								
Gender								
Male	15	(23.81)	15	(23.81)	33	(52.38)	0.082	0.775
Female	28	(24.56)	22	(19.30)	64	(56.14)		
Total	43	(36.75)	37	(20.90)	97	(54.80)		
Age (years)								
18-29	13	(23.21)	9	(16.07)	34	(60.71)	1.576	0.455
30-49	19	(21.35)	24	(26.96)	46	(51.69)		
50 years or more	10	(31.25)	7	(21.88)	15	(46.88)		
Total	42	(23.73)	40	(22.60)	95	(53.67)		
Job Role								
Administrator	3	(18.75)	2	(12.50)	11	(68.75)	5.293	0.726
Technical	4	(40.00)	2	(20.00)	4	(40.00)		
Teaching and Research	6	(21.43)	8	(28.57)	14	(50.00)		
Teaching/Research only	3	(33.33)	2	(22.22)	4	(44.44)		
Other	4	(33.33)	1	(8.33)	7	(58.33)		
Total	20	(26.67)	15	(20.00)	40	(53.33)		
Workstation characteristics								
Location								
Home	7	(21.21)	6	(18.18)	20	(60.61)	0.720	0.698
Office	15	(32.91)	10	(21.74)	21	(45.65)		
Student	28	(28.57)	23	(23.50)	47	(47.96)		
Total	50	(28.25)	39	(22.03)	88	(49.72)		
Time spent at residence or workstation								
Up to 1 year	10	(17.54)	11	(19.30)	36	(63.16)	10.671	0.014
2-5 years	12	(17.14)	11	(15.71)	47	(67.14)		
6-10 years	12	(52.17)	3	(13.04)	8	(34.78)		
10+ years	7	(26.92)	7	(26.92)	12	(46.15)		
Total	41	(23.30)	32	(18.18)	103	(58.52)		
Window in the room or workstation								
No	4	(17.39)	5	(21.74)	14	(60.86)	0.356	0.551
Yes	43	(27.92)	32	(20.78)	79	(51.30)		
Total	47	(26.55)	37	(20.90)	93	(52.54)		
Important to have a window in the room or immediate work area								
Not at all important	5	(31.25)	4	(25.00)	7	(43.75)	5.874	0.053
Moderately important	6	(20.00)	1	(3.33)	23	(76.67)		
Very important	26	(19.85)	34	(25.95)	71	(54.20)		
Total	37	(20.90)	39	(22.03)	101	(57.06)		

Lighting control at the workstation								
Wall switch with room sensor	26	(27.66)	21	(22.34)	47	(50.00)	0.309	0.578`
Other	19	(22.89)	16	(19.28)	48	(57.83)		
Total	45	(25.42)	37	(20.90)	95	(53.67)		
Glare problems at the workstation								
No	38	(31.40)	25	(20.66)	58	(47.93)	0.516	0.0473**
Yes	12	(24.00)	17	(34)	20	(40.00)		
Missing	50	(29.24)	39	(22.81)	82	(47.95)		
Main heating/cooling system at current workstation								
Hot water radiator	35	(27.13)	29	(22.48)	62	(48.06)	2.306	0.679
Storage heaters	1	(9.09)	1	(9.09)	9	(81.81)		
Warm air systems	3	(30.00)	1	(10.00)	6	(60.00)		
Air conditioning	4	(19.05)	5	(23.81)	12	(57.14)		
Others	2	(22.22)	2	(22.22)	5	(55.56)		
Total	45	(25.42)	38	(21.47)	94	(53.11)		
Access to temperature controls at the workstation								
Time switch	5	(14.71)	4	(11.76)	25	(73.52)	5.380	0.250
Radiator valves	23	(33.33)	14	(20.28)	32	(46.38)		
Storage dials	4	(23.53)	4	(23.53)	9	(52.94)		
Multiple	6	(35.29)	5	(29.41)	6	(35.29)		
Others	11	(27.50)	6	(15.00)	23	(57.50)		
Total	49	(27.68)	33	(18.64)	95	(53.67)		

****p < 0.01, ** p < 0.05, ** p < 0.1, N = sample size, % = percentage*

- **Satisfaction with temperature adjustment at the workstation**

Referring to Table 7.8, the results show significant associations between the respondents' report of their satisfaction with temperature adjustment at the workstation and three independent variables. First, the location has a strong and significant association with the respondent's satisfaction with the temperature adjustment at the workstation, with those working from home more likely to report high satisfaction (63.64%) [χ^2 (2, N=177) = 13.197, p<0.01]. Second, the time the respondent has spent at the residence or workstation was also associated with the satisfaction over-temperature adjustment. However, it was only significant at the 10% level of significance. Moreover, among the 57 respondents who had only spent up to 1 year at the residence or workstation, 57.89% reported high satisfaction [χ^2 (6, N=177) = 11.034, p<0.1]. Finally, there was also a significant association between the access to temperature controls at the workstation and the temperature adjustment. Among the respondents who reported using multiple temperature controls, 88.89% of them reported high satisfaction with the access to temperature controls at workstation [χ^2 (8, N=79) = 14.428, p<0.1].

Table 7.9 Bivariate Results of Satisfaction with the temperature adjustment at the current workstation and Sociodemographic characteristics using Cross Tabulation- Chi-Square Test.

Variable	Satisfaction with temperature adjustment at the current workstation						χ2	*p*-value
	Low		Neutral		High			
	N	(%)	N	(%)	N	(%)		
Personal Characteristics								
Gender								
Male	19	(30.16)	17	(26.98)	27	(42.86)	0.724	0.395
Female	41	(35.96)	21	(18.42)	52	(45.61)		
Total	60	(33.90)	38	(21.47)	79	(44.63)		
Age (years)								
18-29	21	(38.18)	14	(25.45)	20	(36.36)	0.925	0.629
30-49	31	(35.22)	15	(17.05)	42	(47.73)		
50 years or more	11	(34.38)	8	(25.00)	13	(40.63)		
Total	63	(36.00)	37	(21.14)	75	(42.85)		
Job Role								
Administrator	7	(43.75)	2	(12.50)	7	(43.75)	3.927	0.864
Technical	5	(50.00)	1	(10.00)	4	(40.00)		
Teaching and Research	8	(28.57)	7	(25.00)	13	(46.43)		
Teaching/Research only	3	(33.33)	1	(11.11)	5	(55.56)		
Other	5	(41.67)	1	(8.33)	6	(50.00)		
Total	28	(37.33)	12	(16.00)	35	(46.67)		
Workstation characteristics								
Location								
Home	6	(18.18)	6	(18.18)	21	(63.64)	13.197	0.001***
Office	24	(52.17)	6	(13.04)	16	(34.78)		
Student	30	(30.61)	32	(32.65)	36	(36.73)		
Total	60	(33.90)	44	(24.86)	73	(41.24)		
Time spent at residence or workstation								
Up to 1 year	15	(26.32)	9	(15.79)	33	(57.89)	4.706	0.021**
2-5 years	26	(36.62)	17	(23.94)	28	(39.44)		
6-10 years	6	(26.09)	2	(8.70)	15	(65.22)		
10+ years	9	(34.62)	7	(26.92)	10	(38.46)		
Total	56	(31.64)	35	(19.77)	86	(48.58)		

Window in the room or workstation								
No	6	(28.57)	5	(23.81)	10	(47.62)	0.210	0.646
Yes	54	(34.61)	25	(16.03)	77	(49.36)		
Total	60	(33.89)	30	(16.95)	87	(46.84)		
Important to have a window in the room or immediate work area								
Not at all important	4	(25.00)	3	(18.75)	9	(56.25)	0.171	0.918
Moderately important	8	(26.66)	8	(26.66)	14	(46.66)		
Very important	39	(29.77)	26	(19.85)	66	(50.38)		
Total	51	(28.81)	37	(20.90)	89	(50.28)		
Lighting control at the workstation								
Wall switch with room sensor	36	(38.30)	23	(24.47)	35	(37.23)	1.269	0.260
Other	31	(37.35)	13	(15.66)	39	(46.99)		
Total	67	(37.85)	36	(20.34)	74	(41.81)		
Glare problems at the workstation								
No	36	(29.75)	19	(15.70)	66	(54.55)	1.490	0.222
Yes	20	(40.00)	10	(20.00)	20	(40.00)		
Total	56	(32.75)	29	(16.96)	86	(50.30)		
Main heating/cooling system at current workstation								
Hot water radiator	44	(34.37)	32	(25.00)	52	(40.63)	6.225	0.183
Storage heaters	3	(27.27)	3	(27.27)	5	(45.45)		
Warm air systems	7	(70.00)	1	(10.00)	2	(20.00)		
Air conditioning	7	(35.00)	1	(5.00)	12	(60.00)		
Others	2	(25.00)	3	(37.50)	3	(37.50)		
Total	63	(35.60)	40	(22.60)	74	(41.80)		
Access to temperature controls at the workstation								
Time switch	6	(17.65)	13	(38.24)	15	(44.11)	9.268	0.045**
Radiator valves	24	(34.78)	15	(21.74)	30	(57.97)		
Storage dials	2	(11.76)	6	(35.30)	9	(52.94)		
Multiple	3	(27.27)	3	(27.27)	11	(64.71)		
Others	17	(42.50)	5	(12.50)	18	(45.00)		
Total	52	(29.38)	42	(23.73)	83	(46.90)		

****p < 0.01, ** p < 0.05, N = sample size, % = percentage*

7.5 Sociodemographic Characteristics and the overall impression of their workstation

7.5.1 Descriptive Statistics

Referring to Table 6.13, Columns 1 & 2 (Chapter 6), indicates that a large majority have a positive impression of the current workstation; 45.57% reported that their current workstation is good or has even lighting, 29.11% reported that it is bright and 25.32% is dark, unevenly lit or have another impression of their workstation. When split by location, more than half of the respondents who work from home reported that their workstation was good or has even lighting compared to 41.30% of those who worked from the office. However, more respondents who work from the office (32.61%) reported that their workstation is bright compared to those who work from home (24.24%). In terms of the overall satisfaction with the current workstation, more than half reported average satisfaction with the current workstation (53.16%), and on average, one-quarter of the respondents (n=20) reported high satisfaction. When split by location, the same proportion of respondents working from home reported average and high satisfaction with their current workstation (45.45%), and 9.09% reported low satisfaction. Only 10.87% of the respondents reported high satisfaction for those working from the office, and 30.43% reported low satisfaction. Finally, a large majority of the respondents spend at least 4 hours at their workstation (82.28), like those working from home or the office (see Table 6.13).

7.5.2 Bivariate Results

- **The general impression of current room or workstation**

Referring to Table 18, the results only show significant associations between whether there is a window in the room or workstation and the general impression of the workstation. The respondents who have a window in their room or workstation are more likely to report their workstation as bright (42.95%) than those without (38.10%). Moreover, the results suggest that more than 60% of the respondents without a window reported that their rooms or workstations were dark, unevenly lit or described them in a low manner [$\chi2$ (2, N=177) = 1.059, $p<0.05$].

Table 7.10 Bivariate Results of Satisfaction with the general impression of the current room or workstation and Sociodemographic characteristics using Cross Tabulation-Chi-Square Test.

Variable	**The general impression of current room or workstation**						**χ2**	***p*-value**
	Dark[a]		**Good[b]**		**Bright[c]**			
	N	**(%)**	**N**	**(%)**	**N**	**(%)**		
Personal Characteristics								
Gender								
Male	16	(25.40)	19	(30.16)	28	(44.44)	0.393	0.531
Female	26	(22.80)	44	(38.60)	44	(38.60)		
Total	42	(23.73)	63	(35.60)	72	(40.68)		
Age (years)								
18-29	6	(10.91)	23	(41.82)	26	(47.27)	3.863	0.145
30-49	17	(19.77)	31	(36.05)	38	(44.19)		
50 years or more	9	(28.13)	15	(46.88)	8	(25.00)		
Total	32	(18.50)	69	(39.88)	72	(41.62)		
Job Role								
Administrator	1	(6.25	8	(50.00)	7	(43.75)	9.662	0.290
Technical	2	(20.00)	6	(60.00)	2	(20.00)		
Teaching and Research	11	(39.29)	12	(42.86)	5	(17.86)		
Teaching/Research only	3	(33.33)	2	(22.22)	4	(44.44)		

Other	3	(25.00)	5	(41.67)	4	(33.33)		
Total	20	(26.67)	33	(44.00)	22	(29.33)		
Workstation characteristics								
Location								
Home	8	(24.24)	17	(51.52)	8	(24.24)	4.893	0.087
Office	12	(26.09)	19	(41.30)	15	(32.61)		
Student	19	(19.39)	31	(31.63)	48	(48.98)		
Total	39	(22.03)	67	(37.85)	71	(40.11)		
Time spent at residence or workstation								
Up to 1 year	15	(26.32)	24	(42.11)	18	(31.57)	1.059	0.787
2-5 years	17	(23.61)	27	(37.50)	28	(38.89)		
6-10 years	5	(21.74)	8	(34.78)	10	(43.48)		
10+ years	8	(30.77)	12	(46.15)	6	(23.08)		
Total	45	(25.42)	71	(40.11)	61	(34.46)		
Window in the room or workstation								
No	6	(28.57)	7	(33.33)	8	(38.10)	1.059	0.0303**
Yes	33	(21.15)	56	(35.90)	67	(42.95)		
Total	39	(22.03)	60	(33.90)	78	(44.07)		
Important to have a window in the room or immediate work area								
Not at all important	5	(31.25)	4	(25.00)	7	(43.75)	1.296	0.523
Moderately important	4	(13.33)	14	(46.67)	12	(40.00)		
Very important	31	(23.67)	52	(39.70)	48	(36.64)		
Total	40	(22.60)	70	(39.55)	67	(37.85)		
Lighting control at the workstation								
Wall switch with room sensor	22	(23.40)	30	(31.91)	42	(44.68)	0.062	0.803

Other	21	(25.30)	29	(34.94)	33	(39.76)		
Total	43	(24.30)	59	(33.33)	75	(42.37)		
Glare problems at the workstation								
No	27	(22.31)	52	(42.97)	42	(34.71)	2.262	0.133
Yes	17	(34.00)	14	(28.00)	19	(38.00)		
Total	44	(25.73)	66	(38.60)	61	(35.67)		
Main heating/cooling system at current workstation								
Hot water radiator	36	(29.51)	37	(30.33)	49	(40.16)	5.232	0.264
Storage heaters	1	(9.09)	2	(18.18)	8	(72.73)		
Warm air systems	7	(50.00)	3	(21.43)	4	(28.57)		
Air conditioning	4	(40.00)	4	(40.00)	12	(60.00)		
Others	3	(30.00)	3	(30.00)	4	(40.00)		
Total	51	(28.81)	49	(27.68)	77	(43.50)		
Access to temperature controls at the workstation								
Time switch	7	(20.59)	14	(41.18)	13	(38.24)	2.773	0.596
Radiator valves	13	(18.84)	20	(28.98)	36	(52.17)		
Storage dials	5	(29.41)	5	(29.41)	7	(41.18)		
Multiple	3	(17.65)	8	(47.06)	6	(35.30)		
Others	12	(30.00)	10	(25.00)	18	(45.00)		
Total	40	(22.60)	57	(32.20)	80	(45.20)		

****p < 0.01, ** p < 0.05, ** p < 0.1, N = sample size, % = percentage*

- **Satisfaction with current workstation**

Referring to Table 7.10, the results show significant associations between the respondents' report of their satisfaction with their current workstation and three independent variables. First, the result suggests a strong and statistically significant relationship between the location and the satisfaction with the workstation, and those who responded from home were more likely to report high satisfaction with their workstation (45.45%) [$\chi 2$ (2, N=177) = 19.33, p<0.01]. Second, the type of lighting control is associated with satisfaction with the current workstation; those with wall switches with room sensors were more likely to report average satisfaction with their current workstation [$\chi 2$ (2, N=177 = 0.906, p<0.05]. Finally, the type of heating/cooling system at the current workstation also exhibited strong associations with the overall satisfaction with the current workstation. The results suggest that those with storage heaters were more likely to report high overall satisfaction with their current workstation, followed by hot water radiator (36.51%) and warm air systems (33.33%) [$\chi 2$ (2, N=177) = 12.629, p<0.05]. Also, there was a strong relationship between access to temperature and satisfaction with the current workstation. The people who have accessed to multiples had the highest satisfaction (76.47%) [$\chi 2$ (2, N=177) = 12.629, p<0.05]

Table 7.11 Bivariate Results of Satisfaction with the current workstation and Sociodemographic characteristics using Cross Tabulation-Chi-Square Test.

Variable	Satisfaction with the current workstation						χ2	*p*-value
	Low		Average		High			
	N	(%)	N	(%)	N	(%)		
Personal Characteristics								
Gender								
Male	14	(22.22)	23	(36.51)	26	(41.27)	0.843	0.359
Female	16	(14.06)	49	(42.98)	49	(42.98)		
Total	30	(16.95)	72	(40.68)	75	(42.37)		
Age (years)								
18-29	23	(40.35)	15	(26.32)	19	(33.33)	9.486	0.009
30-49	23	(26.14)	28	(31.82)	37	(42.05)		
50 years or more	6	(18.75)	19	(59.38)	7	(21.88)		
Total	52	(29.37)	62	(35.03)	63	(35.60)		
Job Role								
Administrator	2	(12.50)	9	(56.25)	5	(31.25)	4.142	0.844
Technical	3	(30.00)	5	(50.00)	2	(20.00)		
Teaching and Research	4	(14.29)	16	(57.14)	8	(28.57)		
Teaching/Research only	3	(25.00)	3	(33.33)	3	(33.33)		
Other	3	(25.00)	7	(58.33)	2	(16.67)		
Total	15	(20.00)	40	(53.33)	20	(26.67)		
Workstation characteristics								
Location								
Home	3	(9.09)	15	(45.45)	15	(45.45)	19.33	0.0063**

Office	14	(30.43)	27	(58.70)	5	(10.87)		
Student	15	(15.30)	32	(32.65)	51	(52.04)		
Total	32	(18.08)	74	(41.81)	71	(40.11)		
Time spent at residence or workstation								
Up to 1 year	8	(14.04)	13	(22.81)	36	(63.16)	13.037	0.005**
2-5 years	19	(27.14)	24	(34.29)	27	(38.57)		
6-10 years	8	(33.33)	8	(33.33)	8	(33.33)		
10+ years	5	(19.23)	15	(57.69)	6	(23.08)		
Total	40	(22.60)	60	(33.90)	77	(43.50)		
Window in the room or workstation								
No	7	(22.59)	11	(35.48)	13	(41.94)	0.005	0.946
Yes	30	(20.55)	56	(38.36)	60	(41.10)		
Total	37	(20.90)	67	(37.85)	73	(41.24)		
Important to have a window in the room or immediate work area								
Not at all important	2	(12.50)	6	(37.50)	8	(50.00)	0.029	0.986
Moderately important	3	(10.00)	11	(36.67)	16	(53.33)		
Very important	14	(10.69)	54	(41.22)	63	(48.10)		
Total	19	(10.73)	71	(40.11)	87	(49.15)		
Lighting control at the workstation								
Wall switch with room sensor	26	(27.66)	37	(39.36)	31	(32.98)	0.906	0.0341**
Other	21	(25.30)	26	(31.33)	36	(43.37)		
Total	47	(26.55)	63	(35.60)	67	(37.85)		
Glare problems at the workstation								
No	21	(16.54)	57	(44.88)	49	(38.58)	3.161	0.075

Yes	15	(30.00)	15	(30.00)	20	(40.00)		
Total	36	(20.34)	72	(40.68)	69	(38.98)		
Main heating/cooling system at current workstation								
Hot water radiator	26	(20.63)	54	(42.86)	46	(36.51)	12.629	0.013**
Storage heaters	2	(18.18)	2	(18.18)	7	(63.64)		
Warm air systems	3	(33.33)	3	(33.33)	3	(33.33)		
Air conditioning	10	(47.62)	7	(33.33)	4	(19.05)		
Others	2	(20.00)	8	(80.00)	0	(0.00)		
Total	43	(24.30)	74	(41.81)	61	(34.46)		
Access to temperature controls at the workstation								
Time switch	9	(26.47)	12	(35.30)	13	(38.24)	10.01	0.04
Radiator valves	14	(20.29)	32	(46.38)	23	(33.33)		
Storage dials	1	(5.88)	6	(35.30)	10	(58.82)		
Multiple	0	(0.00)	4	(23.53)	13	(76.47)		
Others	10	(25.00)	14	(35.00)	16	(40.00)		
Total	34	(19.21)	68	(38.42)	75	(42.37)		

****p < 0.01, ** p < 0.05, N = sample size, % = percentage*

- **Number of hours spent at the workstation**

Referring to Table 7.12, the results show significant associations between the respondents' reports of their productivity measured by the number of hours spent at the workstation and four independent variables. First, age is significantly associated with satisfaction with the number of hours spent at the workstation, with older persons (i.e., 50 years or more) spending more time at their workstation (4 hours or more). 96.88% of those who reported that they are 50 years or more reported spending 4 hours or more. This declines to 61.79% of those within the 30-49 age bracket and 58.92% of those between 18 and 29 years [$\chi2$ (2, N=177) = 15.709, $p<0.05$]. Second, the result suggests a strong and statistically significant relationship between the location and the number of hours spent at the workstation, and those who responded from home reported spending more time at their workstation. On average, 93.94% of those who reported from their homes reported that they spent 4 hours or more at their workstation compared to 73.91% and 57.14% of those who responded to the survey from the office and students respectively [$\chi2$ (2, N=177) = 16.340, $p<0.01$]. Third, the current workstation's heating/cooling system also exhibited strong associations with the number of hours spent at the workstation. The results show that all the respondents who reported that their main source of heating/cooling is from air conditioning; this is closely followed by those who use hot water radiators. Among the 49 respondents who use hot water radiators as their main heating/cooling system, 91.84% of them reported that they spent four or more hours at their workstation [$\chi2$ (4, N=177) = 26.745, $p<0.01$]. Finally, the results suggest a significant association between the access to temperature controls and the number of hours at the workstation. Out of the seventeen respondents who reported using multiple temperature controls, 100% of them reported that they spend at least four hours at their workstations. This is followed by those who use radiator valves (82.60%) and time switches (67.65%). Overall, 72.88% of the respondents reported spending 4 or more hours at their workstation [$\chi2$ (4, N=177) = 19.194, $p<0.01$].

Table 7.12. Bivariate Results of Satisfaction with the number of hours spent at the workstation and Sociodemographic characteristics using Cross Tabulation-Chi-Square Test.

Variable	**Satisfaction with the number of hours spent at the workstation**				**χ2**	***p*-value**
	Less than 4 hours		**4 hours or more**			
	N	**(%)**	**N**	**(%)**		
Personal Characteristics						
Gender						
Male	21	(33.33)	42	(66.67)	0.057	0.811
Female	36	(31.58)	78	(68.42)		
Total	57	(32.20)	120	(67.80)		
Age (years)						
18-29	23	(41.07)	33	(58.92)	15.709	0.0004***
30-49	34	(38.20)	55	(61.79)		
50 years or more	1	(3.13)	31	(96.88)		
Total	58	(32.77)	119	(67.23)		
Job Role						
Administrator	2	(12.50)	14	(87.50)	5.963	0.202
Technical	3	(30.00)	7	(70.00)		
Teaching and Research	4	(14.29)	24	(85.71)		
Teaching/Research only	3	(33.33)	6	(66.67)		
Other	0	(0.00)	12	(100.00)		
Total	12	(16.00)	63	(84.00)		
Workstation characteristics						
Location						
Home	2	(6.06)	31	(93.94)	16.340	0.0003***
Office	12	(26.09)	34	(73.91)		
Student	42	(42.86)	56	(57.14)		
Total	56	(31.64)	121	(68.36)		
Time spent at residence or workstation						
Up to 1 year	21	(36.84)	36	(63.16)	10.359	0.016
2-5 years	24	(33.80)	47	(66.20)		
6-10 years	8	(34.78)	15	(65.21)		
10+ years	1	(3.85)	25	(96.15)		

Total	54	(30.50)	123	(69.50)		
Window in the room or workstation						
No	8	(38.10)	13	(61.90)	0.243	0.622
Yes	51	(32.69)	105	(67.31)		
Total	59	(33.33)	118	(66.67)		
Important to have a window in the room or immediate work area						
Not at all important	4	(25.00)	12	(75.00)	4.056	0.137
Moderately important	13	(43.33)	17	(56.67)		
Very important	33	(25.19)	98	(74.81)		
Total	50	(28.25)	127	(71.75)		
Lighting control at the workstation						
Wall switch with room sensor	30	(30.61)	68	(69.39)	0.255	0.614
Other	27	(34.18)	52	(65.82)		
Total	57	(32.20)	120	(67.80)		
Glare problems at the workstation						
No	37	(30.58)	84	(69.42)	2.847	0.0916
Yes	9	(18.00)	41	(82.00)		
Total	46	(26.90)	125	(73.10)		
Main heating/cooling system at current workstation						
Hot water radiator	31	(24.60)	95	(75.40)	26.745	0.00002***
Storage heaters	8	(72.73)	3	(27.27)		
Warm air systems	5	(50.00)	5	(50.00)		
Air conditioning	0	(0.00)	20	(100.00)		
Others	6	(60.00)	4	(40.00)		
Total	50	(28.25)	127	(71.75)		
Access to temperature controls at the workstation						
Time switch	11	(32.35)	23	(67.65)	19.194	0.0007***
Radiator valves	12	(17.40)	57	(82.60)		
Storage dials	9	(52.94)	8	(47.06)		
Multiple	0	(0.00)	17	(100.00)		
Others	16	(40.00)	24	(60.00)		
Total	48	(27.12)	129	(72.88)		

***p < 0.01, ** p < 0.05, ** p < 0.1, N = sample size, % = percentage

7.6 Spearman Rank-Correlation Analysis

Correlation analyses were also carried out to provide an overview of the direction of the relationship between the outcomes of interest, i.e., satisfaction with the lighting system, ventilation/airflow, heating and cooling, the impression of workstation and productivity (number of hours spent at the workstation). For this analysis, we focus on significant associations at the 5% level or lower. For the satisfaction with the existing artificial electric lighting at the workstation, the rank analyses revealed significant positive associations between the outcome and seven other outcomes. The respondents who reported high satisfaction with the existing artificial electric lighting also reported high satisfaction with the position of the light fittings (r= .817, p<0.01); high satisfaction with the light control measures (r=.712, p<0.01); high satisfaction with the natural lighting (r=.401, p<0.01); high satisfaction with temperature (r=.342, p<0.01); high satisfaction with the level of comfort (r=.501, p<0.01); high impression with the workstation (r=.389, p<0.01); and high overall satisfaction with the workstation (r=.384, p<0.01) (Table 7.13).

Apart from its positive association with the existing artificial electric lighting, the satisfaction with the position of light fittings at the workstation also revealed significant positive associations with five other outcomes. The respondents who reported high satisfaction with the position of light fittings also reported high satisfaction with the lighting control measures (r=.619, p<0.01); high satisfaction with the natural lighting (r=.346, p<0.01); high satisfaction with the level of comfort (r=.449, p<0.01); strong impression with the workstation (r=.379, p<0.01); and high overall satisfaction with the workstation (r=.260, p<0.05) (Table 7.13).

The satisfaction with the lighting control measures at the current workstation is also positively associated with seven other outcomes. The respondents who reported high satisfaction with the lighting control measures also reported high satisfaction with the natural lighting (r=.398, p<0.01); high satisfaction with the level of control over the control over ventilation/airflow (r=.254, p<0.05); high satisfaction with the level of the ventilation/airflow (r=.305, p<0.05); high satisfaction with temperature (r=.283, p<0.05); high satisfaction with the level of comfort (r=.450, p<0.01); high impression with the workstation (r=.328, p<0.01); and high overall satisfaction with the workstation (r=.418, p<0.05) (Table 7.13).

The satisfaction with the natural light at the current workstation is also positively associated with four other outcomes beyond those presented above. The respondents who reported high satisfaction with the natural lighting also reported high satisfaction with the level of control over the control over ventilation/airflow (r=.310, p<0.05); high satisfaction with the level of the ventilation/airflow (r=.396, p<0.01); high impression with the workstation (r=.528, p<0.01); and high overall satisfaction with the workstation (r=.298, p<0.05) (Table 7.13).

The satisfaction with the level of control over ventilation/airflow at the current workstation is also positively associated with four other outcomes beyond those presented above. The respondents who reported high satisfaction with the level of control over the ventilation/airflow also reported high satisfaction with the level of the ventilation/airflow (r=.895, p<0.01); high satisfaction with temperature (r=.491, p<0.01); high satisfaction with the level of comfort at the current workstation (r=.273, p<0.05); high satisfaction with temperature adjustment (r=.523, p<0.01); and high overall satisfaction with the workstation (r=.711, p<0.01) (Table 7.13).

The satisfaction with the ventilation/airflow level at the current workstation is also positively associated with four other outcomes beyond those presented above. The respondents who reported high satisfaction with the level of the ventilation/airflow also reported high satisfaction with temperature (r=.465, p<0.01); high satisfaction with the level of comfort at the current workstation (r=.271, p<0.05); high satisfaction with temperature adjustment

($r=.461$, $p<0.01$); and high overall satisfaction with the workstation ($r=.739$, $p<0.05$) (Table 7.13).

The satisfaction with the temperature at the current workstation is also positively associated with three other outcomes beyond those presented above. The respondents who reported high satisfaction with the temperature also reported high satisfaction with the level of comfort at the current workstation ($r=.266$, $p<0.05$); high satisfaction with temperature adjustment ($r=.772$, $p<0.01$); and high overall satisfaction with the workstation ($r=.720$, $p<0.01$) (Table 7.13).

The satisfaction with the comfort level at the current workstation is also positively associated with two other outcomes beyond those presented above. The respondents who reported high satisfaction with the level of comfort also reported high satisfaction with the temperature adjustment ($r=.282$, $p<0.05$); and high overall satisfaction with the workstation ($r=.557$, $p<0.01$). Moreover, those who reported high satisfaction with the temperature adjustment at their current workstation also reported high overall satisfaction with the workstation ($r=.735$, $p<0.01$) (Table 7.13). The results presented do not report any significant associations (positive or negative) between the number of hours spent at the workstation (a measure of productivity) and the other outcomes of interest (satisfaction with lighting, ventilation, temperature and the workstation itself).

Table 7.13 Spearman rank-order Correlation Matrix Between Outcomes of interest-Satisfaction with Workstation and Number of hours spent at the workstation.

	(a)	(b)	(c)	(d)	(e)	(f)	(g)	(h)	(i)	(j)	(k)	(l)
(a)	1											
(b)	.817***	1										
(c)	.712***	.619***	1									
(d)	.401***	.346***	.398***	1								
(e)	.117	.001	.254**	.310**	1							
(f)	.202*	.058	.305**	.396***	.895***	1						
(g)	.342***	.196	.283**	.179	.491***	.465***	1					
(h)	.501***	.449***	.450***	.201*	.273**	.271**	.266**	1				
(i)	.179	.075	.219*	.065	.523***	.461***	.772***	.282**	1			
(j)	.389***	.379***	.328***	.528***	.129	.223*	-.080	.183	-.120	1		
(k)	.384***	.260**	.418***	.298**	.711***	.739***	.720***	.557***	.735***	.078	1	
(l)	.148	.045	.030	-.021	-.070	-.104	.005	-.085	-.183	.024	-.084	1

Notes:

(a) Satisfaction with existing artificial lighting at the workstation
(b) Satisfaction with the position of light fittings at the workstation
(c) Satisfaction with the lighting control measures at the current workstation.
(d) Satisfaction with the natural lighting at the current workstation
(e) Satisfaction with the level of control over ventilation/airflow at the workstation
(f) Satisfaction with the level of the ventilation/airflow at the workstation
(g) Satisfaction with the temperature at the current workstation
(h) Satisfaction with the level of comfort at current workstation
(i) Satisfaction with temperature adjustment at the workstation
(j) The general impression of current room or workstation
(k) Satisfaction with current workstation
(l) Number of hours spent at the workstation

7.7 RESPONSES FROM THE ESTATE DEPARTMENT TEAM

7.7.1 Which groups within the university should have the most significant interest in this relationship: Kindly rate below in terms of priority please:

The survey's target groups of respondents are classified as some of the University's most important stakeholders (Estate directors, technicians). In a built environment such as a university or urban ecosystem, various industry sectors play critical roles throughout the building's life cycle, particularly lighting systems. These stakeholders play critical roles in ensuring that the best performance is maintained and sustained. According to Marzouk & Fayez, (2018), each of these stakeholders serves as an agent influencing the building's life cycle for a specific period; during this time, the building tends to evolve systematically in response to various interventions or interests to continue fulfilling its primary purpose of providing a comfortable and safe environment for its users or occupants.

However, these interventions may not always proceed as planned since opposing stakeholder interests might jeopardise the timely maintenance of lighting systems. As a result, groups' degree of interest and engagement in collaborating with maintenance teams to reach the required level of occupant satisfaction. This will enable more sustainable performance if the interaction between stakeholders, end-users, and facilities is improved, resulting in increased user perception, satisfaction, and productivity (McArthur & Powell, 2020).

7.7.2 When upgrading lighting systems in the university, kindly rank or rate these issues or risks that lead to less-than-optimal performance?

Considering the survey responses, the issues raised were well-represented as factors that can contribute to less-than-optimal performance. However, time constraints and the orientation and size of the rooms are the most significant issues or risks. Heinicke et al., (2018) conducted a research experiment to support the orientation and space of the rooms as a risk factor that can result in less-than-optimal performance. They used an actual office at the University of Southern California (USC) and had participants increase the lighting levels in the room using various controls due to the room's orientation and space. This enabled the residents to open the blinds and use natural light rather than artificial illumination. Another school of thought, Deambrogio et al., (2017), considered the use of functional distribution analysis and the conditions of natural and artificial lighting with building plans and orientation as determinants and actual lighting conditions as stimulants based on the intended use of classrooms, laboratories, teacher rooms, utility rooms, and other building-related rooms. Meanwhile, to continue meeting user and occupant expectations regarding maintenance costs, energy consumption, environmental performance, and ease of use, the ability to manage time effectively is critical for optimal lighting performance.

7.7.3 What measures can you suggest on how these issues or risks can be controlled, minimized to improve the sustainability of the building lighting systems?

The respondent suggests several measures for addressing these issues or risks to improve the sustainability of building lighting systems, including careful monitoring of costs and performance, acting on complaints, good specifications that adhere to current industry standards, replacement or installation of complicated lighting control systems, use of standard switches and control gear, quality design and selection of equipment, and staff awareness.

Several of these recommendations aim to improve residents' comfort, health, and well-being. These proposed improvements, if implemented strategically, will considerably enhance the building's lighting system (de Bakker et al., 2017). Marzouk & Fayez, (2018) contend that other variables such as organisational structure, funding, and other policies might mitigate some of the respondent's emphasised measures. It is thus vital to strike a balance between these strategies by ordering them sequentially to attain the desired effect.

7.7.4 What are the three aspects of lighting system installation or performance that should be improved upon or sustained in the lighting systems in schools or universities?

Three factors of lighting system performance that one respondent cited to enhance lighting systems include flexibility to adapt to natural lighting conditions, energy savings, whole life pricing, and quality. Yoomak and Jettanasen (2018) emphasised some of these factors to assist the development of lighting systems and performance in terms of quality, productivity, and comfort. However, the necessity to provide an enabling environment, such as via design solutions, information provision, quality standards, operations, and maintenance, is equally critical to the University's sustainability in terms of lighting performance.

7.8 Analysis of responses from the Estate Department and Sustainability Team staff.

7.8.1 Which groups within the university should have the most significant interest in this relationship: Kindly rate below in terms of priority please:

The groups identified for the survey or respondents are categorized as some of the key stakeholders in the University. According to Darby et al., (2016), each of these stakeholders, depending on the areas or workstation, serve as an agent influencing the life cycle for a specific period; during this time, the building tends to evolve with the various interventions or interests systematically to continue to fulfil its primary purpose of providing a comfortable and safe environment to its users or occupants.

However, sometimes these interventions do not go according to plan as different stakeholders' interests can be conflicting whilst affecting the maintenance of the lighting systems as at when due. Therefore, the groups' level of interest and participation to collaborate with the maintenance teams to achieve the desired level of satisfaction for the occupants. This will allow for a more sustainable performance if the relationship between the stakeholders, the end-users and the facilities lead to more user perception, satisfaction and productivity (Zuhaib et al., 2018).

7.8.2 When upgrading lighting systems in the university, kindly rank or rate these issues or risks that can lead to less-than-optimal performance?

About the survey responses, the issues highlighted were well represented as factors that can lead to less-than-optimal performance. However, time constraints and orientation and space of the rooms are the highest-ranked issues or risks. A research experiment carried out by Yu et al., (2018) supported the orientation and space of the rooms as one of the risks involved that can lead to less-than-optimal performance using an actual office at the University of Southern California (USC) with the participants increasing the lighting levels of the room with the use of the different controls because of the orientation and space of the room. This also allowed the occupants to open the shades and use natural light rather than artificial lighting. Another school of thought, Deambrogio et al. (2017), also considered the use of functional distribution analysis and the conditions of natural and artificial lighting with building plans and orientation as a determinant and actual lighting conditions as a stimulant using the intended use of the classrooms, laboratories, teacher rooms, utility rooms and other rooms associated to the building. Meanwhile, to continue to meet the expectations of the users and occupants in terms of the maintenance cost, energy consumption, environmental performance, and ease of use, the ability of how time is being managed is essential to the optimal lighting performance.

7.8.3 What measures can you suggest on how these issues or risks can be controlled, minimized to improve the sustainability of the building lighting systems?

Some of the measures suggested on how these issues or risks can be controlled to improve the sustainability of the building lighting systems by the respondent are carefully monitoring of costs and performance, action on complaints procedure, good specifications following current industry standards, replace or installing complicated lighting control systems, use of standard switches and control gear, quality design and selection of equipment, staff awareness, use of low energy, planning and lighting management systems.

Some of these suggestions are geared towards impacting the occupants' comfort, health and wellbeing. These measures, as suggested, if well managed strategically, will significantly improve the building lighting system (de Bakker et al., 2017). However, Yoomak et al., (2018) argue that other factors like the organization structure, budget and other policy could reduce some of these measures highlighted by the respondent. Therefore, it is necessary to ensure a striking balance between these measures by prioritizing one after the other to achieve the desired outcome.

7.8.4 What are the three aspects of lighting system installation or performance that should be improved upon or sustained in the lighting systems in the schools or university?

One of the respondents highlighted three aspects of lighting system performance to improve the lighting systems: flexibility to adapt to natural lighting conditions, other respondents mentioned energy-saving, whole life costing, and quality. Some of these aspects have been highlighted by Yoomak et al., (2018) to support the improvement of the lighting systems and performance in quality, productivity and comfort. However, the need to provide an enabling environment like design solutions, information supply, quality standards, operations and maintenance is also vital to sustainability in the lighting performance of the University.

7.8.5 In your opinion, how would you rate the relationship between the performance of the building lighting systems, mental health, comfort and productivity or efficiency at work in the schools or University?

Considering the results in Table 6.9 (Chapter Six), the results revealed significant associations between respondents' responses on the rating of the building lighting at the workstation and five independent variables. This association was based on the satisfaction of the respondents to independent variables such as location of the workstation, window at the workstation, glare problem at the workstation, lighting control systems as well access to temperature control system. The identified high rate of satisfaction can also be related to the recent and ongoing improvement in the university including the university workstation. To this end, it could therefore be inferred that the satisfaction from the above independent variables in relation to the building lighting systems and this is an indication the building lighting systems are rated high. Conclusively, relationship between the performance of the building lighting systems, mental health, comfort and productivity or efficiency at work in the schools and University is rated as high. This result is like the study of Al-Ghaili et al. (2020) in a study that reviewed that building energy savings- lighting systems performance, the study established different levels of satisfaction for different lighting systems and as such, the building lighting system was rated high.

Some of the benefits of having a good relationship between the building lighting systems and other factors as identified by Shealy (2016) include reduced energy and water consumption, higher occupancy rates, improved psychological, physical health and sustainable design with a combination of technological advances like high-performance ventilation systems to reduce respiratory illness and more desk lighting to reduce computer glare, considerations for building orientation, windows that face space enhance occupant comfort and mental focus.

However, if these relationships are not well managed and sustained, this will significantly affect the well-being and health of the building users, not excluding the service personnel and operators. This sentiment was corroborated by Nielsen et al., (2016), this is still the case, and the relationship must be maintained at all costs to have a sustainable relationship.

7.9. Summary and Links

The chapter summarised the primary findings from the survey questions, allowing for an evaluation of the research study considering the research questions. Considering the literature studies on lighting and building systems and performance, some of the input from surveys and interviews verified some of the researchers' assertions in the literature reviews. In contrast, others had divergent perspectives on lighting system difficulties, most notably on the quality of the impression, artificial illumination, and comfort. The link between lighting systems in buildings, mental health, productivity, and the group is most influential on the relationship. The primary stakeholders in the built environment, notably those in the school's senior administration, were recognised as having the most significant stake in this connection.

CHAPTER 8: DISCUSSION OF MAJOR FINDINGS

8.1 Introduction

The chapter will discuss the results that are critical to this research and will be supported by current relevant literature. Particularly in relation to the building lighting and heating performance and their impact on users, following the findings of prior relevant research. For better understanding, this chapter will be divided into three major sections. The first section captures the discussions of results in chapter 5, the second section captures the discussions of the results obtained in chapter 6, the third section captures the discussion obtained in chapter 7 while the last section gives a holistic discussion about the study results.

8.1.1 Discussions of Results in Chapter Five

The research focused on the examination of the lighting and heating systems within the University of Huddersfield, utilizing it as a case study, as outlined in the research methodology. Consequently, this chapter aims to assess the performance of lighting and heating systems within buildings related to the research topic, specifically their nature before and after improvements. Additionally, it aims to identify how these performances contribute to critical factors and components of a sustainable building performance framework within the University of Huddersfield's environment or community. Notably, the primary campus comprises a mix of repurposed mill buildings and purpose-built structures. The study designates the University buildings as its case study, with a particular focus on two structures, namely the Oastler and Percy Shaw buildings.

The Oastler building stands out as one of the newest structures on campus. Its distinctive features include collaborative learning spaces equipped for device connectivity and group work. Students studying Linguistics and Modern Languages benefit from state-of-the-art facilities within the Oastler building, including an Experimental Laboratory, a Linguistics Laboratory, and Language Laboratories equipped with advanced multimedia capabilities for viewing and recording. Furthermore, the Oastler building provides both work and leisure facilities, with PC stations scattered throughout the building for productivity and various seating areas for socializing. Additionally, the Oastler building houses academic offices, conference rooms, a 300-seat lecture theatre, a 180-seat area dedicated to practice-based learning, and event spaces.

Conversely, the Percy Shaw building serves as a hub for the School of Art, Design, and Architecture, offering top-notch amenities such as a café, a comprehensive workshop, and access to the design center with critical industrial and technological resources, including digital measuring tools and quick photocopying machines. It also features staff offices and lecture rooms essential for teaching within the school. The strategic location of this facility for both staff and students underscore its importance in the research area. Notably, the institution recently underwent renovations to expand and enhance these facilities.

Prior to conducting the survey, the researcher engaged in meetings with key members of the University's estates department, observed the case study site firsthand, and conversed with various stakeholders within the buildings. This approach allowed the researcher, acting as a non-participant observer, to maintain a field notebook to record observations, subsequently transformed into a collection of field observational transcripts.

Additionally, before initiating the investigation, the researcher requested structural designs for lighting and heating systems in selected buildings, enabling a preliminary assessment of the research area based on initial observations. Consequently, the researcher reviewed pertinent documents related to the inquiry into lighting performance in this case study.

In this case study, questionnaires were administered to gather further insights into the lighting performance inquiry. This chapter offers a comprehensive analysis of the data obtained through survey questionnaires primarily distributed to respondents within the University of Huddersfield's School of Arts and Humanities.

8.1.2 Discussions of Results in Chapter Six

To address the study objectives, the study collected data that helped answer our research questions. Evaluations were conducted at various times and locations within the institution, including those who were working from home due to the circumstances of the period.

Furthermore, data obtained were analyzed in chapter six using different statistical tools. To begin with, data were analyzed using descriptive statistics with the use of values and percentages. For example, the study made use of descriptive statistics to analyze the demographic status of the respondents and the results revealed that a larger percentage of the respondents were the university staff working in the university with a population 46 representing 77% of the total population. Furthermore, the descriptive analysis also revealed other demographic status of the respondents such as age, gender job roles among others, Not only was descriptive statistics (values and percentages) used for demographic status of the respondents, but it was also used to capture the study objectives by representing the views and opinions of the respondents in numbers and percentages. For example, the analyses revealed that 71% of the respondents claimed that the most used heating system at the workstation was hot water radiator.

However, for substantial results to be achieved, the study further made use of other analytical tools such as different regression and T-test analyses tools. For objective one, the study made use of one-sample T-test and found that the most used heating and lighting systems at the workstation were hot water radiator and wall switch respectively. For objective two, that is the determination of the satisfaction of the users of lighting and heating system at the workstation, the study made use of binary logistic regression analysis. The result found that the users were satisfied with the lighting and the heating systems being used on the workstation.

For objective three, that is the challenges attributed to the use of lighting and heating at the workstation, the study made use of one-sample T-test. The result revealed that an average of 40.33 of the respondents reported that no challenge as far as the lighting and heating systems were concerned. However, an average of 16.67 claimed there were challenges confronting the lighting and heating systems at the workstation.

Therefore, to achieve objective four, that is the effects of lighting and heating systems on the users of workstation, the study made use of bivariate regression analysis. The result revealed that both lighting and heating systems had significant influence on the performance of the workstation. For objective five, the study made use of one—sample statistics to determine the commonly used temperature control system at the workstation. The result from the analysis showed that the most commonly used temperature control system was thermostatic.

8.1.3 Discussions of Results in Chapter Seven

Several results were obtained in Chapter Seven, however, the critical results from the chapter are revealed as thus. From Chapter Seven, Chi-Square analyses reveal significant variations between work area and glare problems. Those working from home without glare issues are highly satisfied with their artificial lighting (location: $\chi 2$ (2, N=177) = 5.233, $p<0.05$; glare problems: $\chi 2$ (2, N=177) = 9.183, $p<0.05$). However, gender and age showed no significant differences in satisfaction with workstation lighting. Also, result from chapter seven revealed that there were no significant associations (at a 5% significance level) between independent variables and user satisfaction with light-fitting positions at workstations. However, having a window in the workstation is statistically significant at the 10% level, with those having a window reporting higher satisfaction ($\chi2$ (2, N=177) = 2.038, $p<0.1$). Gender and age do not significantly affect satisfaction with light-fitting positions at workstations. In furtherance, the study revealed that most independent variables are not significantly linked (at a 5% significance level) to user satisfaction with workstation lighting control. However, gender and glare problems are notably associated with satisfaction. Women tend to report higher satisfaction ($\chi2$ (2, N=177) = 8.189, $p<0.05$), as do those without glare issues ($\chi2$ (2, N=177) = 6.125, $p<0.05$) (refer to Table 11). Age and job role showed no significant differences in respondents' reported satisfaction with workstation light fitting placement.

8.1.4 Holistic Discussions about the Study Results

This survey revealed that larger percentage of the students as well as university's workers working from home and in the office were satisfied with the lighting and heating systems at their workstations. The enjoyment of utilities may be subjective, depending on the users' or occupiers' opinion on pleasant or acceptable. It might be because of the enormous impact on the well-being and health of the building's users. According to Zuhaib et al. (2018), these effects are essential by establishing performance strategies and operational level management tools aimed at ensuring users are satisfied to a certain level, which can be linked between energy-efficient design strategy, occupant behaviour, and organisational structure, as supported by research (Scofield, 2019). However, despite the satisfaction with the lighting system at the workstation, a certain small percentage (28%) of the respondents including workers from home and office as well as students identified there was glare lighting problem at the workstation. To continue to satisfy the demands and expectations of the users, the building's architecture, systems, and technology must be energy efficient. This ensures that illumination effects are decreased to increase comfort for users or occupants, which may, directly and indirectly, influence the degree of pleasure.

Lighting and heating systems are one of the building's physical features, and it is on this premise that a physical performance assessment may be performed. Furthermore, lighting and its settings may substantially impact energy consumption and occupant happiness and productivity (Lamb and Kwok, 2016). Darby et al. (2016) on the other hand, claims that the process of lighting design entails incorporating light into the fabric of a building. On the other hand, the success of lighting and heating solutions depends on and varies with various building types and the individual demands of each project. The standard for facility operators and building designers is to develop and implement appropriate lighting controls for standard lighting layouts and structures as a guide to attaining efficient and effective lighting solutions (Yoomak and Jettanasen, 2018).

Compared to the other variables, the survey results were typically more acceptable. To get positive feedback from a significant number of respondents, the individuals or occupants would not have been subjected to prolonged, very dark and consistent artificial lighting conditions, nor would they have been denied natural sunshine, which is necessary for their welfare and comfort (Sithravel et al., 2018). This rationale has been discovered to promote dayshift occupant psychophysiological well-being, which is critical in the workstation setting. Furthermore, the respondent's level of satisfaction corroborated Durosaiye et al. (2019), the definition of Post Occupancy Evaluation as the process of determining the quality and standards of design and construction, including space planning, resource consumption, internal environmental quality, maintenance and occupancy costs, user comfort, satisfaction, and outcomes. Because this emphasises and pays particular attention to the building's residents or users. As a result, it is critical to continue using the post-occupancy assessment approach to determine the degree of comfort and satisfaction with the facility or utilities installed for the occupant at the workstation.

Furthermore, research demonstrated that users' management of lighting systems at alternate workstations was minimal. A lighting control system is critical for creating a pleasant and acceptable working environment while minimising energy usage. That is why this subject is relevant to this study; the design of the lighting systems is critical since improperly designed and commissioned control systems may result in an unpleasant degree of interior air temperature and inadequate lighting conditions. According to the survey replies, the majority of how the lighting is controlled at the workstation is through a wall switch paired with a room sensor. This sort of lighting management is supported by the suggestion of Ding et al. (2021) that, even if a sensor lighting switch is available, switching on should be done manually in most workplaces, schools, and residential accommodation. On the other hand, Yamin-Garreton et al. (2017) believe that occupants' flexibility or autonomy to alter the lighting of their workplaces to their preferences has a good influence on their job satisfaction, motivation vigilance, and visual comfort. Furthermore, lighting conditions and controls vary depending on location, but the lighting environment should directly influence mood, circadian rhythms, attention, vision, circadian rhythms, and cognition (Edward, 2021).

According to Eleyowo and Amusa (2019), lighting systems use most of the power in the built environment, including buildings, schools, and workplaces. Some of the reasons include that these lighting systems are often employed throughout the day since they frequently improve job performance and comfort. However, it cannot be empirically established if the lighting system at the university consume more power than the heating system. Contrarily, Lange et al. (2021) affirmed lighting systems' relevance, stating that lighting accounts for at least 19% of global power usage. Because of the rising demand for illumination and its consumption, the requirement for workplace management measures will grow over time. Therefore, the respondent's position and the facility's availability of these measures resulted in the respondent's degree of satisfaction.

Furthermore, research revealed that many users seldom had issues, while others encountered lighting systems at alternate workstations from the sun. The bulk of the replies implies that the respondent had very few glare issues. Perhaps one of the reasons for this is the buildings' orientation or the usage of shading devices to lessen the influence of glare issues in the rooms. Some of these solutions aid in enhancing interior visual comfort by increasing daylighting uniformity and decreasing the need for artificial illumination (Mohamed et al., 2017).

Furthermore, data revealed that hot water radiators were the most regularly used heating/cooling system at workstations, followed by warm air heaters, air conditioning, and portable heaters. In contrast, electric radiators and electric storage heaters were the least commonly used heating/cooling system. Hot water radiators are more efficient than steam radiators in homes and public areas because they flow hot water through the system using a pump, allowing the water to travel at a predictable rate. Warm air heaters are also used for heating since they pull in air from outside and warm it over a gas flame before circulating it around the structure and distributing it via ducts, vents, or grills situated in various rooms. Air conditioning maintains room temperature but has limitations, whilst one person may only use portable heaters at a time. This data is consistent with Amber et al. (2017) whose study found out that educational institutions and university campuses use considerable energy due to year-round operation and occupancy of offices, libraries, lecture halls, seminars, conference rooms, and labs. As a result, most building owners employ hot water radiators to save energy while maintaining a high level of productivity.

Similarly, findings from the results revealed that the most used temperature controls in the workplace, as reported significant users, were room thermostats/thermostatic radiator valves, appliance thermostats, and storage heater dials. In contrast, the workstations least commonly used temperature controls were a programmer and simple open or close radiator valves. The kind of structure determines the temperature controls that would be used. However, whatever temperature control is adopted, it must reflect people's thermal comfort or some component of the thermal comfort. It is not as easy as maintaining an average interior air temperature of 21^0C throughout the year to make a building pleasant. In addition to air temperature, thermal comfort is affected by various environmental parameters such as air velocity, radiant temperature, relative humidity, and the uniformity of circumstances. Personal variables such as clothes, metabolic heat, health, and acclimatisation may also influence the suitable heating system. Based on the comments and analyses, the most regularly utilised by users have been determined to boost their productivity while enabling the facility to function at capacity.

Furthermore, research revealed that more university workers at home and in the office as well as students were happy with the heating/cooling systems at alternate workstations. A significant number of the workstation users were satisfied with the heating/cooling system implemented at the institution. The exciting thing about existing buildings is that they are sometimes renovated, especially in a university with a constant demand for performance and improvement. This could be due to a change in style, technology, taste, and business demands. According to Shealy (2016), some of the benefits of having a good relationship between the building lighting systems and other factors include reduced energy and water consumption, higher occupancy rates, improved psychological and physical health, and sustainable design with a combination of technological advances such as high-performance ventilation systems to reduce respiratory illness and more desk lighting to reduce computer glare, considerations for building orientation.

However, some similarities were observed in the results obtained from the workers working from home, the staff working in school and the students. Prominent in this similarity is the satisfaction of the staff working in the school, staff working at home and students to the lighting and heating conditions. This is an indication that a larger percentage of the staff working from home as well as school and students were satisfied lighting and heating conditions at the workstations. However, the peculiar shortcoming common to the respondents is the glare problem with a total of 28% of the respondents affirming to the problem.

However, failure to adequately managed and maintained these connections substantially impact the well-being and health of the building's users, not to mention the service staff and operators. This opinion was echoed by Nielsen et al. (2016), and the connection must be maintained at all costs to have a sustainable partnership.

8.2 Summary of this Chapter

The chapter reviews existing literature to support findings in chapters 6 and 7. It discusses the applicability of these findings in public and private workstations. The importance of lighting in buildings is highlighted, affecting occupant well-being. A lighting control system, mainly using wall switches and room sensors, is vital for comfort and energy reduction. Lighting systems consume a significant portion of global electricity. Daylighting methods improve visual comfort and reduce artificial lighting demand. Effective time management enhances workplace lighting. Temperature control methods in workstations include radiators, air conditioning, and thermostats. Environmental factors impact thermal comfort. Building lighting links to mental health, requiring proper management. Post-occupancy assessment is crucial for comfort. Hot water radiators and certain thermostats are commonly used. Positive building lighting relationships lead to lower energy use, improved health, and sustainability. The next chapter presents conclusions.

CHAPTER 9: CONCLUSIONS AND RECOMMENDATIONS

9.1 Introduction

The research investigates building lighting and heating systems and their effect on building performance and occupants with the aim of improving the satisfaction levels of lighting and heating system at the University of Huddersfield.

Furthermore, the chapter of this thesis includes an introduction, background, research gap, reason for doing the study, and comprehensive research questions to support the thesis. In chapter two, a detailed literature review is synthesised correctly to define the purpose and objectives of the thesis in the context of the study field. The third chapter described the study technique and the philosophical viewpoint that drives the investigation. More specifically, a presentation of the second analysis of the data gathered using questionnaires to achieve the desired aim and objectives concerning the use of different recognised scholars such as Saunders et al. (2016), where research onion was used as a vital tool that supported the research study and laid the foundation for the research methodology. Chapter four gave the conceptual framework to guide the researcher in doing the investigation. The case study was reviewed in detail in Chapter 5, and the case study was analysed. Description of the samples and an analysis of the demographic data acquired through questionnaires. While chapter six covers the final phase of research based on data acquired via standardised surveys with the Estate team. Chapter seven presents a cross-case study of the data acquired, emphasising similarities and differences in views to reach conclusions on lighting and heating system performance and its relevance to workplace productivity. Furthermore, this chapter summarises the actual outcomes of the research goal and objectives, emphasising the implication and contribution to the theory and practice in the research field and the study's limitations and future research work.

9.2. Synthesis of Objectives

As stated in Chapter 1, Section 1.3.1, the study objective is to explore the effects of lighting and heating systems on building performance and occupants.

As a result, seven research goals were developed and extensively analysed to accomplish the study's purpose. However, the primary purpose was to assess user satisfaction with and control over lighting and heating systems at the workplace. The first aim was principally addressed in parts 2.1 and 2.4 of the literature review chapter. The second purpose was to investigate the most frequently utilised lighting and heating systems and the temperature controls at the workstation. The third aim was to determine the risk level associated with lighting and heating performance difficulties based on their respective influence on performance objectives and frequency of occurrence. The fourth purpose was to determine the strategies or approaches that may be used to address the issues and risks related to the lighting and heating structure and performance in schools. The final purpose was to ascertain the most frequently used temperature controls at users' workstations. The sixth purpose was to ascertain consumers' satisfaction with heating and cooling systems. The last purpose was to assess the impact of lighting and heating systems on users, building performance, and occupants.

These aims were examined using a variety of perspectives and findings from the current corpus of research. Thirdly, the data were analysed using various building management strategies or procedures to resolve the obstacles or concerns. The study was conducted by comparing the findings acquired from the various available literature reviews. The fourth purpose was to provide a framework for optimising the lighting systems in buildings. These goals were further reviewed by consulting current literature to elicit different and succinct perspectives on how to optimise the building's lighting and heating systems.

9.2.1 Objective 1: To investigate the commonly used lighting and heating systems at the workstation building.

The first objective was to investigate the commonly used lighting and heating systems at the workstation building. It could be deduced from the result that the most used heating system was hot water with radiation followed by the air condition. The result therefore means that the mostly used heating system by students and staff both at home and office is hot water with radiation. The study further established that the mostly used lighting system by the staff and students at the workstation was the wall switch with room sensor.

9.2.2 Objective 2: To examine the level of users' satisfaction in the use of lighting and heating systems at the workstations buildings.

The initial goal was to assess user satisfaction with the lighting and heating systems at the workstation. This aim was primarily reviewed via the literature, and questionnaires and surveys supplemented it. This objective's outcomes or discoveries are emphasised and given in chapters 2, 6, and 7, respectively. As a result, it is possible to infer that both University staff working from home and in the office as well as students were satisfied with the lighting systems at alternate workstations. The pleasure derived from utilities was subjective, considering the users' or occupiers' perspectives on what is considered pleasant or satisfying, and this could be linked to the considerable influence on the well-being and health of the building's users.

9.2.3 Objective 3: To identify the challenges associated with the lighting and heating system at the workstation buildings.

The third purpose was to determine the challenges associated with lighting and heating performance based on their respective influence on performance objectives and frequency of occurrence. It may be inferred that many users had few issues. However, others had lighting systems at their primary and alternate workstations due to the sun. The respondents had very few glare issues, as a higher proportion of the replies showed. Perhaps one of the reasons for this is the buildings' orientation or the usage of shading devices to lessen the influence of glare issues in the rooms.

On the other hand, the heating system issues stemmed from the control component of the systems. The control mechanisms caused problems for respondents. This was owing to the system structure at their primary workstation. In contrast, the responder evaluated the control systems at the alternate workstation, which enabled a self-control measure to improve their degree of comfort.

9.2.4 Objective 4: To examine the effects of lighting and heating systems on the performance of the workstation buildings.

The fourth objective was to examine the effects of lighting and heating systems on the performance of the workstation buildings. To achieve the objective, inferences were drawn from objective three. The result in objective three showed that more than half of the respondents with a percentage of 68% were satisfied with the lighting system at the workstation. While a lower percentage of 9% of the respondents were dissatisfied. Considering this wide gap between those respondents who were satisfied and those who were dissatisfied, it can be concluded that the effects of lighting system are positive.

Like the, to determine the effect of heating systems on the performance of workstation buildings, inferences were drawn from the result obtained in objective three. From the result in objective three, majority of the respondents with a percentage of 63% were satisfied with the heating system at the workstation while a lower percentage of 20% of the respondents were dissatisfied. Considering this wide gap between those respondents who were satisfied and those who were dissatisfied, it can be concluded that the effects of lighting system are positive.

9.2.5 Objective 5: To investigate the commonly applied temperature controls among the users at their workstations.

The fifth objective was to determine the most frequently used temperature controls by users at their workstations, and it could be argued that the most frequently used temperature controls by users at their workstations, as indicated by a greater percentage of users, were room thermostat/thermostatic radiator valves, appliance thermostat, and storage heater dials. In contrast, programmer and simple open/close radiator valves were less frequently used.

9.2.6 Objective 6: To examine the levels of satisfaction of the applied temperature controls at the workstation buildings.

Result for this objective was inferentially deduced from the satisfaction with the temperature control system at the workstation. The level of satisfaction helped to infer if the temperature controls at the workstations were effective or not. It can therefore be inferred that a larger percentage of the respondents were very satisfied with temperature control system, and this means that a higher number of students believed that the temperature control system was effective than the staff.

9.3. Contribution of Theory

The research demonstrates the influence of optimising the building's lighting and heating performance and systems on the University. As a result, the research adds to the current body of theory by highlighting the difficulties or hurdles related to the performance and systems of building lighting and heating. As a result, the risk associated with these obstacles was investigated concerning the research field. However, other articles or works of literature verified these observed issues and proposed potential methods for mitigating the effects on users and their productivity.

Additionally, this research study demonstrates significant knowledge and theory via detailed empirical analysis or examination of the building lighting and heating performance systems and their influence on users and their productivity overtime at the university.

However, unlike other previous studies whose studies focus on performance of lighting and heating performance in offices or residential area, this study focuses its attention on the performance of building lighting and heating systems at the workstation using university as a case study. To this end, the study establishes that the lighting and heating system performance at the university were satisfactory. The result corroborates with the university guidelines by establishing that the lighting and heating systems are satisfactory. However, the study slightly defers from the university guidelines by establishing that there are still existing glare problems at the considered workstations.

9.4 Limitation of the Study

The evidence gathered throughout the researcher project's data gathering method included diverse sources and a well-structured case study protocol and process. This is to assure the study's credibility and validity; the philosophical concept and paradigm underpinning this research study impose certain constraints on the survey undertaken, which is more socially constructive and takes a more objective approach. The research study further evaluated the findings with questionnaires and surveys to address this constraint. Additionally, the epidemic hindered testing the sections inside the building that house the lighting and heating systems. As a result, the data acquired in the research study region were restricted, as respondents were dispersed, making it more difficult to elicit more information about the case study location. Thus, practicability and execution remain untested since they are beyond the focus of the study now.

9.5 Further Research

As a result, the suggestion for more study is offered below. No test of the final framework for this study's applicability or implementation was conducted since this was beyond this thesis's research scope. Thus, the research study advises that the final framework be used to following university projects to assess its validity, practical efficacy, and applicability across the board.

Additionally, because the concept of key performance indicators was discovered in the literature concerning the built environment industry, it would be desirable to conduct an empirical study on the other utilities that support building performance in a similar case study context within a university community or setting.

9.6 Conclusion Summary

The just concluded study extensively explored the building lighting and heating systems and effects on building performance and occupants using University of Huddersfield as a case study. The study focused on the investigation of building lighting and heating systems and their effects on building performance and occupants. To achieve this aim and the study objectives, different statistical methods were used ranging from the inferential and descriptive statistics which includes, values and percentages, binary logistic regression analysis, bivariate regression and T-test. Prominent among the results obtained was that the heating and the lighting systems had significant effects on the performance of the building and the users of the workstation. The study thesis's preliminary results have been summarised above in this final chapter.

This concluding chapter discussed how the research thesis's purpose and goals were accomplished via the philosophical attitude adopted, the collection of data instruments, and the application of the analytical measures used throughout the research thesis. The study thesis's primary objective is to develop a framework for improving current satisfactory levels for lighting and heating systems and their impact on users or occupants. This framework is developed and useful for any university which has heating and lighting systems. Also, the benefit of the framework is for different university participants such as students and staff who use lighting and heating systems. Additionally, the research thesis identified the primary aspects affecting the areas for improvement within the lighting and heating systems and alternate methods for improving these systems through the various assessment procedures linked with building management systems. However, the issues revealed allowed improvement and identified potential solutions today or in the future. Additionally, although this study makes significant contributions to theory, the outcome enables future investigation into the subject's application, emphasis, and context.

APPENDICES

Appendix 1

The University of Huddersfield – School of Art Design and Architecture
BUILDING LIGHTING AND HEATING SYSTEMS AND THE EFFECT ON BUILDING PERFORMANCE AND OCCUPANTS.

Dear Respondent,

Thank you for considering taking part in this survey. The questionnaire is part of a research project for my PhD in Architecture and the Built Environment at the University. The purpose of my overall project is to investigate the social, economic, technical and environmental impact of building lighting and heating systems on building owners, facilities managers and occupants. This is also related to obsolescence and sustainability.

To achieve the aim of this research, it is important to carry out a thorough assessment of building performance via surveys such as building users survey, post occupancy evaluation techniques and how the management and performance of systems are reviewed and can be improved over time. It is based on this, that these questions have been formulated to achieve the objectives of the research area. I hope to use this survey to investigate how staff opinions change as they work from home during this COVID-19 pandemic and challenging times, this strategy is to continue to investigate the lighting performance in relation to residential building performance. This will also allow the researcher to understand the perspective of staff, irrespective of their location and compare with the data in the university buildings.

The survey should take no longer than about 7 or 8 minutes. The information provided by you in this questionnaire will be kept confidential and solely used for research purpose only. It will not be used in a way which allows identification of your individual responses – for instance there will be no link in the completed analysis to individuals or houses. If there are any other worries or questions, please feel free to contact me via babatunde.animashaun@hud.ac.uk . My supervisor is Prof Adrian Pitts (a.pitts@hud.ac.uk) and the survey preparation has been discussed with the School Manager and Estates and Facilities Staff.

1. Name (optional)………………………………………………….

2. Job Role……………………………………………………… **(Not a must to say)**

3. Gender? (a) Male [ ] (b) Female [ ] (c) Prefer not to say [ ]

4. Age? (a) Up to 20 [ ] (b) 20-29 [ ] (c) 30-39 [ ] (d) 40-49 [ ] (e) 50-59 [ ] (f) over 60 [ ] (g) Prefer not to say [ ]

5. How long have you lived at your residence or alternative workstation?
(a) Up to 1 year [ ] (b) 2-5years [ ] (c) 6-10 years [ ] (d) Above 10 years [ ]

6. On a typical day, how long do you spend at your alternative personal workstation/room/space?
(a) Less than 2 hours [ ] (b) 2-4 hours [ ] (c) 4-6 hours [ ] (d) More than 6 hours [ ]

   If less than 4 hours, kindly indicate/list any other main work location and how long you are there Location……………………………………Hours per day……………………..

7. Number of hours at your alternative location where you spend more than 4 hours?
(a) Up to 1 hour [ ] (b) 2 – 5 hours [ ] (c) 6- 10 hours [ ] (d) Above 10 hours [ ].

8. Do you have a window in your room or work area?
(a) Yes [ ] (b) No [ ]

9. How important is it to you to have a window in your room or immediate work area?
(a) Very important [ ] (b) Moderately important [ ] (c) Not important [ ]

10. What is your general impression of your room/work area?
(a) Bright [ ] (b) Dark [ ] (c) Good/even lighting [ ] (d) Unevenly lit [ ]
(e) Other (Please specify………………………

QUESTIONS ABOUT LIGHTING SYSTEMS AT YOUR ALTERNATIVE WORKSTATION

11. How satisfied are you overall with the existing artificial (electric) lighting at your workstation?
(a) Very satisfied [ ] (b) Satisfied [ ] (c) Neither satisfied nor dissatisfied [ ]
(d) Dissatisfied [ ] (e) Very dissatisfied [ ]

12. Overall, how satisfied are you with the position of the light fittings at your work station?
(a) Very satisfied [ ] (b) Satisfied [ ] (c) Neither satisfied nor dissatisfied [ ]
(d) Dissatisfied [ ] (e) Very dissatisfied [ ]

13. How is the lighting controlled at your workstation?
(a) Switch at wall [ ] (b) Centrally Controlled by building management [ ] (c) Do not know [ ]
(d) Other (Please specify) …………………………………….

14. How would you rate the lighting control measures at your workstation?
(a) Very satisfied [ ] (b) Satisfied [ ] (c) Neither satisfied nor dissatisfied [ ]
(d) Dissatisfied [ ] (e) Very dissatisfied [ ]

15. How would you rate the natural daylighting at your workstation?
(a) Very satisfied [ ] (b) Satisfied [ ] (c) Neither satisfied nor dissatisfied [ ]
(d) Dissatisfied [ ] (e) Very dissatisfied [ ]

16. Are there any glare problems at your workstation?
(a) no or very rarely [ ] (b) yes from the sun [ ] (c) yes from the artificial lighting [ ]

17. If you could change the lighting in your work area, what would you do? Please tick all that apply.
[ ] Change the location of the overhead lighting fixtures relative to your workstation.
[ ] More light from the overhead lighting fixtures
[ ] Less light from the overhead lighting fixtures
[ ] Change the color appearance of the lighting produced by the lighting fixtures
[ ] Be able to control the brightness/light output of the overhead lighting fixtures
[ ] Get better access to a window view and daylight
[ ] I would not change anything.

QUESTIONS ABOUT HEATING/COOLING SYSTEMS AT YOUR ALTERNATIVE WORKSTATION

18. What is your main heating/cooling system at your work station?
(a) Electric radiators [ ] (b) Hot water radiators [ ] (c) Electric storage heaters [ ]
(d) Portable heaters [ ] (e) Warm air heaters [ ] (f) air conditioning [ ] (g) Don't know [ ]

19. What temperature controls apply to your workstation that you have access to? (tick all that apply)
(a) Programmer [ ] (b) Simple open/shut radiator valves [ ] (c) Appliance thermostat [ ]
(d) Room thermostat/Thermostatic radiator valves [ ] (e) Storage heater dials [ ] (f) Don't know [ ]

20. Overall, how satisfied or dissatisfied are you with the heating/cooling provision at your workstation?
    (a) Very satisfied [ ]   (b) Satisfied [ ]   (c) Neither satisfied nor dissatisfied [ ]
    (d) Dissatisfied [ ]   (e) Very dissatisfied [ ]

21. How satisfied are you in general with the level of comfort at your workstation?
    (a) Very satisfied [ ]   (b) Satisfied [ ]   (c) Neither satisfied nor dissatisfied [ ]
    (d) Dissatisfied [ ]   (e) Very dissatisfied [ ]

22. How satisfied or dissatisfied are you with the level of control you have over the temperature at your workstation?
    (a) Very satisfied [ ]   (b) Satisfied [ ]   (c) Neither satisfied nor dissatisfied [ ]
    (d) Dissatisfied [ ]   (e) Very dissatisfied [ ]

22. How satisfied or dissatisfied are you with the level of ventilation/air flow at your workstation?
    (a) Very satisfied [ ]   (b) Satisfied [ ]   (c) Neither satisfied nor dissatisfied [ ]
    (d) Dissatisfied [ ]   (e) Very dissatisfied [ ]

23. How satisfied or dissatisfied are you with the level of control over ventilation/air flow at your workstation?   (a) Very satisfied [ ]   (b) Satisfied [ ]   (c) Neither satisfied nor dissatisfied [ ]
    (d) Dissatisfied [ ]   (e) Very dissatisfied [ ]

Appendix 2

STRUCTURED INTERVIEW FOR THE ESTATE DEPARTMENT, UNIVERSITY OF HUDDERSFIELD

University of Huddersfield – School of Art Design and Architecture

BUILDING LIGHTING AND HEATING SYSTEMS AND THE EFFECT ON BUILDING PERFORMANCE AND OCCUPANTS.

Dear Respondent,

Thank you for considering taking part in this survey. The interview questions are part of a research project for my PhD in Architecture and the Built Environment at the University. The purpose of my overall project is to investigate the social, economic, technical and environmental impact of building lighting and heating systems on building owners, facilities managers and occupants. This is also related to obsolescence and sustainability.

To achieve the aim of this research, it is important to carry out a thorough assessment of building performance via surveys such as building users survey, post occupancy evaluation techniques and how the management and performance of systems are reviewed and can be improved over time. It is based on this, that these questions have been formulated to achieve the objectives of the research area. I hope to use this interview questions to investigate how staff opinions change as they undertake the moves between buildings as part of the reorganisation linked to the construction of the Barbara Hepworth Building.

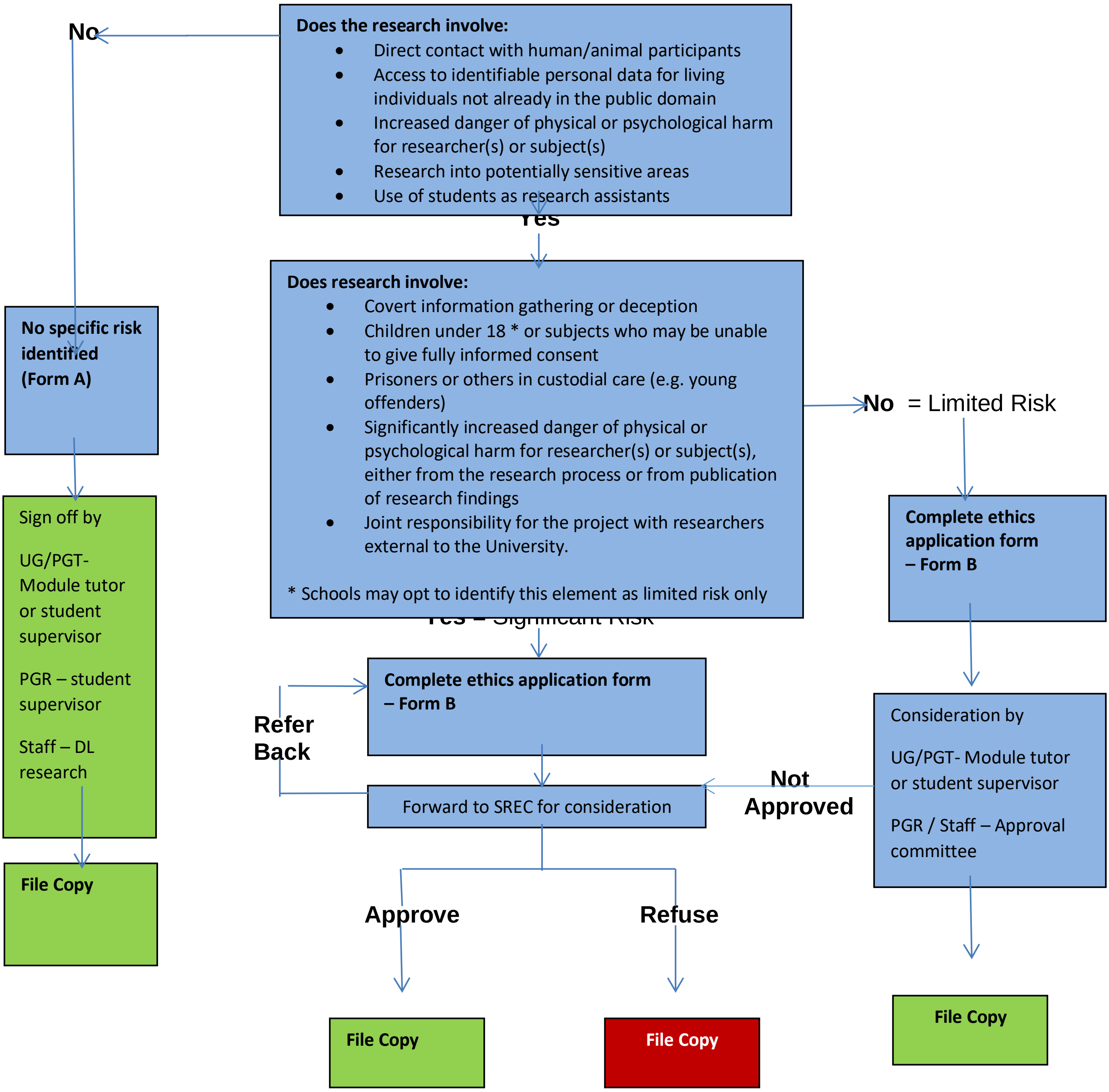
The interview questions should take no longer than about 10 or 15 minutes. The information provided by you from this interview questions will be kept confidential and solely used for research purpose only. It will not be used in a way which allows identification of your individual responses – for instance there will be no link in the completed analysis to individuals or specific room numbers. If there are any other worries or questions, please feel free to contact me via babatunde.animashaun@hud.ac.uk . My supervisor is Prof Adrian Pitts (a.pitts@hud.ac.uk) and the interview preparation has been discussed with the School Manager and Estates and Facilities Staff.

- How important is it to you to have a window in your room or immediate work area?
- What is your general impression of your room/work area?

- How satisfied are you overall with existing artificial (electric lighting at your workstation?
- How is the lighting controlled on your workstation?
- How would you rate the lighting control measures at your workstation?
- Are there any glare problems at your workstation?
- What is your general impression of your room /work area?
- How satisfied are you overall with the existing artificial (electric) lighting on your workstation?
- Overall, how satisfied are you with the position of the light fittings on your workstation?
- How is the lighting controlled on your workstation?
- How would you rate the lighting control measures at your workstation?
- How satisfied are you in general with the level of comfort on your workstation?
- In your opinion, how would you rate the relationship between the performance of the building lighting systems, mental health, comfort and productivity or efficiency at work in the schools or University?
- Which groups within the university should have greatest interest in this relationship: Kindly rate below in terms of priority please?
- When upgrading lighting systems in the university, kindly rank or rate these issues or risks that can lead to less-than-optimal performance?
- What measures can you suggest on how these issues or risks can be controlled, minimized to improve the sustainability of the building lighting systems?
- What are the three aspects of lighting system installation or performance that should be improved upon or sustained in the lighting systems in the schools or university?

Appendix 3

School of Art, Design and Architecture
Project Proposal
Consideration for research and enterprise ethics approval requirements



Form A

School of Art, Design and Architecture

No Specific Ethics Risk Declaration

Researcher: Babatunde Animashaun

Programme and Module (where appropriate): PhD

Research Project Title: Obsolescence in Building Lighting Systems and The Effect on Building Performance and Occupants.

In signing this declaration, I am confirming that my proposed project does not involve:

- direct contact with human/animal participants
- access to identifiable personal data for living individuals not already in the public domain
- increased danger of physical or psychological harm for researcher(s) or subject(s)
- research into potentially sensitive areas
- use of students as research assistants

My proposed project does not therefore require an ethics review and I have not submitted a Research Ethics Application Form.

If any changes to the project involve any of the criteria above, I undertake to resubmit the project for approval.

Signature of Researcher: B.A **Date: 31/10/2018**

Counter-Signatory:

Role:

In signing this Declaration, I confirm that I have reviewed the proposed project and am satisfied that that it does not involve any specific ethics risk as defined by the school policy.

Countersignature: **Date:**

Form B

THE UNIVERSITY OF HUDDERSFIELD
School of Art, Design and Architecture

ETHICAL REVIEW
(Limited or Significant Risk)

APPLICABLE TO ALL STUDENTS and STAFF

Undergraduates and taught postgraduates, lease complete and return via email to your Project / Dissertation Supervisor along with the required documents (shown below)

Staff and research students, please complete and return via email to school research administrator (S.E.Baines@hud.ac.uk) along with the required documents (shown below).

SECTION A: TO BE COMPLETED BY THE APPLICANT

Before completing this section please refer to the School Research Ethics web pages which can be found at this link. Applicants should consult the appropriate ethical guidelines.

Please ensure that the statements in Section C are completed by the applicant (and supervisor for PGR students) prior to submission.

SECTION A: TO BE COMPLETED BY THE STUDENT/ Pi

Before completing this section please refer to the School Research Ethics web pages which can be found at this link.

Students should consult the appropriate ethical guidelines. The student's supervisor is responsible for advising the student on appropriate professional judgement in this review.

Please ensure that the statements in Section C are completed by the student and supervisor prior to submission.

Project Title:	Obsolescence in Building Lighting Systems and The Effect On Building Performance and Occupants.
Student:	Babatunde Animashaun
Student number:	U1670826
Course:	Architecture and The Built Environment
Supervisor:	Adrian Pitts
Project start date	17/09/2017
Risk level: (limited or significant)	Limited

SECTION B: PROJECT OUTLINE (TO BE COMPLETED IN FULL BY THE STUDENT)

Issue	Please provide sufficient detail for your supervisor to assess strategies used to address ethical issues in the research proposal
Aim / objectives of the study These need to be clearly stated and in accord with the title of the study. (Sensitive subject areas which might involve distress to the participants will be referred to the Course Approval Panel).	. The aim is to contribute to filling this gap by understanding and investigating the socio-economic, technical and environmental impact of building lighting systems on the building owners, facilities managers and occupant. **Objectives**

	To identify and review the current and future socio-economic, technical and environmental challenges faced by the building owners, facilities manager and occupant as it relates to building lighting systems. • To explore the risk levels of the identified and reviewed challenges based on their relative levels of impact on the performance goals and frequency of occurrence. • To analyse the results through some innovative measures, methods or techniques for addressing the challenges/issues. • To develop a model for the optimization of the building lighting systems.
Brief overview of research methodology The methodology only needs to be explained in sufficient detail to show the approach used (e.g. survey) and explain the research methods to be used during the study.	The mixed method approach will be adopted for this research study. Qualitative approach will consider the process of observation of the case study as it relates with the demographic, culture and background. While the use of quantitative approach will be analysed, compared studies and presented in form of statistics and the use of line charts will be adopted to present the responses gotten from the respondents and case studies.
Does your study require any third party permissions for study? If so, please give details	N/A
Participants Please outline who will participate in your research. If your research involves vulnerable groups (e.g. children, adults with learning disabilities), it must be referred to the Course Assessment Panel.	Participants will have to be the users/occupiers of the building, maintenance management teams, client or owners of the building.
Access to participants Please give details about how participants will be identified and contacted.	The participants will initially be contacted through email, and then by telephone conversations. Apart from that Researcher will utilize my personal contacts. The interviews and focus group discussions will be conducted, meeting face to face with the participants.
How will your data be recorded and stored? Please confirm that as a minimum this will comply with the university data storage policy and the Data Protection Act. Please indicate also any further specific details.	Recorded with the aid of audio visuals equipment and the use of university store drive. The collected data will be transcribed and transferred to a computer being protected by password. The researcher will endeavour to ensure that the storage of the data complies with existing National and/or International Data Protection Laws and codes. To document the findings, the collected data will be coded and analysed using NVivo package.
Informed consent. Please outline how you will obtain informed consent.	Informed consent will be done via the completion of a consent form through the permission of the school authorities. Proper information will be disseminated to the participant informing them about how the information gotten will be used. Questionnaires will be used in accordance with the research and for academic purpose only.
Confidentiality Please outline the level of confidentiality you will offer respondents and how this will be respected. You should also outline about who will have access to the data and how it will be stored. (This should be included on information sheet.)	There will be assurances from the questionnaires stating the level of confidentiality that the research will protect for the study. All data will be kept confidential and secure. Hard copies of responses received will be destroyed immediately upon entry. While soft copies or recordings will be entered and kept on a protected computer.
Anonymity Do you intend to offer anonymity? If so, please indicate how this will be achieved.	The questionnaire will make use a computer aided program for the survey allowing a high level of anonymity.

	The name of the participants will be removed, unless they wish to be named. However, as a researcher we may have to take more than this basic step to protect a participant's identity. Other information can help to identify people, for example: job title, age, gender, length of service, and strongly expressed opinions. In all, this anonymity will continue even during result discussion with fictitious names used to replace real names where necessary.
To what extent could the research induce psychological stress or anxiety, cause harm or negative consequences for the participants (beyond the risks encountered in normal life). If more than minimal risk, you should outline what support there will be for participants.	N/A
Does the project include any security sensitive information? Please explain how processing of all security sensitive information will be in full compliance with the "Oversight of security - sensitive research material in UK universities: guidance (October 2012)" (Universities UK, recommended by the Association of Chief Police Officers)	N/A

Retrospective applications. If your application for ethics approval is retrospective, please explain why this has arisen.

SECTION C – SUMMARY OF ETHICAL ISSUES (TO BE COMPLETED BY THE STUDENT)

Please give a summary of the ethical issues and any action that will be taken to address the issue(s).

Risk	Potential impact	Likelihood (Very Low/Low/Medium/High)	Mitigation
Face to face interviews and focus group discussions on the research study to further gather information that is needed in order to get the desired result.	- Participants might be stressed a little	Very Low	The venues for the Interviews and focus group discussions will be in safer environment with necessary support. Offer to cease interview in case of emergency
Data collection in unfamiliar environment with unknown participants	Researcher may be stressed too	Very Low	Will Obtain necessary permissions from the right authorities Secure a place prior to the data collection day. Also ensure that contacts are established prior to the data collection

SECTION D – ADDITIONAL DOCUMENTS CHECKLIST (TO BE COMPLETED BY THE STUDENT)

Please supply to your supervisors' copies of all relevant supporting documentation electronically. If this is not available electronically, please provide explanation and supply hard copy

I have included the following documents

Information sheet	Yes	☐	Not applicable	☐
Consent form	Yes	☐	Not applicable	☐
Questionnaire	Yes	☐	Not applicable	☐
Interview schedule	Yes	☐	Not applicable	☐

SECTION E – STATEMENT BY APPLICANT

I confirm that the information I have given in this form on ethical issues is correct.

Signature: B.A Date: 31/10/2018

Affirmation by Supervisor
I can confirm that, to the best of my understanding, the information presented by the student is correct and appropriate to allow an informed judgement on whether further ethical approval is required

Signature ________________________________ Date: ____________________

SECTION F: SUPERVISOR RECOMMENDATION ON THE PROJECT'S ETHICAL STATUS (UG/PGT)

Having satisfied myself of the accuracy of the project's ethical statement, I believe that the appropriate action is:

Approve	
Approve subject to recommendations [please specify]	
Approve subject to conditions [please specify]	
The project proposal needs further assessment by xxx	
The project needs to be returned to the student for modification prior to further action (details of required modifications must be provided)	
Reject	

<u>Taught Students</u>

Undergraduate and Taught Postgraduates- All documentation must be submitted to Unilearn as part of the assessment submission.

<u>Research students/ Staff</u>

Staff and Research students- All documentation must be submitted electronically to school research administrator (S.E.Baines@hud.ac.uk).

All enquiries should be directed to school research administrator (S.E.Baines@hud.ac.uk).

Appendix 1

Sample Information sheet
(required for submission with application for ethical approval)

University of Huddersfield
School of Art, Design and Architecture

<u>Participant Information Sheet</u>

Research Project Title: Obsolescence in Building Lighting Systems and The Effect on Building Performance and Occupants.

You are being invited to take part in a research project. Before you decide, it is important for you to understand why this research is being done and what it will involve. Please take time to read the following information and discuss it with others if you wish. Ask if there is anything that is not clear or if you would like more information. May I take this opportunity to thank you for taking time to read this.

What is the purpose of the project?
The research project is intended to provide the research focus for a module which forms part of my degree. It will attempt to contribute to filling this gap by understanding and investigating the socio-economic, technical and environmental impact of building lighting systems on the building owners, facilities managers and occupant.

Why have I been chosen?
To provide greater insight on the building lighting systems and how it affects you at the workstation

Do I have to take part?
Participation on this study is entirely voluntary, so please do not feel obliged to take part. Refusal will involve no penalty whatsoever and you may withdraw from the study at any stage without giving an explanation to the researcher.

What do I have to do?
You will be invited to take part in **interview, questionnaire,** this should take not more than 30 minutes of your time. Kindly assist in this regard.

Are there any disadvantages to taking part?
There should be no foreseeable disadvantages to your participation. If you are unhappy or have further questions at any stage in the process, please address your concerns initially to the researcher if this is appropriate. Alternatively, please contact Professor Adrian Pitts at the School of Art, Design & Architecture, University of Huddersfield.

Will all my details be kept confidential?
All information which is collected will be strictly confidential and anonymised before the data is presented in any work, in compliance with the Data Protection Act and ethical research guidelines and principles.
What will happen to the results of the research study?

The results of this research will be written up in the final thesis and relevant publications, solely used for academic purposes only. If you would like a copy, please contact the researcher (Babatunde Animashaun, babatunde.animashaun@hud.ac.uk)

What happens to the data collected?
With the permission of participants, interview data will be audio recorded possibly with supporting notes. All the data collected, will be transcribed and transferred to a computer ensuring the data protection by password and anonymised before storage. Name of the participants will not be revealed in any outcomes of the research. The data received will solely be used for academic purpose in understanding the concept of obsolescence in building lighting systems.

Will I be paid for participating in the research?
(Provide a clear statement of payment arrangements for compensation for the participant's time and inconvenience and any out-of-pocket expenses if applicable.) Please note that there is no payment for this research

Where will the research be conducted?
Buildings at the University of Huddersfield, United Kingdom

Criminal Records check (if applicable)
(N/A)

Who has reviewed and approved the study, and who can be contacted for further information?

Professor Adrian Pitts
Department of Architecture and 3D Design
University of Huddersfield
Queensgate
Huddersfield HD1 3DH, UK
Tel (+44) 01484 473288 (direct line)
(+44) 01484 472281 (reception)
Fax: (+44) 01484 472440
email: a.pitts@hud.ac.uk

Name & Contact Details of Researcher: Babatunde Animashaun
babatunde.animashaun@hud.ac.uk
+447502023099

Appendix 2

Sample Participant Consent Form
(required for submission with application for ethical approval)

University of Huddersfield
School of Art, Design and Architecture

Participant Consent Form

Title of Research Study: Obsolescence in Building Lighting Systems and The Effect On Building Performance and Occupants.

Name of Researcher: Babatunde Animashaun

Participant Identifier Number:

☐ I confirm that I have read and understood the participant Information sheet related to this research, and have had the opportunity to ask questions.

☐ I understand that my participation is voluntary and that I am free to withdraw at any time without giving any reason.

☐ I understand that all my responses will be anonymised.

☐ I give permission for members of the research team to have access to my anonymised responses.

☐ I agree to take part in the above study

Name of Participant:

Signature of Participant:

Date:
Name of Researcher: Babatunde Animashaun

Signature of Researcher: B.A

Date: 31/10/2018

Appendix 3

Sample Researcher Consent Form
(required for submission with application for ethical approval)
University of Huddersfield
School

Researcher Consent Form

This form is to be used when consent is sought from those responsible for an organisation or institution for research to be carried out with participants within that organisation or institution. This may include schools, colleges or youth work facilities.

Title of Research Study: Obsolescence in Building Lighting Systems and The Effect on Building Performance and Occupants.

Name of Researcher: Babatunde Animashaun

School/College/organisation: Art, Design & Architecture

Describe i) the purpose of the research study

ii) the data collection methods to be used

iii) which pupils/groups/classes will be selected for this study.

i) The purpose of this research is to contribute to filling this gap by understanding and investigating the socio-economic, technical and environmental impact of building lighting systems on the building owners, facilities managers and occupant.

ii) The use of semi and structured interview questions will be adopted for data collection technique and procedures. A pilot survey instrument will be done to ensure the reliability of the questions associated with the research study. This will be targeted to the organization core which involves the functional units which is strategic and directly affecting the client. It will also target the occupants and users of the buildings.

These questions will be distributed and collected with the use of a web-based survey instrument, the survey monkey. The survey monkey is one of the leading web-based survey instrument companies that help researchers solve survey instrument problems. This tool and other tools will provide and deliver the survey instrument to be used in this research for the collection data.

iii) The buildings to be used will be selected based on the peculiar characteristics to allow for a fair representation from the respondents. Therefore, this research proposes to use the holistic and the embedded case study. Firstly, the research is establishing the University buildings as a single case study. Secondly, the research will adopt two to three building in the University and study as an embedded case study. The reason for this choice is because the physical characteristics of the buildings are different with different shapes and sizes of the rooms and offices. This will allow for a more representation and interpret the phenomenon from the information given by the respondents and participants.

☐ I confirm that I give permission for this research to be carried out and that permission from all participants will be gained in line within my organisation's policy.

Name and position of senior manager:

……………………………………………………………………………………………

Signature of senior manager….………………………………………………

Date: …………………………

Name of Researcher: …Babatunde Animashaun

Signature of Researcher: B.A

Date: 31/10/2018

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