School of Design and Built Environment

The Influence of Indoor Environment Quality on Academic Productivity in the Open-plan Workplace

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DECLARATION

To the best of my knowledge and belief, this thesis contains no material previously published by any other person except where due acknowledgement has been made.

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

Signed: Samhar Rashid

Date: November 2021

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ABSTRACT

Advances in technology and a drive for increased economic efficiency have resulted in many organisations adopting an open-plan workplace design. Within the education sector, academics are facing increased demands on performance, driven by changes in work roles responses to space pressures, increased student numbers and recruitment of high-profile staff. In addition, there is an increasing need for staff to work more collaboratively, particularly in relation to the exchange of knowledge between the education sector and industry partners. In response to these changes, it has become necessary to adapt and evolve new academic workplaces that are flexible enough to cope with these new demands. While a number of studies have evaluated the effect of indoor environment quality (IEQ) on productivity in commercial open-plan workplaces, only a limited number of studies have focused on the education sector. Due to the unique nature of academic work, which distinguishes it from the other sectors, it is not applicable to apply the results of previous studies related to other spaces such as commercial ones to academic spaces. Therefore, there is a clear need for a study solely concerned with academic work spaces. This thesis bridges the gap identified in the existing literature that reveal limitations and lack of studies concern with academic workplace and productivity. More specifically, this research investigates the effectiveness of the open-plan office layout for academic work within the tertiary education sector and aims to determine which aspects of IEQ impact upon academic productivity within this context. The research question is: **"How does the indoor environment quality impact upon academic productivity in open-plan workplaces?"** This gives rise to the objectives, which are to:

- Evaluate the impact of IEQ on satisfaction.
- Evaluate the impact of IEQ on mood.
- Evaluate the impact of IEQ on motivation.
- Evaluate the impact of IEQ on productivity, and
- Explore whether the impact of IEQ on satisfaction, motivation or mood affects academic staff perceptions of productivity.

A case study-mixed method methodology was adopted, to explore the effects of six individual IEQ factors (thermal comfort, air quality, lighting, sound levels, workplace layout and colour) on academic staff satisfaction, motivation, mood and productivity. In addition, the relationships of satisfaction, motivation and mood with productivity were explored. Three

academic open-plan workplaces in Western Australia were selected for the study. Four instruments were used for data collection: physical measurements, a questionnaire survey, a series of semi-structured interviews with academics working in open-plan workplaces, and researcher observations.

The results show that some IEQ factors had a significant impact on academic satisfaction, motivation, mood, and productivity. Particularly, the sound level and workplace layout proved to have the greatest impact. More specifically, distraction from the conversations of other colleagues, and the lack of visual and auditory privacy had the biggest negative impact on productivity. In addition, the study confirmed a strong relation between academic productivity on the one hand and satisfaction, mood, and motivation on the other. By increasing satisfaction, mood, and motivation the productivity increases and vice versa. Also, the study concluded that applying Australian Standards for workplace design does not necessarily guarantee the provision of a work environment that supports user comfort and performance. As a result, academic workplaces need specific designs that facilitate academic work activities and take into consideration sound levels and workplace layouts' impact to create private, secure and quiet office spaces. This study ultimately provides a better understanding of the academic open-plan workplace, including guidelines on how to reach the optimal design that meets all the requirements of academic work, and is thus an important reference for future research.

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CHAPTER 1: INTRODUCTION

1.1 Introduction

Open-plan offices have attracted much attention in organization studies, which have found that the physical environment of the workplace can trigger organizational work change, such as when and where the occupant does the work (Smollan 2015). For example, Hurdley (2010) stated that corridors in a university building have been used by academic staff not just as walkways, but also as places for work-related conversations.

The open-plan workplace was adopted as an alternative to individual offices to support and enhance creativity, collaboration, and social interaction among occupants, in addition to allowing better use of the space through new, flexible workplace design (Clarke, Kenny and Loxley 2015). Contrary to expectations, a number of studies have proven that the open-plan layout can prevent interaction among employees (Bernstein and Turban 2018; Gaskell 2018; Orel and Almeida 2019; Kim and de Dear; 2013). For example, Bektas (2013) reported that occupants in open-plan workplaces tend to personalise their space in order to maintain their sense of privacy. This territorial demarcation prevents occupants from effective interaction. Similar to these findings, Bernstein and Turban (2018) showed that occupants' concerns about causing distraction to their colleagues resulted in less collaboration between occupants in an open-plan workplace. Moreover, some studies showed that an open-plan workplace has a negative impact on environmental comfort, wellbeing, and productivity (Danielsson and Bodin, 2008; Kaarlela-Tuomaala et al. 2009; Pejtersen et al. 2006). However, it has been argued that these results stem from the fact that most of the open-plan workplaces are poorly designed. Oldman and Rothe (2017) found that people in open-plan workplaces generally tend to experience more negative impact than in individual workplaces, but at the same time, open-plan workplaces demonstrated the highest-performing results in comparison with individual offices. These findings were based on the results of a survey conducted in industry with 250,000 participants. The study suggested that a comfortable physical work environment could greatly minimise the negative impacts associated with open-plan workplaces.

The tertiary education sector has been exposed to many changes, such as in market demand, academic identity, responses to space pressures, increased student numbers, the development of teaching delivery methods, and the increasing workload on academics. In line

with these changes, and mimicking the commercial sector, open-plan in some universities has been represented as a solution to fulfil all these requirements and support work transformation (Wilhoit et al. 2016; Lancione and Clegg 2013). For example, universities which this applies are the UTS Business School in Sydney (Lancione and Clegg 2013) and the Dutch University of Utrecht (Gastelaars 2010).

As in other sectors, the purpose of adopting open-plan offices in universities is to increase productivity, efficiency, and sustain collaboration and interaction between occupants (Hassel 2016). However, a study conducted by Wilhoit et al. (2016) found that the outcomes of academic open-plan workplaces are complex and sometime contrary. The authors stated that open-plan may not be operative for academic purposes due to unintentional social consequences such as change resistance, lack of control over the space, and staff members threatening to leave the university. The researchers suggested that academic workplace design should seek solutions to these issues through designs that fulfil academic requirements and enable academic staff to work effectively and sustainably (Wilhoit et al. 2016).

The physical environment, including indoor environmental quality (IEQ) such as temperature, lighting, noise, air quality, layout and furniture, includes the environment quality of a building and its influence on the wellbeing and behaviour of the occupants (Mujeebu 2019). Indoor environment quality has a crucial role in work satisfaction and influences occupants' performance in the workplace (Gifford 2014). Prior studies in environmental psychology have shown that an employee's satisfaction with his/her physical environment is a key indicator of individual wellbeing and performance (Yee, Yeung and Cheng 2008; O'Neill 2008). Vischer and Wifi (2017) emphasised that satisfaction with environment quality is achieved when the work environment meets occupants' needs and has a positive effect on their morale and productivity, enhancing their quality of work and of life. This suggests that satisfaction with a workplace environment exceeds a general evaluation of what occupants like or dislike about their work environment. Building performance should be assessed by evaluating the environment's ability to support occupants' needs. Fassoulis and Alexopoulos (2015), in their study of productivity in the University of Athens (UOA) and its relation with workplace satisfaction, found that the administrative staff were not satisfied with their new open-plan workplace, because they believed that the new design did not support their work types, and that had a negative effect on their perception of productivity.

A significant relationship has been found between the physical environment and emotions in the workplace. Ashkanasy, Ayoko and Jehn (2014) explained that poor IEQ in open-plan workplaces may cause emotional reactions such as anger, which has negative outcomes (Weiss and Cropanzano 1996). Similarly, Kim (2014) stated that the physical environment of the workplace has a significant impact on emotional and behavioural outcomes, which in turn impact work performance.

The move of academic staff from traditional individual offices into shared open-plan layouts creates different mood responses from workers. Academic work, which is competitive while also collaborative, takes place in a stimulating environment that produces both negative and positive mood responses (Stets 2010). This study argues that the impact of mood and motivation within the complexities of the higher education workplace is an important consideration in design and, so far, is an under-explored area of research. The shift to open-plan in workplace design has a significant impact on the occupants' satisfaction, mood, motivation, and individual productivity, and has attracted interior designers and environmental psychology researchers who wish to better understand the impact of the physical work environment on occupants (Bluyssen, Aries and van Dommelen 2011; Vischer 2008).

This study focuses on how IEQ influences occupants' productivity in academic open-plan workplaces for several reasons. Firstly, while many studies have focused on IEQ and its impact on occupant's satisfaction and productivity in commercial open-plan offices, limited studies have investigated the influence of the IEQ of academic open-plan work environments on the occupants' productivity (Sadick, Kpamma and Agyefi-Mensah 2020; Wilhoit et al. 2016). Secondly, academic activities are unique and diverse, including writing and research, administrative work, and meetings with students, which require a high level of concentration and collaboration. Given this diversity, expectations of productivity in an academic setting are different from those in other sectors, and a better understanding is needed of the IEQ effect in academic workplaces. Thirdly, this research addresses literature disagreements on this subject and gives a consistent perspective on the impact of IEQ on occupant productivity in academic open-plan workplace.

1.2 Research Aim and Objectives

The aim of this study is to explore the impact of six IEQs (temperature, air quality, lighting, sound level, layout, colour) in open-plan workplaces on academic productivity within the tertiary education sector. The intention is to evaluate the suitability of open-plan layout for academic purposes and establish a knowledge base for optimum workplace design that supports academic work needs.

This study identifies links between the key factors of IEQ and the mood associated with academic work satisfaction and motivation, and individual academic's perceived productivity in open-plan workplace. Therefore, the main question is: "How does indoor environment quality impact upon academic productivity in open-plan workplaces?" This is further expressed via the following sub-questions:

1. To what extent does the IEQ influence academic satisfaction, mood, and motivation in open-plan workplaces?
2. Which IEQ factor/s has the most influence on occupants' satisfaction, mood, motivation, and perceived productivity?
3. To what extent are open-plan workplaces suitable for academic purposes? And how might academic workplaces function differently?
4. To what extent do feelings of satisfaction, mood or motivation affect academic perceptions of productivity?

To address the research question, the researcher has the following five objectives:

- Evaluate the impact of IEQ on satisfaction.
- Evaluate the impact of IEQ on mood.
- Evaluate the impact of IEQ on motivation.
- Evaluate the impact of IEQ on productivity, and
- Explore whether the impact of IEQ on satisfaction, motivation or mood affects academic staff perceptions of productivity.

1.3 Research Methodology

This research consists of a combination of qualitative and quantitative methods and is designed

in four stages: literature review, case studies, data collection, data analysis and conclusions. The four stages are outlined below.

1. A preliminary review of the literature was conducted from articles, publications, texts, and journals related to the research subject, focusing on trends in workplace design, the academic workplace, and the impact of the indoor environmental quality of a workplace on behaviour and wellbeing. To this end, interdisciplinary literature was reviewed, including discipline areas such as interior design, built environment, environmental psychology, and organizational change, to obtain a better understanding. The results from the literature review were used to conceptualise a framework for evaluating the impact of the physical environment of an open-plan workplace on the occupant.

2. Three case studies were undertaken to investigate academic productivity in open-plan workplaces. In 2015, the researcher visited a number of universities in Perth, Western Australia, in order to identify open-plan academic workplaces suited to the research. Five open-plan workplaces were identified: two in Curtin University, two in the Central Institute of Technology and one in Edith Cowan University. Three open- plan workplaces (two in Curtin and one in the Central Institute of Technology) were purposefully selected for in-depth study using the criteria listed below. They were Curtin University Policy (CUSP), Curtin Teaching and Learning (CTL) and Central Institute of Technology (CIT). The criteria for selection were, firstly, open-plan layout divided into small spaces by low panels that separate workstations occupied by academics (Oommen, M. Knowles and Zhao 2008). Secondly, workplaces that have been designed, built, or refurbished with an open-plan layout between 2010 and 2015. Thirdly, the workplace includes a variety of alternate work settings for the occupants, such as permanent individual workstations, meeting rooms, and some enclosed offices. Fourthly, the size of the open-plan workplaces is medium, accommodating 9-24 occupants, and large, accommodating more than 24 people, to provide rich information relevant to academic experience. Finally, the cases were selected purposively to reflect the different types of academic work in addition to the usual academic activities; in particular, CUSP focuses on research work, CTL focuses on administration work, and CIT focuses on teaching work.

3. Case study mixed methods were used for data collection: quantitative data (physical environment measurements and questionnaire) and qualitative data (interviews and

researcher observations). The findings from the literature review were used as the theoretical base for the development of the questionnaire and interview. The methods for data collection are detailed below:

- Physical measurement refers to measurement of the basic IEQ factors, including lighting illuminance (lux), sound level (dB), thermal conditions (temperature ℃ and relative humidity in %), and air quality (carbon dioxide (CO2) concentration in ppm). The physical measurements were performed in each of the three open-plan environments studied, once during the morning and once in the afternoon. Primarily, the physical measurements were taken in order to draw comparisons between the IEQ of each of the three case studies and the recommended Australian Standards for occupant comfort.
- Questionnaire data were gathered from academics in each of the three selected open-plan workplaces, with the aim of evaluating how occupant satisfaction, mood, and motivation are affected by IEQ, and what impact that has on academic productivity.
- Interviews were conducted with individual academics directly after completing the questionnaire, to further explore whether occupant productivity, satisfaction, mood, and motivation are affected by IEQ, and in what ways.
- Research observations were recorded during visits to each of the case studies to measure factors such as occupancy rates, notable features, and occupant behaviour.

4. Data analysis was undertaken on the data collected from the literature review and case studies to determine the effect of each indoor environment quality factor on academic productivity. The quantitative data gathered from the questionnaire were analysed and then organized through SPSS statistics software, while the qualitative data were organized by using Nvivo software, then analysed manually by the researcher using three stages of coding: open coding, axial coding and selective coding.
5. Finally, data from the literature review together with the qualitative and quantitative results were discussed in order to synthesise findings.

1.4 The Significance of the Study

The significance of this study is threefold.

Firstly, tertiary education plays a significant role in developing societies by creating and disseminating knowledge, skills, ideas, entrepreneurships, relationships, and future thinking. Academic work is always evolving, and academics from part of a diverse and complex group of workers in the tertiary education sector. Therefore, investigating the role of IEQ within the academic open-plan workplace in regard to workers' satisfaction, mood, motivation, and productivity is an important measure to ensure that the workplace supports the academics' activities and their psychological well-being.

Secondly, open-plan workplaces for academics have not been given adequate attention or scrutiny in the literature. This research seeks a nuanced understanding of what works well for academics in open-plan environments in terms of satisfaction and productivity and what does not. This study will address the limitations of research into academic open-plan workplaces and will add new knowledge to help professionals and designers to better understand and design academic open-plan workplaces, becoming an important reference for future research. It is hoped that this study will be useful in raising awareness of the need for workplace design that improves workers' productivity and comfort, and that further studies will be conducted in this field.

Finally, the purpose of this study is to contribute to new knowledge with regard to the significance of the indoor environment quality and its perceived impact on occupant satisfaction, mood, motivation and productivity. The outcomes of the study inform understandings of how the academics interact with the indoor environment quality in order to undertake their work.

1.5 Structure of the Dissertation

This dissertation is divided into five chapters, which are related and complementary to each other.

Chapter 1 begins with a discussion of the research background, then introduces the research aim and objectives, provides a summary of the methodology and methods employed in this study, and the significance of the research. Finally, the chapter presents an outline of the dissertation.

Chapter 2: The literature review was generated from peer reviewed publications including books, reports and journal articles, sourced through Curtin library catalogues, ProQuest, Wiley Online Library, Emerald, JSTOR, Google Scholar, and relevant websites. The literature review covered three subjects in three sections. The first section includes an overview of tertiary education and evaluation of academic workplace environments. The second section covers the physical open-plan environment and provides a theoretical framework for the impact of the physical work environment and occupant satisfaction. Finally, empirical studies of the impact of six indoor environment quality factors (IEQ) on occupants in open-plan workplaces are discussed.

Chapter 3 presents and discusses the structure of the research design and the chosen methodology. It also provides the justification of the adopted methods of quantitative and qualitative data collection. Information on the data collection procedures, the questionnaire and interview design, and the case study selections (including the sample population) are given. The primary form of data analysis of both methods is also discussed in this chapter, in addition to the research trustworthiness and ethical considerations.

Chapter 4 consists of an in-depth description of the cases, findings of quantitative data including physical measurements and results from the questionnaire, and the results of the semi-structured interviews; the two sets of results were then merged together to interpret the data, based on convergent design from Creswell and Plano Clark's (2007) four techniques of designing mixed methods. This was done for each case study separately: CUSP, CTL, and CIT open-plan workplaces.

Chapter 5 provides a discussion of the combined quantitative and qualitative results. In this chapter, key findings are discussed in relation to the current research objectives and how they relate to prior research. In addition, the overall findings, the contributions of the research, and conclusions are summarised. The theoretical and practical implications of the research are explained, and recommendations made for future study.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

This study explores design of open-plan academic workplaces by focusing on the relationships between academics and their physical work environment, including indoor environment quality (IEQ). The literature review provides a foundation for this study by presenting an overview of contemporary tertiary education in terms of academic identity and recent changes in academic work. Productivity in tertiary education is discussed, followed by an overview of the academic workplace. Then the open-plan workplace is discussed as a construct, starting with a historical review of literature on open-plan workplaces across the 20th and 21st centuries, highlighting the key characteristics. This leads to an evaluation of the contemporary workplace, focusing on open-plan design and discussing some of the controversial points of open-plan workplaces, such as occupant interactions and privacy. In addition, this chapter provides a theoretical framework for how the physical environment affects occupants' behaviour, satisfaction, mood, and motivation in relation to their productivity. Finally, it evaluates the effect of the key IEQ factors that have a significant effect on occupants' satisfaction and performance in the workplace.

The literature review draws on contemporary workplace literature, with a particular focus on the general open-plan workplace to contextualise the academic workplace. The research instruments and the interpretation of the thesis findings are presented. While there are a number of studies investigating workplace design for general purposes, there is limited research, and therefore, a lack of evidence for the effect of workplace design solutions on productivity, particularly in the academic context (Sadick, Kpamma and Agyefi-Mensah 2020; Wilhoit et al. 2016). This chapter adopts a cross-disciplinary perspective that includes higher education studies, environmental psychology, organisational behaviour, architecture and interior architecture, to inform a synthesised framework for this study.

2.2 Tertiary Education

Tertiary education (TE) is an important sector in most countries and contributes not only to determining a student's prospects in life, but also informs the general population's knowledge and expertise in all aspects of life activities. It contributes to strengthening the global and local economies and the capacity of societies. In Australia, the National Tertiary

Education Union (NTEU) states that "academics are critical to the overall ability of an institution to achieve excellence in teaching and research" (Allport 2007, 27).

Traditionally, academic productivity focused on two main activities, teaching and research (Altbach 2016; Fanghanel 2012). However, since the 1980s, TE worldwide has undergone profound changes (Altbach 2013; Altbach 2016), leading to a rolling series of significant restructures within the tertiary education sector, including TE in Australia. With the impact of technologies and significant shifts in funding models, the historic model of academic activities has changed to involve the creation of new knowledge, ways in which this is disseminated, and how it is to be applied. In addition, expectations for collaboration have increased, with academics more often being expected to work in teams rather than as individuals, to be responsible for collegial development, to be active in external engagement with industry and practice, to build international engagement, and to engage in interdisciplinarity (Hassell 2020). Academics are expected to perform various additional activities, including research grant applications, administering research contracts, participation in teaching award programs, supervising PhD research to completion, and delivering teaching and research across multiple geographic locations and multiple electronic platforms. We need to understand how and why shifts have occurred over time, and what is driving the change towards the academic's open-plan workplace, and to evaluate this trend's suitability for academic productivity education (Courtney 2013).

Traditionally, for most academics, the workplace has primarily been an individual office. However, over the past decade or more, the TE sector has moved towards open-plan workplaces for academics. This shift to the open-plan workplace has coincided with changes in academic activities, as described above. However, the consequences of these changes are yet to be understood. For many, these are seen as a positive opportunity for teams to work more closely in collaboration, with increasing interaction among the workers. Others debate the effects on academic privacy and the ability to think deeply over sustained periods of time (Nordback, Hakonen and Tienari 2021). The questions are, do those factors (collaboration, team interaction, and privacy) remain relevant to productivity, and what are the environmental factors that impact on academic productivity?

Hassell (2020) and Cai et al. (2017) posit that changes in contemporary academic work are being driven by market demands, with the aim of stimulating both innovation and economic advancement. In response to this drive, universities in Australia have been

encouraging academics to increase their collaboration with industry and their contributions to innovation, thereby making research and teaching more productive and more applicable (Dane 2017). This push has increased university funding. For example, between 2000 and 2017, research funding from industry rose by 90 per cent to $730 million (Norton and De Costa 2018). In addition, the increase in international student numbers has contributed significantly to both university incomes and Australia's prosperity.

Another driving force that leads to adoption of open-plan workplaces is changes in academics' identity. Academics have become increasingly mobile, moving often between institutions and countries (Crozier and Woolnough 2020; Bristow et al. 2017). Today, the make-up of any discipline cohort is more internationalised, and more entrepreneurial. Diversity is highly valued, as are a broader set of research and job skills that go beyond traditional discipline boundaries for academic productivity (Hassell 2020). In addition, the new generation of academics are bringing different skills and attitudes to the workplace. They also bring expectations that they will progress in their careers, and that the workplace will facilitate this with more open, controllable, flexible, and technology-rich spaces that promote wellbeing (Hassell 2016). Universities can attract new students by providing convenient environments that support diverse academic activities (Dane 2017).

Funding and space pressures have pushed universities to increase campus space utilisation rates (Valks et al. 2021). Kwiek and Antonowicz (2013) stated that academics spend 30%–40% of their work week in their office; the remainder of their time, they are engaged with other activities related to teaching, meetings with students, annual leave, and working in labs or in the field — for example, in hospital. Universities are motivated to minimise empty desks by enabling workplace flexibility and change.

Increases in student numbers (Coates and Goedegebuure 2010), and changes to traditional teaching methods with new approaches, have created new challenges for universities, leading to changes in their requirements for academic workplaces, which, for a long time, had remained immune to change. In this context, Scottish Funding (2006) Spaces for Learning report described the process of changing from the instruction model to the learning model, and how transformation had an impact on developing the role of higher educational institutes from a place of education to a place of learning production to fulfil the emerging needs in education. In response, many higher education institutions have moved

towards digital learning and teaching strategies (Currie and Eveline 2011; Halloran and Friday 2018)

2.2.1 Productivity in Tertiary Education

Universities in Australia have increasingly been subjected to globalisation (Altbach 2016). Globalization can be defined generally, according to Beck (2007), as a process in which countries lose their identities, independence, and orientations due to their engagement in different international and supranational organizations. Moreover, globalisation can be seen as a process that leads to the integration of the economy through financial and business activity around the world (Martens and Raza 2010). Globalisation in terms of tertiary education may include rapid development and expansion of information technology, increased demands of tertiary education, increased number of enrolled students in tertiary education (international and local students) and the financial stringency of funding (Altbach 2016). This, in turn, has put added extra pressure on universities to achieve their goals. In addition, universities have become increasingly internationalised, as competition became global (Altbach 2016). The market for student income is a global market. This is particularly evidenced by recent trends in comparative global positioning, with data collected across a range of performance indicators that are then published through university league tables that compare university global rankings.

Global ranking is constructed based on different criteria, depending on the judgement of the ranking organisation. For example, in 2003, Shanghai Jiao Tong University issued the first classification for global academic ranking called Academic Ranking of World Universities (ARWU) with the aim of comparing universities across the world in terms of academic performance and scientific research (Hou and Jacob 2017, p. 31). Since 2003, many other ranking systems have emerged; for example, the annual QS World University Rankings and Times Higher Education (Hou and Jacob 2017, p. 29). It is important to note that the global ranks do not measure quality of education and student needs, and they focus on scientific fields more than other fields (Hou and Jacob 2017).

The global rankings have a significant effect on a university's ability to maintain and build its institutional position and reputation (Henry, Marshall and Ramburuth 2013). A university's ranking can have an impact on its economic growth by attracting local and international students, in addition to industry partners and private investors (Halloran and Friday 2018). The impact of rankings extends beyond the university and are considered an

indicator of the economic and competitive strength of any country (Halloran and Friday 2018; Salmi 2009). In Australia, the TE sector is struggling to keep pace with international competitiveness, to attract high quality academics, produce high quality recognised research, build exemplary learning and teaching reputations, and provide work environments that enable both academic track records of innovation and the building of new knowledge (Gaston, Heimeriks and Hoekman 2017).

In this climate, the university's management needs to allocate resources to meet the extra demands of academic activities, in order to be considered competitive within global ranking systems. They also need to monitor their resources to ensure that they are properly allocated. Therefore, performance measurement has become necessary for educational institutions. Universities have attempted to adopt strategies to measure their performance in terms of teaching, research, and services (Comm and Mathaisel 1998). Key Performance Indicators (KPIs) are a measurable value that determines how effectively the education institutions are achieving their aims and directs their policy formulation and target setting. KPIs measure factors that are linked to the drivers of success in TE. For example, financial KPIs measure profits, costs, and fund raising (Ordenes 2019). Administrative/enrolment KPIs are utilised to understand how students are passing through the institution, for example, by measuring the percentage of students who enrol in universities. Student outcome KPIs are a measure of the number of students per class, as well as the ratio of the number of students per teacher (Duncan, Tilbrook and Krivokapic-Skoko 2015). Research KPIs are considered an indicator of the amount of interaction between universities and communities by providing information and research of interest to communities and contributing to their progress. Using KPI measures helps education institutions to monitor, evaluate and direct university policy and future directions (Duncan, Tilbrook and Krivokapic-Skoko 2015).

2.2.2 Evaluation of Academic Workplaces

As considered in the previous section, academic work activities have changed dramatically due to market demands, academic identity changes, funding and space pressures, increased student numbers, and the development of teaching delivery methods. As a result, academic work has become more complex and the workload on acdamics has increased. In managing these changes,the physical academic workplace is also undergoing changes in a way that suits the needs of the new tasks. This section evaluates the academic workplace and discusses how the new workplace suits the evolving diversity of academia.

Although academic workplace designs vary from one university to another, some common features can be recognised within most universities in Australia. Academic workplaces have often been cellular offices, or small shared offices including separate desks, a meeting space for two to four people for consultation with students and colleagues, storage cabinets, and bookshelves that are usually full of books and papers (Gorgievski et al 2010, Pinder et al 2009). The size and facilities of the offices provided were based on hierarchy and position of the person within the university (Fink 2005); i.e., with larger offices for professors and heads of school (Figure 2-1).

Figure 2-1 Traditional academic workplace (Rashid 2015).

Additionally, there is usually a large meeting room for holding large group meetings and seminars. An academic department usually consists of rows of offices, arranged on either side of a central corridor. Social interaction space for staff is often limited to a corridor, breakout or kitchen area. Due largely to the nature of the work and the need for the spaces to accommodate both focus group and private conversations, the HE sector has been slow to follow the workplace changes witnessed in other sectors (Parkin et al. 2011; Hassel 2014). In comparison, generally, administrative staff often occupy open-plan workplaces, due to the nature of their work, which follows their corporate counterparts with clear institutional hierarchies. Full-time academic staff are the slowest to accept changes in workplaces which stem from lack of hierarchy and a more traditional orientation such as the needs for freedom from distraction, privacy, and secure offices (Hassell 2020).

The open-plan workplace has developed, presumably, as an alternative to cellular offices to meet changing needs and enhance creativity, critical thinking, and collaboration

(Dane 2017), with improved space utilisation through new, flexible workplace design. (Clarke, Kenny and Loxley 2015). In 2016, Hassell ran a project to collect information from seven recently designed academic open-plan workplaces in Australia by interviewing the workplace stakeholders and analysing the floor plans. The project aimed to expose the main drivers of academic workplace change. The study concluded that space efficiency is not necessarily the main objective of academic workplace change. Rather, the objective is to encourage more interaction and engagement with the place (Hassell 2016). Based on these aims, the workplace design shifted from enclosed offices to more flexible open-plan workplaces, including set of workstations for employees, small, enclosed rooms for concentrated work, and meeting rooms for sharing information. More recently, workplace design has moved towards a variety of settings that allow employees to choose according to the type of work activity to support their work throughout the day; this is often called an activity-based workplace (Arundell et al. 2018). According to Dane (2017), a key approach for designing successful academic workplaces is for the design to be based upon existing and emerging academic work. Some studies evaluate the workplace by measuring the suitability of the space to the progression of the academic work. These studies found that the most common concerns about open-plan workplaces in universities are noise, privacy, and unwanted disruptions which affect deep thinking tasks as well as professional identity (Lou and Ou 2019; Baldry and Barnes 2012; Kang, Ou and Mak 2017).

There are other studies that emphasise the positive features of open plan, such as interaction and communication with colleagues and industry partnerships. For example, a study conducted by Loughborough University in the United Kingdom (Parkin et al. 2011) to explore shared work environments for academics examined various academic spaces from individual office facilities to open-plan with hot-desks for group centred research. There was widespread agreement among the academics that opening out the workplace encouraged informal interaction, which was extremely valuable for their work. On the other hand, the participants indicated some negative influences of open plan, such as lack of privacy and a high level of noise. The study concluded that the trend for open plan work environments is growing due to pressure on building costs, but more significantly, a recognition of the importance of interaction and collaboration between researchers. Gorgievski (2010) conducted a post-occupancy evaluation in Delft University to examine the response of academic staff to a new open-plan workplace. The results showed that the academics were dissatisfied with the lack of privacy and security, the noise, and the lack of storage space.

However, overall, the participants' experience was considered to be positive because of the benefit of the increased interactions. The study noted that the daily occupancy level in the workplace was low at just under thirty per cent, as many academics work from home. This fact tempered the success of the new workplace (Gorgievski 2010).

There is an increasing trend for designing open-plan workplaces throughout the world. Although there are many studies of open-plan offices, additional research specifically looking at academic open-plan workplaces is still needed (Wilhoit et al. 2016). Academic work patterns and their workplace layouts are usually quite different from other common open-plan offices, such as those for commercial work.

2.3 Physical Environment of Open-Plan Workplace

This section provides a historical overview of the development of the workplace over time, highlighting some of the drivers of change, and the evolution of the open office with its problems and contradictions. It also provides a theoretical framework for understanding how the physical environment of the open-plan workplace affects occupants' behaviour, satisfaction, mood, and motivation, and the relationship of these with workers' productivity.

2.3.1. Historical Review of Workplace

Across the last century and the beginning of the 21st century, the open-plan workplace has evolved based on changes in the nature of work and economic and technological developments. The purpose of this section is to outline the development of the open-plan workplace and to define its key characteristics and the philosophies behind the design through an analysis of the literature. This historical review covers the development of workplace design during the last century, exploring how design contributes to organisational goals, and how design supports work requirements and potential future needs.

The period across the late 19th and 20th century has witnessed advancements in building techniques and high-rise buildings, which have created the new cityscape. The design of these buildings was supported by Fredrick Taylor's scientific management concept (Taylorism). Taylorism office design is characterised by central surveillance for clerical workers who sit in rows of desks. In this sense, Taylorism was the first spark for the emergence of the open-plan office, which was considered the best solution to accomplish tasks at that time. In this period, designers did not consider the physiological and

psychological aspects for the workers, and the managers treated workers as units of production (Duffy 1999; Sundstrom 1986). An example of this design is Frank Lloyd Wright's design for the Larkin Administration Building in 1906 (Figure 2.2).

Figure 2-2 Larkin Administration Building / Frank Lloyd Wright / Buffalo, New York / 1904-06. 2016, Digital Image. Reproduced from: flickr

The figure shows the workers sitting in rows of desks, with the layout organised hierarchically to facilitate circulation of papers. At the time, inflexible layouts and the central manager's strict supervision limited workers' interactions. At this stage, the open-plan layout was similar to factory design, with desks arranged in rows facing the same direction. The first open-plan prototype was characterised by the absence of barriers, which allowed continuous monitoring of employee by mangers. Hofbauer (2000) stated that the degree of interaction in this office was limited due to the nature of office design which limited interaction between workers.

In the academic context, during these times, university workplaces often consisted of rows of individual academic offices, and other support spaces located on both sides of a central corridor or surrounding a central area. Social interaction was usually limited to the circulation spaces and tea rooms. In most universities, offices for academic staff included workstations for work requiring concentration, and a small space for student meetings and professional visitors (SMG 2006). The size of office was generally based on academic position within the community (Pinder et al. 2009). For example, large academic offices for

Deans and senior staff may be equipped with a workstation, meeting table, storage cabinets and a sitting area, whereas junior staff may have small individual offices or share two- or three-person offices. Administrative and clerical staff frequently shared offices, sometimes in open-plan areas. In general, there was no significant change in the design of academic workplaces between 1900 and the 1990s (Pinder et al. 2009).

The open office continued to spread and began gaining credibility in the workplace in the 1940s. This period witnessed a developing awareness of the physical and sociotechnical needs of workers (Rassia 2017), giving workers freedom of movement. While this allowed for more collaboration, there was more for the managers to monitor. In addition, indoor environment quality gradually improved as organisations realised that comfortable office furniture and convenient ventilation systems improved workers' productivity (Sundstrom 1986). The open-plan office from The Johnson Wax building, designed by Frank Lloyd Wright, New York 1939, represents a good example of open-plan design (Figure 2.3). The workplace showed more space allocated for each person and more flexibility in workers' movements, allowing collaboration (Rassia 2017).

Figure 2-3 Carol M. Highsmith, Work area at the Johnson Wax Building, headquarters of the S.C. Johnson and Son Co., Racine, Wisconsin. 2011, Digital image. Reproduced by PICRYL.

After the Second World War, there was a need to find design solutions that support the idea that all employees share equal responsibility and power, thereby reducing the hierarchy that Taylorism emphasised for decades. The goal of these changes was to increase productivity and profit. A new design emerged in Germany during the mid-1950s to mid-1960s (Kotlyarov 2015) and was further developed throughout the 1960s by Eberhard and Wolfgang Schnelle. Known as Burolandschaft (office landscape), these ideas marked an

important turning point in the history of office design. The new office design was characterised by a group of desks within one workplace, and partitions, such as plants, paintings, and natural elements between these groups of desks. The design also incorporates adjustable and movable desks to improve visual communication within the work environment and to support team work rather than individual work (Hofbauer, 2000). Hofbauer (2000) stated that “management theories" have been adopted in office design, focusing on the well-being of workers in the first place.

By the mid-1970s, heavy criticism of the open-plan workplace designs emerged, with a demand for more control and privacy over the work environment (Duffy 1992). In response, the Herman Miller Company introduced the concept of cubicle open-plan offices (Kotlyarov 2015). The cubicles concept provided private workspace that was surrounded by three partitions within the open-plan workplace (Kotlyarov 2015). This design dominated workplace design from the mid-1970s till the 1990s. Though the cubical design was supposed to create a balance between privacy and interaction for employees, it failed to minimise the level of noise, which caused distraction and concentration difficulties for the workers, resulting in lowered productivity (Kim and de Dear 2013).

The 1990s represent the beginning of the rise of the Information Age. Developments in computer technology, use of the World Wide Web, and the resultant reduction in the amount of paper and storage required in the workplace, all contributed to the spread of the idea of hot-desks and mobile workplaces, as employees could work from anywhere at any time, using the internet and their laptops (Neumann 1999). Hot-desking emerged as a trend, with different employees becoming quite mobile throughout their workdays, as they adopted impermanent workstations during different time periods and types of activities, while at the same time saving on space and resources (Rassia 2017). This period focused on the concept that one design does not fit all, therefore, diversity in design appeared to suit different work needs. In the 1990s, academic workplaces were influenced by an urgent need for new buildings, or major remodelling of workplace designs that supported both the economic rationalist movement and the revolutionary developments in computer technology (Pinder et al. 2009). The key design feature of that time was the emergence of small and medium-sized seminar rooms to accommodate the increasing number of tutorial groups (SMG 2006).

One of the distinguishing characteristics of working in the 2000s is that organisations have taken advantage of contemporary technology in their work, such as the internet, to give

their employees flexibility and freedom from working exclusively in the office (Plaskoff 2017; Metzker 2010). Creative organisations have provided their buildings with entertainment facilities and bright colours, to make workplaces feel more comfortable or more like home, thereby blurring the boundaries between work and home. Organisations at the forefront of the technological revolution have used workplace design to attract elite talent in their particular fields. An example for this trend of workplace design is the Google office in Dublin, Ireland, the design supports an office culture that promotes collaboration between employees by providing different designs that support particular activities. Open-plan workplaces in different sectors spread fast compared to the slower pattern in the higher education sector. The transition to open-plan offices in the higher education sector was, in part, a consequence of building costs. In addition, it reflects a growing awareness of the importance of interaction and collaboration in improving performance and knowledge flow (Pinder et al. 2009).

In the 2010s, workplaces were designed to promote informal interaction and collaboration globally. Designers realised that the office should no longer designed for the needs of the building's owner. Instead, the needs of the workers became dominant in the design (Kaufmann-Buhler 2020). Increasingly, offices have incorporated sustainable design such as green buildings and energy efficiency (Reppeto and Stone 2009). Activity-based working (ABW) environments began to emerge in many organisations. The idea was to provide a combination of options, including open office workspaces, with other task-oriented spaces (also known as "agile" or "flexible" working); the aim was to eliminate many problems accompanied with open-plan, such as distraction and lack of sound privacy, by providing individual offices with the required equipment to complete tasks (Arundell et al. 2018). ABW design provides a flexible work environment in which workers can choose the workplace according to the nature and the needs of the tasks they perform. In the last few years, ABW layout has emerged in universities (Berthelsen, Muhonen and Toivanen 2018); for example, Massey University in New Zealand provides a variety of settings that suit a range of different academic tasks, such as individual and collaborative work, concentration work, phone conversations, and meetings with colleagues.

2.3.2 The Contemporary Workplace

To discuss the field of new workplace design, it is important to first understand the philosophy of the contemporary design of work environments. This section tracks key shifts

in the workplace in the new millennium, as reported in the international literature. First, work has become more dependent on knowledge than ever before, and thus technology and social skills have become one of the most important characteristics of work (Pyoria 2005). Knowledge work tends to be collaborative work, leading to changes in the organisations that direct that work. Organisations have become more competitive, less hierarchical in structure and decision authority, changing recruitment to more casual contracts, and providing fewer lifelong jobs (Heerwagen, Kelly and Kampschroer 2016).

A second important factor that has been contributing to workplace design change is that the employees' demographics are changing as well. Formerly, the workplace witnessed three successive generations. The first generation, called Baby Boomers (born 1946-64) have mostly retired; Generation X (born 1965-79) and Generation Y or Millennials (born 1980-2004) compose today's workforce (Holmberg, Hribar and Tsegai 2017). The newest generation has different working styles and preferences. The characteristics of the period called for new ways of working with mobility and telecommunications, which provide, for example, opportunities to work outside of the office environment (Howitz-Bennett 2014). Millennials are motivated by communication, teamwork, diversity, and flexibility in the work environment (Nosworthy 2015; Plaskoff 2017). The workspace design will influence whether the Millennial is attracted to an organisation, and whether the design supports work activities that they are interested in participating in (Holmberg et al. 2017).

Finally, the tools available to do the work are changing. The digital age of employment emerged during the latter half of the twentieth century and has continued to the present day (Cascio and Montealegre 2016). This change has had a significant effect, not only on the way we work, but also on where we work. For example, telecommuting is a new way of working that has dramatically affected the workplace by allowing the worker to work anywhere, including the office, home, or a café, and extends operating hours from 9-5 towards a 24-hour, seven days a week (24/7) culture (Bresnahan, Brynjolfsson and Hitt 2002; Frey and Osborne 2017). Telecommuting has several benefits for teleworkers. One of the benefits of telecommunication is reduction of the cost for both the stockholders and the workers in terms of office costs and in savings on transportation, clothing and food. As a result, the new situation offers more freedom for people in terms of the ability in organise their personal responsibilities such as work, family and leisure activity (Algrari 2017). Recently, many people across the globe have experienced working from home due to

COVID-19. However, telecommuting can also lead to feelings of isolation and increased levels of overwork (Algrari 2017).

Within the complexities of these changes, it seems that the 'one size fits all' workstation cannot meet the needs of everyone (Greene and Myerson 2011; Cole, Oliver and Blaviesciunaite 2014). The following sections will discuss new trends in workplace design.

2.3.2.1 The Open-plan Workplace

The term 'open-plan' refers to an open space divided into small spaces by movable, low panels that separate workers (Oommen, Knowles and Zhao 2008). Historically, in 1939, the pioneer architect, Frank Lloyd Wright, designed Johnson Wax building, the first open-plan office to fit the needs of clerical employees (Rassia 2017). In this office, new features were added to improve the internal working environment; for example, acoustic isolation materials and better lighting were added, and the thermal comfort improved to enhance workers' productivity. The idea of this design was to provide a workplace with bright lights and acoustic materials and place many workers on one floor to increase their productivity (Sundstrom 1986). After World War II, and specifically during the late 1950s, designers' awareness of the need to give more space for workers to interact with each other has increased. They developed a new model of workplace layout called Action Office (Haynes, Suckley and Nunnington 2017). This model was characterised by various work settings, such as meeting rooms, large individual workstations, and some more enclosed spaces. The design sustained communication and provided a good level of privacy (Haynes et al. 2017). The open-plan layout has dominated workspaces in commercial sectors (Wong 2013). According to Veitch et al. (2007) the main reasons for the 'favourable attitude' towards open plan workplaces related to the economics and interaction benefits. The economic benefits are gained through less space provided per person, which encourages employers to adopt this concept of workplace design (Duffy 1999; Lansdale et al. 2011). Moreover, open-plan design has been reported to save up to 20% in development costs and energy, such as through ventilation system efficiency (Oommen, M. Knowles and Zhao 2008). A study by Shahzad (2016) compared the effect of thermal control on satisfaction and energy consumption in two types of workplaces: the individual office, where the participants have control over thermal environment, window and blind; and the open-plan workplace, where the participants have limited control over the thermal environment, window and blind. The results indicated that energy consumption in individual offices was much higher than in open-plan workplaces.

Another advantage of the open-plan office lies in the collaborative and social environment it provides for employees. This includes improved casual interaction, knowledge sharing, innovation, and reduced stress (O'Neill (2007). As offices become more open, the opportunity for collaboration between employees increases dramatically, as employees can freely interact and share information with other colleges within the office.

However, studies have proven that the open-plan layout can also prevent interaction amongst employees (Gaskell, 2018). For example, Bernstein and Turban's (2018) study found that the actual interaction between occupants in open-plan workplace was reduced by 70% in comparison with interaction in individual offices. The study suggested that the open-plan workplace makes everyone observable and that gives rise to employees creating other strategies to maintain the sense of privacy, such as sending emails instead of having actual conversations which anyone around can hear. Furthermore, (Kim and Dear 2013) agreed that the high level of noise that comes from background interactions causes distraction for those people who are not participants in the interaction. According to Sundstrom (1978), such social communication in an open-plan work environment may have a negative impact on workers' stress, eventually causing discomfort, lowering performance levels, and causing a decline in satisfaction and productivity. A lack of privacy, a noisy environment, and thermal conditions are factors that negatively impact employees' satisfaction within the work environment and hinder employees' performance of their tasks (Tanabe, Haneda and Nishihara 2015).

Moreover, open-plan offices have a negative effect on health and transmission of disease (Pejtersen et al. 2011, Colenberg et al 2020). A study conducted by Oommen, Knowles and Zhao (2008) found that working in open-plan environments causes stress and high blood pressure, which leads to higher rates of absenteeism. A study of Pejtersen et al. (2011) in which 2403 participants participated compared the open-plan workplace and the individual office to investigate the number of absentees due to illness in both offices. It was found that absentee days in the open-plan workplace were sixty-two percent more than in workplaces with individual offices.

Considering the advantages of collaboration in open-plan workplaces and the need for privacy that individual offices meet, a multi-ABW workspace with areas for open interaction and other areas for private concentration is found to keep the office place running to its best capacity (Pochepan 2018). ABW design of a space that supports the differing needs of

workers gives the employee responsibility and sufficient space, within boundaries, to decide how, where, when, and with whom to work (Berthelsen, Muhonen and Toivanen 2018). This is achieved by providing a diversity of spaces to support the performance of each required workplace activity, such as open areas for collaborative work, meeting rooms for formal meetings, small individual offices for deep thinking tasks, game rooms for entertainment, and kitchen areas for social interaction (Berthelsen, Muhonen and Toivanen 2018).

A study conducted by Candido et al. (2019) investigated the effect of office layout on workers' satisfaction, daily activity, and productivity perceptions. The study collected empirical evidence from previous studies conducted on the same participants who had occupied open-plan offices then were relocated into an ABW office. The results showed that the ABW participants were significantly more satisfied with their indoor environment quality and perceived productivity. Office layout was found to be a significant element that motivates the daily activity of the occupants. A study of four ABW workplaces conducted by Haapakangas et al. (2018) for the Swedish Transport Administration Agency aimed to investigate factors that affect perceived productivity, wellbeing, and the time consumed to select an appropriate design setting. A survey was conducted 12 months after the relocation. The results showed that evaluation of individual performance is intrinsically linked to the individual's satisfaction with the internal environmental, communication and privacy, and the higher level of satisfaction is positively reflected in the personal productivity. However, the participants reported that time consumed to find a suitable design setting had a negative impact on their productivity. Arundell et al. (2018) investigated eating behaviours, workplace satisfaction, and productivity before and after moving to an ABW workplace. A self-report survey and interviews were used to collect data from 21 participants. The results stated that the occupants in the ABW showed improvements in terms of physical activity, satisfaction with their physical environment and social relationship with colleagues. However, the results also showed a drop in perceived productivity. The authors explained that the time taken to adapt to the new environment should be considered, since the participants had only spent six to nine months in the ABW workplace, and they might need a longer time to adjust.

The use of technologies, including for information and communication, affects changing work patterns, which leads workplace design towards being smart and flexible, with more open space and less privacy. However, it is not yet known whether such workplace design contributes positively to academic productivity.

2.3.3 Territory, Personalisation and Identity in Open-Plan Workplaces

The concept of territory in the workplace relates to the need to keep a certain distance from others, as well as a feeling of ownership over a space (Sundstrom 1986). In general, a territory is an area occupied by a person, or group of people, through various physical/social objects (Haynes, Greene and Myerson 2011). The concept of territory in the workplace extends beyond the physical barriers of spaces into another dimension, such as having a level of control over the workplace (Altman 1975). Vischer (2008) identified two types of control in the workplace: 'mechanical control' and 'empowerment'. Both types represent a form of territoriality. Mechanical control refers to control over physical ambient conditions; for example, adjustable and movable furniture, switchable lighting, heating, and being able to control sound. The second type of control, empowerment, refers to how powerful workers feel when they are enabled to participate in workplace decision-making. In addition to meeting the psychological comfort needs of workers, providing empowerment control can help workers to adapt more quickly to an environment. A lack of control over a workplace has been described as demotivating (McCoy and Evans 2005).

The psychological value of territory often stimulates workers to express themselves by personalising the spaces they occupy (Fischer 1989; Sundstrom, Herbert and Brown 1982). Personalisation is expressed in terms of environmental psychology as: "the display of personal or work-related items or the arrangement of the workspace to distinguish the occupant from others" (Sundstrom 1986, 218). Personalisation of space is effected by rearrangements that demonstrate an individual's identity as a form of self-expression. Personalisation in the workplace gives a visual indication of the identity of the occupant, which expresses their ownership of the place (Pratt and Rafaeli 2001). According to Brunia and Hartjes-Gosselink (2009) and Wells, Thelen, and Ruark (2007), personalisation can help to promote oneself in a workplace, and can positively or negatively affect emotions, job satisfaction, productivity, a sense of territory, and a sense of position. Wells et al. (2007) found that by making the workplace environment more pleasing, and by enhancing an emotional attachment to the workplace, personalisation may also play a role in helping an employee to cope with workplace related stress. Reducing opportunities for personalisation in the workplace, which is often a high risk in open-plan layouts, not only negatively affects the level of occupants' satisfaction, but also engenders negative feelings associated with a lack of territory (Vischer and Fischer 2005).

2.4 The Physical Work Environment

Over the past decade, changes have occurred in the design of academic workplaces for many reasons, including, but not limited to, the attempt to mimic the design of commercial offices and transit to open-plan offices, as well as the technological advances that provided the opportunity to work at any time and place (Hassell 2020). This new, flexible workplace has broken down the barriers of traditional office working hours, thereby enabling remote work from any place at any time. The shift in the workplace concept has a significant effect on the occupants' behaviours and experiences in the workplace; this change has received the attention of interior designers and environmental psychology researchers who wish to better understanding the correlation between occupants' behaviour and the physical work environment (Bluyssen, Aries and van Dommelen 2011; Vischer 2008).

From a built environment perspective, theories concerned with the physical environment of the workplace posit that the workplace design significantly influences behaviour and performance outcomes (Gifford 2014; Ayoko, Ashkanasy and Jehn 2009; Ashkanasy, Ayoko and Jehn 2014). However, there is limited data on the impact of contemporary open-plan workplace settings on academics and their productivity. This section presents and examines evidence regarding the relationship between the physical work environment and behaviour change and well-being for workers in the open-plan workplace.

According to Vischer (2008), the role of the physical work environment is not only to fulfil basic needs; it includes the need for a workplace where occupants can experience functional and psychological comfort, as described by environmental comfort theory. Environmental comfort premises that when the work environment can provide most of the workers' needs, they will feel safe and be productive (McCoy and Evans 2005; Thatcher and Milner 2012). When the physical environment factors in a workplace are comfortable, this enhances mood and contributes to employees' satisfaction and productivity. For instance,

control over light, thermal environment, and furniture to meet individual preferences have been shown to have a significant impact on occupant's productivity (Lee and Brand 2010).

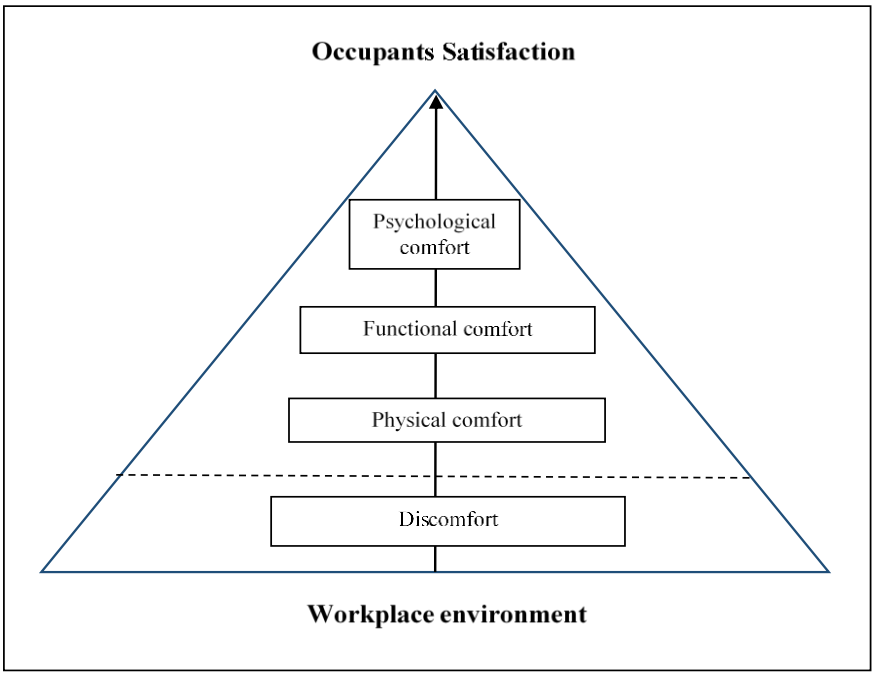

Figure 2-4 Comfort model of workplace environment adapted from (Vischer 2008, 101)

As illustrated in Figure 2-4, the environmental comfort theory breaks down the model for comfort in workplace design into three categories (Vischer 2008): the first is physical comfort, which represents the basic human needs, for example, feeling secure and healthy. The second category is functional comfort, which involves creating an environment able to support different activities performed by employees. For example, the provision of appropriate lighting and layout, and ergonomically designed furniture to meet functional comfort levels. The last category is psychological comfort, which stems from the feeling that the place is appropriate and one has ownership and workplace control. This theory assumes that when the quality of the three comfort levels is achieved, this ensures an optimal work environment that supports work performance. Since the environmental comfort theory was introduced, a number of workplace studies have attempted to evaluate the impact of the three categories of environmental comfort on occupants' performance levels (Vischer 2008; Zibarras and Lewis 2013).

Bluyssen, Aries and van Dommelen (2011) proposed a work environment model to comprehend the potential impact of the physical work environment on levels of comfort. The suggested model highlights the effect of both the physical environment and social context on the personal factors. They investigated the relationship of the physical environment, the social environment, and personal factors, including states of consciousness and mental health (thinking, emotions and memories) on levels of perceived comfort and health. The data were collected by self-report questionnaires from 5732 participants occupying 59 different workplaces and data from the 'European Health Optimisation Protocol for Energy-efficient buildings' (HOPE). The results found a strong relationship between workers' perceived comfort and health with personal factors and physical and social environment. This study emphasised the vital role of the social environment in influencing work performance. It also emphasised the need to take into account the individual differences of workers when designing the physical environment. (Bluyssen, Aries and van Dommelen 2011).

Kim (2014) introduced a conceptual model of organisational performants that emphasised the importance of the physical environment of the workplace on affective and behavioural outcomes, which impacts outcomes of work performance.. The model represents the physical workplace environment (space arrangement, technological alignment of indoor environment, accessibility, and symbolic features) that affects emotional and behavioural responses, ultimately creating better work performance outcomes (Kim 2014, 503). However, this relationship will vary according to individual perceptions of the environment. For example, an earlier study by Fisher and Noble (2004) stated that successful employees are more satisfied than less successful employees with their physical environment.

2.4.1 Satisfaction in the Workplace

Occupants' satisfaction in the workplace environment is mostly related to indoor environment factors such as light, views to the exterior, sound level, temperature, air quality, layout, and furnishings of the workplace (Frontczak et al. 2012). Previous environmental psychology studies suggested that there is a strong relationship between the individual's satisfaction with their physical environment and their individual well-being and performance (Yee, Yeung and Cheng 2008; O'Neill 2008). Since the 1960s, researchers have explored the effects of the environment on occupants' satisfaction; the feeling of satisfaction with the environment is an indicator for evaluating the work environment (Friedmann, Zimring and Zube 1978; Craik 1966).

The concept of workplace environment satisfaction goes beyond what occupants like or dislike to assessment of building performance itself by evaluating how well the building performs to support different activities undertaken by employees (Samani et al. 2018). When users feel satisfied with the physical workplace environment, the workplace is considered to be performing well. A post-occupancy evaluation (POE) is commonly used to evaluate workers' satisfaction with the physical workplace environment. Information gained through the POE can be used both to enhance the quality of existing buildings and to improve the building's performance. Preiser (1995) defined the POE process as a procedure designed to make a comparison between the factual evidence of a building's performance and performance standards and/or codes. Such comparisons should include all positive and negative aspects of the building under evaluation. Preiser and Vischer (2005) stated that POE was originally designed to evaluate a building's performance based on the occupants' experiences: their satisfaction levels, perceptions, preferences and behaviours. The POE is often conducted around 24 months after the building has been occupied but can also be implemented at any time in the life cycle of a building (Khalil and Husin 2009). In principle, the evaluation includes the collection of relevant data regarding the occupants and the building through questionnaires, interviews, and field visit observations. By measuring the occupants' satisfaction, POE can expose the benefits and reveal aspects of the IEQ that need to be improved and/or developed in workplaces (Lee and Guerin 2009).

A number of studies suggest that an occupants' productivity correlates with their satisfaction and comfort levels within the workplace. Studies show that when the worker rates their workplace as an unsatisfactory environment, the perception of productivity levels drops (Leaman and Bordass 2007). A study conducted by professional researchers, ZZA Responsive User Environments (2013), was commissioned by the School of Economics and Political Science in London; they were keen to know the effect the new workplaces had on the occupants and so requested to evaluate their newly completed building at 32 Lincoln's Inn Fields (32 LIF) in terms of how the indoor environment affects their occupants. The school invested £56m to provide a contemporary and flexible workplace for staff and postgraduate students. ZZA's POE examined two categories of occupants, the first being 'residents', including academic staff who occupied both individual and shared offices, administrative staff, who occupied shared offices, and postgraduate students, who were working in open-plan offices. The second category was 'non- resident' occupants, including students who were occupying learning and social spaces in a transitory way. The POE

participants were asked to complete a questionnaire to identify experiences in the workplace. The survey covered key aspects of the work environment, including furniture, indoor environment quality, and how users felt about their environment and the building's management. From the academic staff surveyed, 70% were satisfied with the 'individual office' workplace environment, whereas 30% believed that the traditional workplace (individual offices) reduces the opportunity for interactions and improvements through collaborative work. They also emphasised the importance of informal social spaces, such as a kitchen, which provide good opportunities for discussion among academics. Results from the administration staff showed that 50% identified noise from people in corridors, social spaces, doors, and mobile phone conversations as a significant issue affecting their satisfaction and performance. Results from the postgraduate students showed that they were, overall, satisfied with their open-plan layout. However, 43% identified the lack of clarity surrounding visitors' arrangements as a problem (ZZA 2013).

2.4.2 Mood and Emotion in the Workplace

Wang and Boubekri (2011) stated that there is a strong influence of the physical environment on occupants' emotions in the workplace. However, research into mood within the TE sector is limited and mainly confined to students rather than the academics, despite the shifts that TE faces in the way of working and workplace design, which can potentially engender different mood responses from workers. Leathwood and Hey (2009, 429) claim that mood is difficult to evaluate in the TE workplace, because it covers many different job sectors, ranging from administrative work and marketing through to academic research. Moreover, it is an important consideration that the nature of academic work is competitive (through a structured hierarchy of promotional scales), while also collaborative (necessitating frequent interactions with a diverse population of both students and colleagues), and as such is an environment that engenders both negative and positive mood responses (Stets 2010). In addition, Berthelsen, Muhonen and Toivanen (2018) stated that moving the academic staff from traditional individual offices towards open-plan layouts reduces communication and social support between occupants, causing low job satisfaction. The participants stated that they thought seriously of finding a new job in a new place after the relocation. The study found that there was no improvement in the social and psychological work environment after the transition. Therefore, this study argues that the impact of emotion within the complexities of the tertiary education workplace is an important and, so far, under-explored area of

research. The aim is to understand the impact of the workplace on academics' mood and productivity in an open-plan setting.

When considering emotion in the workplace, research reveals complex interrelations between employees' emotions and wellbeing and factors in their workplace environment. (Weiss and Cropanzano 1996; Ashkanasy et al. 2014). Affective event theory (AET) presents a framework within which emotional events can be understood in depths. The theory deals with the causes and consequences of the occupants' emotional states in the workplace (Weiss and Cropanzano, 1996). AET explains the linkage between the worker's emotions and moods and their reactions to their work environment, which affect productivity and wellbeing. The theory argues that employees are prone to display either affect-driven behaviours or judgement-driven behaviours. Though, originally, AET was developed to investigate job satisfaction in offices, it has been applied to diverse organisational and work-related studies such as health, employee motivation, individual and team performance, and stress (Wegge et al. 2006).

Ashkanasy et al. (2014) present an appropriate theoretical framework based on AET for integrative understanding of how the physical workplace environment, specifically in open-plan workplaces, reshapes occupants' attitudes and behaviour. In Figure 2-6, the model displays three phases: in the first phase, the model links affective events and emotional reactions, and establishes that a variety of workplace events (such as privacy issues and uncontrollable environments) that are stimulated by physical workplace features can reinforce a specific emotional reaction (such as feel annoyed and frustrated). The next phase identifies what emotional reactions mostly affect worker's attitudes toward their work environment. As a consequence of emotional reactions, employees are likely to be involved in conflict, and become territorial (affect-driven behaviour). Ashkanasy et al. (2014) explained that employees in an open-plan workplace with high levels of noise can be expected to have negative emotions, which in turn, cause withdrawal. The last phase shows the affective events in open-plan workplaces may have a direct effect on employees' performance, job satisfaction and even lead to them quitting (judgment-driven behaviour), or they can be mediated by employees' emotions and attitudes to how they fit within their organisation. Certain emotional reactions will likely affect employees' behaviours, leading them to depend on their judgment when doing specific jobs, or workplace behaviour in general. The theory emphasises that the physical workplace environment determines occupants' emotion and behaviour, which ultimately affects individual productivity.

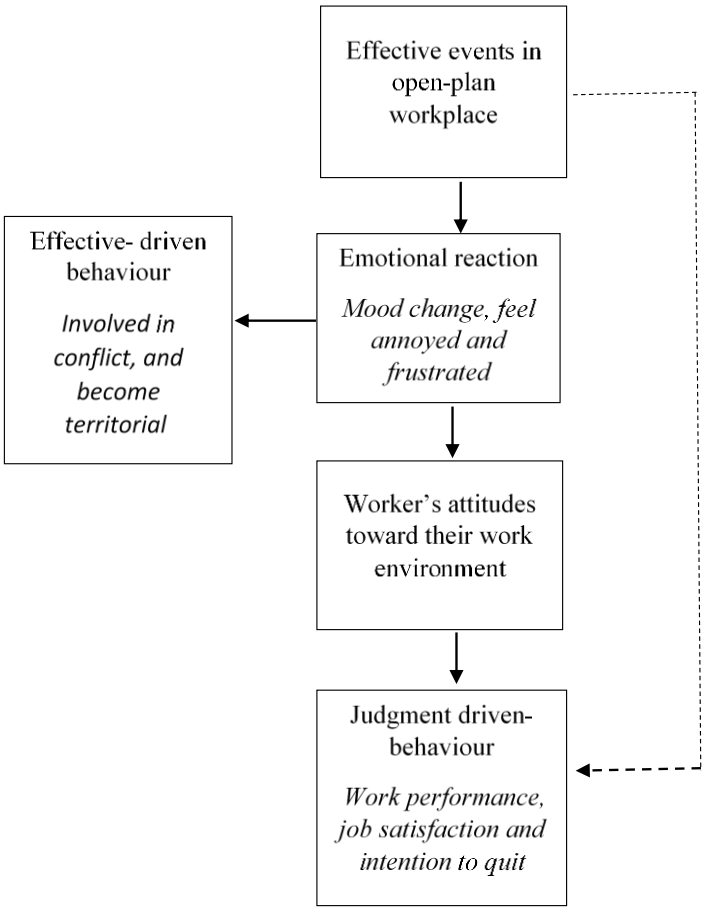

Figure 2-5 A model of the effect of open-plan work environment on workers attitude and behaviour based on effective theory adapted from (Ashkanasy et al. 2014, 1178)

2.4.2.1 Distinguishing Between Mood and Emotion

The conceptualisation of mood and emotion as distinct terms has received much attention in the literature of psychology. The terms seem confusing for many people; however, studies that have attempted to distinguish mood and emotion have concentrated on the structural features of each (Rottenberg, Gross and Gotlib 2005; Watson and Clark 1997). Malik (2011) considers emotions to be feelings raised towards a specific stimulus, person, or event and lasting for only a short time. Importantly, emotion is considered to be produced by an external cause, such as a significant event in life or a 'thing', whether it be real or imagined (Russell and Barrett 1999). According to Ekman (1992), people express six basic types of emotion: anger, fear, sadness, happiness, disgust, and surprise. Mood, on the other hand, is defined here as the experience of a general feeling, often lasting for hours or days (Hofmann et al. 2012); for example, anxiety, depression, energy and fatigue.

Essentially, moods have a cause and can be crucial for workers, because in the workplace, mood impacts the ability to interact with the requirements of the workplace environment (Dimotakis, Scott and Koopman 2011). Moreover, moods experienced as energy and fatigue are feelings of having or not having the capacity to complete mental or physical activities (Jones et al. 2007). As this study is concerned with longer durations of feelings within the workplace environment, it will focus on moods rather than emotions.

2.4.2.2 Studies of Mood in the Workplace

During the 1930s, attempts were made to understand the role of mood on human behaviour in the workplace, mostly focusing on the effect of mood on job satisfaction (Wright et al. 2007; Avey et al. 2010). By the mid-1980s and early 1990s, there was a significant shift towards studies that focused more on understanding the effect of mood on behaviour. A number of studies have demonstrated that employees' mood responses are affected by their experiences at work as well as the quality of their surrounding workplace environments and that, importantly, this can in turn influence workers' performance levels and satisfaction (Lan and Lian 2009; Wang and Boubekri 2011). This section will focus on the impact of the physical workplace environment on the mood of employees.

The mood of the workers can be affected both negatively and positively by a variety of indoor environment elements within the workplace, such as light, colour and temperature (Gifford 2014). Küller et al. (2006), for example, investigated the impact of light on mood in actual workplace environments at different time of the year across four different countries: Argentina, Saudi Arabia, Sweden, and the UK. The workplaces were illuminated by fluorescent light. The results showed that workers were negatively affected at low illuminance, and that they reported being comfortable when the illuminance was at a higher level. However, when the illuminance was too bright, there was a decline in the workers' positive mood (Küller et al. 2006).

Küller, Mikellides, and Janssens (2009) conducted experiments to identify the psychological and physiological effects of colour on occupants in different coloured workplaces. The study first compared the effect of a multi-coloured room with that of a grey room, followed by a comparison between red and blue coloured rooms. The participants spent time in each room completing different tasks, while their brain excitement and heart rates (EEG and EKG) were monitored. The results indicated that both mood and performance of workers were enhanced in the multi-coloured environment compared to the grey room.

When comparing the effects of warm and cool colours, the results indicated that the red room was perceived as more pleasant than the blue room, which could be due to warm colours putting the brain into a more excited state (as shown in the EEG and EKG tests) and causing an occasional and paradoxical slowing of the heart rate.

The layout of workstations has been found to have a significant effect on mood through stimulating interactions. The arrangement and height of partitions between workstations plays a significant role in either preventing or stimulating interactions among co-workers (Kim and de Dear 2013). Dimotakis, Scott, and Koopman (2011) pointed out that the ability to have social interactions with co-workers within the workplace has a direct correlation with mood; when workers experienced positive interactions, this generated positive moods; conversely, negative interactions engendered negative moods.

2.4.2.3 Measurement Methods for Feelings

Three different types of measurements have been commonly used to assess occupants' feelings: self-reported measurements, physiological measurements, and behavioural acts. By far the most widely used is the self-reported measurement method, often used to measure emotional reactions to specific stimuli. This section evaluates some of the most frequently used self-reported measurements.

Verbal self-report

This measurement allows individuals to describe their emotions verbally via open-ended questions, or through rating their emotions utilising a Semantic Differential (SD) scale. SD scales were initially introduced in the 1950s by Charles Osgood as a tool for measuring word and concept meanings. Osgood, Suci, and Tannenbaum (1957, 336-337) found three basic categories to be useful when describing emotional states. Each category includes the opposite polar characteristic. These three categories are evaluated by a scale divided into seven points, started with 'extremely X' and ending with 'extremely Y'. The first category, 'evaluation', represents "good-bad, kind-cruel, wise-foolish, beautiful-ugly, happy-sad, candid-deceitful, sociable-unsociable, friendly-unfriendly, willing-unwilling and honest-dishonest", the second category, 'potency', represents "hard-soft, strong-weak, heavy-light, masculine-feminine, deep-shallow, potent-impotent, severe-lenient, domineering-lax, brave-cowardly and large-small". The last one, 'activity', represents "active-passive, fast-slow, difficult-easy, hot-cold, motivated-aimless, moving-still, excitable-calm, alive-dead, emotional-unemotional and complex-simple" (Osgood et al. 1957, 336-337).

John Flynn, considered to be a pioneer of environmental psychology in the 1970s, was interested in the quality of light in the built environment. A series of studies conducted by Flynn and his colleagues investigated human responses to lighting, including an experimental study in 1973, in which Flynn and his colleagues examined human responses to six different lighting arrangements (Flynn et al. 1973). Flynn's pioneering work on the relationship between environmental psychology and the quality of light in the indoor environment adapted five factors from Osgood's SD rating scale to measure the impressions of occupants: evaluation, perceptual clarity, complexity, spaciousness, and formality. Flynn and his colleagues noted that three factors were more significant than any others — evaluation, perceptual clarity, and spaciousness. The results showed that different lighting conditions can generate different experiences for participants. Flynn also demonstrated a link between lighting modes, including overhead/peripheral, uniform/non-uniform and bright/dim, as well as subjective human responses towards them. Flynn's scale was designed specifically to measure the effect of indoor environment lighting and had not, at that time, been tested or adapted as a tool to measure other IEQ factors (Flynn et al. 1973).

Visual self-report

As a measure of individual feelings, this method is similar, in some respects, to a verbal self-report. However, it focuses on visual forms that reflect different emotions or sensations rather than verbal scales. Self-Assessment Manikin (SAM) and PrEmo are the most commonly adopted visual-self reporting tools used to measure individual feelings. The SAM method was developed by Lang (1980); the method displays three sets of images of a human representing three dimensions: pleasure, arousal, and dominance. PrEmo uses a similar system, but interestingly, was originally produced to measure individual feelings towards design (Desmet, Hekkert, and Jacobs 2000; Desmet 2002). PrEmo consists of 16 figures, each reflecting a particular emotion displayed for a very short time. These figures comprise eight positive emotions (surprise, amusement, satisfaction, desire, fascination, inspiration, admiration, and pleasure) and eight negative emotions (contempt, displeasure, dissatisfaction, boredom, disgust, indignation, disappointment and surprise). The subject is asked to point to a figure that best represents their emotions and feelings and to indicate the degree of this emotion (strong, moderate or weak). One of the main differences between PrEmo and SAM is that multiple feelings can be recorded by using PrEmo. This method is also well suited for use with children and non-native English speakers (Bradley and Lang 1994) and is an indicator of short-term emotion, rather than mood.

Profile of Mood States (POMS)

The Profile of Mood States, POMS, was developed in 1971 by Douglas McNair, Maurice Lorr and Leo Droppleman. POMS is widely used for measuring mood by using a self-reporting questionnaire. The measure was first explored in the USA in 1964, with the original goal being to "construct and develop a useful method for identifying and assessing mood states in psychiatric outpatient populations" (McNair, Lorr, and Droppleman 1971, 620). POMS was subsequently applied in exercise psychology, and later in workplace psychology (McNair, Lorr and Droppleman 1971). Originally, POMS included a long and a short version. The long version contains 65 items for six different factors: tension–anxiety, anger, depression, vigour, confusion and fatigue. The response scale is sorted out into five categories starting from “not at all” to “very strong”. The short version of POMS contains 24 items on four scales (vigour, fatigue, irritability, depression/anxiety). The POMS short version is used to measure either the ‘last 24 hours’ or the ‘last week’. In contrast, the long version is used to measure the ‘last week including today’. This method provides a good indication of mood rather than emotion, and has been commonly used to evaluate workers’ moods in relation to different IEQ factors (Morfeld et al. 2007).

2.4.3 Motivation

Motivation is a basic psychological process (Taghipour and Dejban 2013) that has been described as an internal feeling needed to fulfil and achieve a particular goal (Dobre 2013). Rahim and Daud (2012) consider motivation to be a feeling that stimulates and directs a person’s behaviour and performance. Maslow’s (1943) human motivation framework, which comprises a human basic needs hierarchy, argues that the need to achieve levels of being controls the mind and changes individual behaviour. The hierarchy is categorised into five connected levels of needs. The first level is physiological needs, which represent the basic human requirements such as shelter, food and drink. The second level is safety needs, which represent the need to feel secure through, for example, police and medical care. The third level represents human emotional needs such as love and belonging. The fourth level represents the need for self-esteem, respect, reputation, having self-worth, feeling strong. The top level in Maslow’s hierarchy is self-actualisation. This level indicates that individual is able to realise their full potential and it is possible to achieve the desired goals as well as individual self-realisation. These needs must usually be met sequentially as they complement each other, and there is always a desire to progress to the following needs (Maslow 1943).

According to Santisi et al. (2014), maintaining employees' motivation to work is essential to increasing their satisfaction and performance. Ogbogu (2017) stated that employees with low motivation might show low productivity and negative attitudes. In addition, positive motivation improves the employees' willingness and enthusiasm to complete their tasks (Torres and Sidorova 2015). Self-determination theory (SDT) provides an insight into how motivation, well-being, and employees' productivity are connected. This theory was designed as a framework for studying personality and individual motivation (Ryan and Deci 2018), with propositions focusing on how the surrounding environment facilitates or undermines an individual's sense of willingness, well-being and productivity. SDT posits that autonomy, competence, and relatedness are psychological needs stimulating motivation, engagement with work, and creativity. In addition, SDT theory suggests that there is a relationship between individual performance and wellbeing on one hand and the fulfilment of individual's psychological needs on the other hand, and that providing these needs will have a positive impact on performance (Prentice Jayawickreme and Fleeson 2019).

Gagné and Deci (2005) found that motivation and willingness to perform work are determined by both internal and external causes. Internal motivation comes from a worker's personal enjoyment in undertaking a particular task; for example, for people who are satisfied with their job, their motivation is being able to practise the work itself. The authors added that internal motivation is a very important factor for stimulating creativity. While external motivation steams from the surrounding environment of the individuals, such as the work environment setting, financial reward, fame, and competition are all examples of external motivators (Gagné and Deci 2005).

Academics at universities might be motivated by the income they earn, rewards or improved chances of promotion, or they may be motivated by the need for respect and status through being recognised by colleagues and educated society. In addition, academic staff are usually motivated by the job itself (Zhang 2014). They are influenced the desire for achievement, a sense of responsibility, performance recognition, job significance, and personal growth. These factors have different effects on the academic's motivation at work.

Increasingly, researchers have sought to determine how employees can be effectively and successfully motivated to enhance their productivity, because motivated employees are instinctively interested in their work (Markova and Ford 2011). Motivation plays an important role for every employer who is looking to improve employees' performance and

organisational productivity. Lan, Lian, and Pan (2010) found that motivation and productivity in the workplace can be affected by the qualities of the indoor physical environment. In China in 2013, an experimental study was conducted to evaluate the effects of five different temperatures (22 ºC, 24ºC, 26ºC, 29ºC and 32ºC) on motivation and productivity. The study included 36 participants divided into two groups, A and B. Participants in group A were examined at all five temperatures and those in group B were examined at 26ºC only. As a part of the experiment, the participants conducted a memory typing task, similar to general office work. They were then asked to complete a questionnaire about perceived environment, workload, and motivation to work, measured in a seven-point rating scale: "extremely low (0) very low (1), slightly low (2), neutral (3), slightly high (4), very high (5), extremely high". Results from the study showed that the participants' work was significantly affected by temperature change, and that the participants were more motivated when they were comfortable with the temperature. It also showed that performance increased because of higher motivation, demonstrating that productivity can be affected by the physical environment and worker motivation. The findings show that the optimum temperature range for performance is between 22ºC and 26ºC, and that an overly warm environment has a negative effect on both motivation and worker productivity (Cui et al. 2013).

2.5 Indoor Environment Quality

This section evaluates the effectiveness of indoor environment quality (IEQ) in an open-plan workplace on occupants' perceived productivity. Evaluating IEQ in the workplace helps to determine the success of its design, which has a direct effect on the occupants (Lee and Kim 2008; Landy 1989).

Workplace research has identified several key elements which can impact on occupants' productivity in workplace. The current study adopted and adapted key indoor environment qualities from an IEQ survey by The Centre for the Built Environment (CBE). The IEQ survey is the most popular standardised occupant assessment instrument in the workplace; the objective is to improve the environmental quality and energy efficiency of buildings (https://cbe.berkeley.edu/resources/occupant-survey/). The survey is designed to evaluate building performance and occupant's satisfaction based on seven environmental factors in the workplace: "air quality, lighting, office layout, maintenance, office furnishings, thermal comfort and acoustics quality" (https://cbe.berkeley.edu/resources/occupant-survey/).

This section reviews the existing literature on IEQ to identify the factors considered to be most likely to affect productivity. Each factor will be examined in detail in order to establish its role in open-plan workplaces.

2.5.1 Thermal Conditions

Thermal conditions play an important role in the workplace environment as one of the IEQ indicators (Huizenga et al. 2006). The ASHRAE[1] standard definition of thermal comfort is a "condition of the mind which express[es] satisfaction with the thermal environment" (ASHRAE 2010, 55). Thermal comfort can be determined by four factors: air velocity, room temperature, humidity, and thermal emission (Bluyssen 2010). These factors have an effect on the occupants' perception of thermal comfort; for example, the amount of humidity depends primarily on the temperature of the air, because warmer air holds more humidity than cooler air. People often showed different needs regarding thermal comfort; some theories have emerged that attempt to explain these differences among occupants. For example, the thermal equilibrium theory of the human body suggests that there are individual factors, such as occupant's activity level, age, individual physical differences and preferences such as clothing, all of which have an impact on thermal comfort (de Dear and Brager 2002). Other theories have attempted to interpret the thermal sensation from a different angle and suggest that occupants' expectations and preferences regarding their thermal sensations are determined by their prior expectations. If these expectations are a mismatch with their environment, they will experience feelings of dissatisfaction and discomfort and vice versa; for example, during colder winter months, occupants expect colder conditions inside the building (Nicol and Humphreys 2010).

Muller et al. (2011) stated that thermal comfort can stimulate and irritate the brain to induce different mood responses and occupant's behaviors such as, social interaction. A mutual relation between thermal comfort and state of mood was found in studies conducted separately by Ibrahim et al. (2019). Ibrahim et al. (2019) studied the influence of thermal comfort and assessed how human mood may influence perception of it; for example, anger stimulated negative thermal comfort perceptions among occupants, whereas a happy mood stimulated positive thermal comfort perceptions. Another study dealt with the influence of

[1] The American Society of Heating, Refrigeration and Air-conditioning Engineers is an international organisation that establishes standards for heating, ventilation and air conditioning through its research. Their mission is "to advance the arts and sciences of heating, ventilation, air conditioning and refrigerating to serve humanity and promote a sustainable world" (ASHRAE 2009).

workplace temperature on employees' productivity. The productivity data was collected and measured by analysing literature from previous studies. The results demonstrated that there is a strong link between high indoor temperature and reduced productivity; that is, there is 2% productivity decrease per degree over 25°C (Seppanen, Fisk and Faulkner 2004). However, in contrast to this, it has been found by measuring cerebral blood flow that high temperatures can increase cognitive capacity, which leads to improved productivity quality and speeds up performance (Tanabe, Nishihara, and Haneda 2007).

Thermal comfort is subject to the nature of each individual's responses; therefore, it becomes difficult to set an optimum temperature within an open-plan workplace (Bluyssen 2010; ASHRAE 2010). However, there are standard measurements used to examine and set the best thermal conditions for an indoor environment to be accepted by at least 80% of the occupants. The ideal office temperature, according to AS60068.3.6 (2003) ranges between 20 and 24°C. Even though these standards are adopted and applied in many buildings, there are studies that challenge them.

Professor Richard de Dear, an international expert in thermal comfort, emphasised the importance of employees having control over their workplace temperature settings (de Dear 2012). The level of control that people have influences their psychological response and is directly related to their degree of satisfaction with the workplace environment (Kwon et al 2019). Control over the environment enhances feelings of empowerment and ownership of a space, and provides a certain degree of self-expression that, in turn, positively affects feelings of satisfaction (Sundstrom and Altman 1974). Occupant satisfaction may be positively affected by providing the building's occupants with more than one choice and enabling the occupant to have control over their environment (Hellwig 2015). Shahzad (2016) investigated the impact of thermal control on workers' satisfaction with their environment, comfort level, health and productivity; the study was conducted in both individual and open-plan workplaces. Occupants of the individual offices have a high degree of flexibility and control over their office temperatures, and a blackout window for each office. Occupants of the open-plan workplace in the same study were provided with a limited level of control over the temperature and had limited access to windows. Satisfaction and productivity levels in the individual offices where the occupants exercised high levels of thermal and window control were higher than those of the occupants of the open-plan office. The author concluded that the individual office provides a high level of control over environmental factors.

From all the above, it is apparent that the thermal condition within an office environment influences the employee's psychological and physiological state and therefore their productivity. Furthermore, empowering employees by enabling more control over their office environments, thereby enhancing feelings of ownership, will produce more satisfaction and comfort.

2.5.2 Air Quality

A number of studies have established a positive relationship between indoor air quality (IAQ) and human health and wellbeing (Apte and Salvi 2006). In general, IAQ can be affected by many aspects of the indoor environment, including the ventilation rate and indoor pollution from the building, carbon dioxide (CO_2) concentration, furniture, and the number of occupants and materials (Varjo et al. 2015). For example, using wood for interior design, such as covering the walls, can improve the indoor air quality (Cho et al. 2019). A high rate of CO2 gas indicates an efficient ventilation system It has been shown that reducing the CO_2 levels to below 800ppm improves occupant's satisfaction and reduces negative physical symptoms for occupants (Kabrein et al. 2017).

As open-plan workplaces accommodate more occupants than the individual office, the differences between the two types of offices can influence different workplace temperatures and the amount of contaminants produced in these environments. Poor air quality causes serious physiological issues, such as tiredness and nervousness, whereas AC systems cause "dry eyes and throat, congested or runny noses, itchy and watery eyes, lethargy, headaches, respiratory complaints, chest tightness" (Hodgson and Fisk 2006, 627-632), and psychological issues such as psychological distress and mental disturbance (Kim et al. 2018). Kamaruzzaman and Sabrani's (2011) findings show that the majority of occupants are not satisfied with their office air quality, which is believed to be one of the factors that affect work productivity and stress levels. Clements-Croome (2013) pointed out that most complaints in open-plan workplaces are due to poor ventilation and thermal comfort and the lack of space allocated to each employee, and found that it is possible to increase the productivity of the individual by as much as 4-10 percent when improvements are made to those factors. This is supported by many studies (Mujan, Andelkovic, Muncan, and Ruzic 2019; Mulville, Callaghan and Isaac 2016), which have found that air quality in the workplace has a direct impact on health and well-being.

2.5.3 Lighting

Lighting is a fundamental element of the overall design of any building. It is necessary for optimal visual function, enabling us to see our surroundings and complete our work tasks. Innes (2012) defined indoor lighting as comprising natural daylight as well as artificial lighting. Artificial lighting has many characteristics, each of which has a direct effect on an environment:

Luminance is the intensity of light emitted or reflected by a surface. It is measured by candles per square metre (cd/m^2) and is often used for measuring intensities of displays, for example (Innes 2012).

Illuminance is the light produced by a source which falls on a surface. Lux is used to measure illuminance in lumens per square metre (Innes 2012).

Glare: The consequence of bright light in the field of vision, which causes annoyance, discomfort and/or loss in visual performance and visibility (Sundstrom 1986).

Correlated colour temperature (CCT): This is one of the light characteristics that describes whether a light seems 'cool' or 'warm'. It is measured in degrees Kelvin (K). The colour of light plays a role in determining the impression of a whether a room feels warm or cold (Brandi 2012).

Colour rendering index (CRI): Is a measure of the susceptibility of a light source in terms of its effect on the appearance of color. The CRI scale ranges between 0 and 100 percent, which gives an indication of the accuracy of any source in rendering the color of objects; the higher the reading, the higher the accuracy (Boyce 2003).

Lighting distribution: The spectral distribution of light sources is an important feature of IEQ, with CRI and CCT being used together to describe the spectrum and temperature of a source respectively (Wei et al. 2014). Boyce (2003) found a slightly higher positive response to background lighting using spotlights, which created a more relaxed and attractive environment through influencing the perception of brightness and the appearance of a space.

The Australian Standard sets the level of illuminance for a workstation to be between 160 and 320 lux, depending on the tasks performed, such as typing, reading, or writing (AS/NZ5 1680.0 1998). Cuttle (2013) revealed that many offices suffer from insufficient light, and in some cases, the recommended standards may not provide an office with the

appropriate lighting levels; each task requires a certain level of lighting, and individuals have different requirements and preferences, even when completing the same task. This was demonstrated by Moore et al. (2003), who conducted a long-term study (for a year) on the impact of lighting in four separate open-plan workplaces. The participants in the four workplaces were undertaking office-work activities. The results indicated that, even though the occupants were all undertaking the same type of activities, there were significant differences in lighting preferences.

Artificial light and daylight have a significant part in shaping our perceptions of the indoor environments we occupy, influencing physical, emotional and behavioural responses to the indoor environment. Gifford (2014) points out that lighting intensity and distribution can impact arousal, comfort levels and interpersonal communication. For example, a simulation workplace environment study investigated the effect of two illumination levels, 1000lx and 200lx, on participants' mood, task performance, and physiological effects. The study employed self-report and objective measures such as self-reported mood, auditory Psychomotor Vigilance Task, heart rate, and skin conductance measures for data collecting. The results showed that participants felt more energetic and happier when exposed to 1000lx than to 200lx. There were no significant differences in physiological effect and performance between the two lighting conditions (Smolders and Kort 2014). However, many studies make the link between lighting and occupant satisfaction and productivity (Katabaro and Yan 2019**);** for example, So and Leung (1998) concluded that there is a significant relationship between illuminance and rate of concentration; a high degree of illuminance led to 94% of people feeling more concentrated, while 64% felt more relaxed under low illuminance. Duffy and Wright (2005) also stated that unsuitable lighting can cause concentration difficulties and sleep disorder, with negative effects on individuals' productivity. In addition, access to windows positively affects general health and mood, and increases the interaction between occupants with the outside (Sanchez et al. 2018). A study found that students who study in rooms with good exposure to daylight performed better than students with poor daylight (Al Zaabi, Nassif and Mushtaha 2017). However, sometimes glare and reflection can disturb the occupants and cause headaches (Al Zaabi et al. 2017).

The reaction to intensity of illuminance can differ between men and women and across age ranges. Nelson, Nilsson, and Johnson (1984) showed that, under higher illuminance levels, women had increased levels of concentration, activation, and were more amiable compared to men. Knez and Kers's (2000) study indicated that younger workers

maintained a negative mood in warm white lighting, whereas cool white lighting had the same effect on older workers when engaged in mental work. In addition, the study found younger females can maintain positive and negative moods better than a younger male. These studies suggest that providing uniform lighting for everyone in open-plan workplaces might not support human differences and the preference to achieve individual productivity.

2.5.4 Sound Levels

Several studies have found direct relationships between sound level and occupant productivity, job satisfaction, and health in the workplace (Lee, Back and Chan 2015; Smith-Jackson and Klein 2009; Landström et al. 1995). Acoustic comfort and sound privacy issues have been identified as major factors impacting on occupant satisfaction and productivity (Toftum et al. 2012; Kang, Ou, and Mak 2017; Kim and de Dear 2013). However, with the growth of open-plan workplaces, the existence of various types of noise source, including background sounds, conversation, outdoor noise, and noise from office equipment, are very common features of the contemporary work setting (Lee et al. 2015). As a result, there has been much effort directed towards understanding the impact of sound in the open-plan workplace. Background noise that comes from co-workers' conversation and phone calls is the main reason for the discomfort in the open plan workplace (Mak and Lui 2012). According to a number of studies, background noise can lead to occupants' dissatisfaction and results in low productivity in the workplace (Lee and Aletta 2019; Mak and Lui 2012). For example, noise in the workplace has a disruptive impact on cognitive tasks due to the negative effect of conversational noise on the worker's ability to recall, proofread and complete mentally complicated tasks (Haapakangas et al. 2017). However, occupants can respond towards a noise level in different ways based on their personality and task type; for example, Roskams et al.'s (2019) study conducted in three open-plan office environments investigated how personality characteristics and work activities are correlated to comfortable sound level, productivity, and well-being in the open-plan office. Data collected from 166 participants in a questionnaire indicated that participants highly sensitive to noise were dissatisfied and had lower self-rated productivity because they were annoyed, stressed, and had concentration difficulties due to background noise. Moreover, the study found that the participants who had less social communication in the workplace responded that the workplaces had a negative impact on their productivity and they had lower work engagement. This suggests that the open-plan workplace is more appropriate for certain types of work activity than for others. Other studies have dealt with the impact of noise levels on the

psychology of workers, such as emotion and motivation. Jahncke et al. (2011), for example, simulated an open-plan workplace to investigate task-based performance, physical measures for stress, and self- reported mood and fatigue. Two noise conditions were investigated: high noise, considered to be 51 LAeq, and low noise, considered to be 39 LAeq. The participants in the experiment underwent two sessions, one at low noise and the second at high noise level. Each session lasted for two hours, with memory tasks such as "response inhibition, logical problems and operation span and reading span". The results from the study showed that the participants' performances decreased in the high noise environment, and they were more fatigued and less stimulated to work because of distractions from background noise than they were in the low noise environment.

Some strategies have been proposed in order to control noise in the workplace, such as those by Mahn (2015), who identified the benefits of using specialised materials for absorbing sound and using electronic sound-masking techniques to cover the noise in workplace. However, the case for open-plan workplaces is complicated, because a large number of employees react to the sound level in different ways based on their personalities and the nature of the work. Therefore, the sound levels in open-plan workplace environments need more attention by researchers to find the ideal combination for these strategies to be implemented successfully.

2.5.5 Layout

The layout of the office is described as the systematic arrangement of partitions, furniture, and equipment within an existing floor space (De Croon et al. 2005). Al Horr et al. (2016) and Duffy (1999) identified different types of office layout, based on the architecture and the function: a cell office is a single-person office consisting of immovable partitions and a door; a shared office is where two to three people work in a 'cell' office and use the same office every day; and an open-plan workplace is where barriers such as walls, high partitions, and doors have been removed. Open-plan offices are often large open spaces designed by arranging a number of workstations or cubicles, separated by partitions of varying heights. The open-plan office can be divided into three types based on intended occupancy: small, which accommodates 4-9 occupants; medium, which accommodates 9-24 occupants; and large, which accommodates more than 24 people.

The open-plan office type has been increasingly adopted by a variety of organisations. This is often attributed to the fact that this type of environment encourages communication

between workers and provides value for money to an organisation (Fayard and Weeks 2011; O'Neill 2008). The advantages and disadvantages of open-plan offices have been extensively covered in Section 2.3.2.1, where it is noted that this type of office layout has also been criticised for a lack of visual privacy and increased distraction, both of which can negatively affect occupants' satisfaction and productivity. In a university setting in Ghana, a study by Sadick et al. (2020) investigated different IEQ impacts on occupants' satisfaction and productivity in three academic and professional workplace types: open-plan, individual, and shared offices. The information was collected from academics and support staff across all schools in the university via an online questionnaire survey. The results showed that academic and professional staff were most unsatisfied with privacy and acoustic levels in the open-plan workplace layout: speech privacy, intelligibility of speech, and control over the environment were identified as issues impacting their satisfaction. They were most satisfied in individual offices which had higher levels of privacy and acoustic comfort. The results indicated that lack of acoustic comfort, privacy, ventilation, and thermal comfort have a significant negative influence on productivity for academics in open-plan and shared workplaces and positive influence in individual offices. In contrast, the IEQ impacted positively on professional staff productivity in all office layouts. The authors attributed this contrast to the differences in roles, work activity types, and different levels of thinking and mental engagement between academic and professional staff. Moreover, professionals spend most of their work hours in their offices and therefore are more adapted to their work environment, unlike academics, who spend their time between office work, teaching, and meetings with members of the faculty, students or external partners. Hence, university office layouts should be designed based on different staff activities, and attempt to guarantee optimal workplace environments that meet the needs of different staff activities (Sadick et al. 2020). Candido et al. (2016) studied the impact of three types of open-plan workplace (Candido et al. 2016): activity-based work (ABW), hive, and individual offices, on occupants' satisfaction with IEQ, perceived productivity, and health in commercial workplaces. The study collected the post-occupancy evaluation data from 5,171 participants in 30 workplaces in Australia. This study demonstrated that with the ABW layout, the workers' overall satisfaction and perceived productivity and health were enhanced due to increase interaction, better air quality and building aesthetics. The authors explained that the flexibility and multi-space setting of ABW gives the occupants more control over the way they prefer to work. However, individual offices outperformed the other two types of ABW and hive layouts by providing a good level of visual and sound privacy.

A number of studies have discovered evidence that through facilitating face-to-face interactions, open-plan layouts encourage collaborative work among workers. However, the problems associated with privacy needs and distraction mean that these increased interactions do not always translate into increased productivity (Kaarlela-Tuomaala et al. 2009; Rashid, Wineman, and Zimring 2009). Workstation design, including partition height, attempts to address privacy issues. Partition height plays a significant role in enhancing or discouraging desired interaction among workers. Newsham (2003) suggested that screen heights should be between 1,300 and 1,400 mm high in order to provide acceptable visual privacy, while at the same time allowing the daylight to penetrate the space as much as possible. Appropriate workstation design that provides a sense of visual and sound privacy helps to improve workflow and reduce occupant stress levels (Lindberg et al. 2018). Moreover, workstations can affect the way workers interact with their colleagues (O'Neill 2008); for example, team enclosure workstations are usually designed to accommodate four or six individual workstations situated in a group, as shown in Figure 2-7. This design aims to facilitate teamwork, permitting members of the same team to work together and focus on tasks with minimal interruption from other teams. Furthermore, the amount of space and access to adequate work surface areas have been shown to have a powerful effect, outweighing the effect of all other IEQ factors on overall occupants' workplace satisfaction (Kim and de Dear 2013). Kim and de Dear (2013) explain that the amount of personal space is apparently an essential condition or baseline expectation, whereas holding discreet conversations, for instance, is not a basic expectation in workplace.

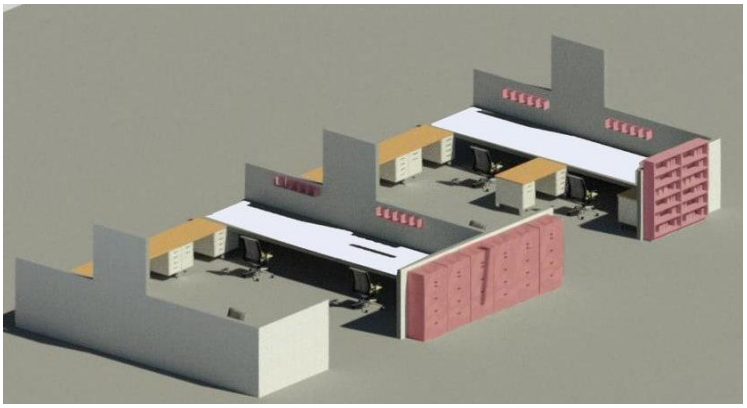

Figure 2-6 Perspective of enclosure workstation (Rashid 2019)

Generally, the studies discussed above agree in principle on the importance and the effect of layout and furniture on workers' productivity and satisfaction. The design of the open-plan workplace allows for a more efficient use of space, because open-plan environments reduce

the overall floor area required. However, the open-plan design decreases visual and acoustic privacy and can affect workers' interactions and productivity.

2.5.6 Colour

While colour is often considered to significantly affect how we perceive the indoor environment, it is not often a focus of IEQ studies. However, colour is included in this study in an attempt to cover a number of IEQ factors that may have an influence on productivity, and in an attempt to understand the relationship between these IEQ factors and the workers' satisfaction, motivation, and mood.

Colour is an optical phenomenon generated by the way light is reflected by any particular surface. Colour perception and preferences are influenced by people's differences in terms of age, gender, cultural aspects, and background (Sorokowski et al. 2014; Baniani and Yamamoto 2015). It has been found that colour in the workplace can influence workers' productivity. The positive changes in the productivity of employees occur when the interior of the workplace is designed with consideration for the workers' needs, especially when this is done well. A number of studies aim to understand how colour may affect productivity; for example, Mehta and Zhu (2009) conducted an experimental study of the effect of colour on cognitive task performance. In this study, the participants first performed a task and then completed a questionnaire. The results showed that red and blue coloured rooms have different associations for cognitive work. Red is associated with avoidance but enhances performance in detail-oriented work. In contrast, blue is associated with motivation and enhances performance of creative tasks. Similarly, an experimental study by Kwallek and Lewis (1990) evaluated the effects of three colours (red, green and white) on workers' productivity and mood in a simulated workplace setting. These participants completed a mood-scale questionnaire both before and after undertaking a reading task in one of the three simulated offices, each of which was coloured red, green or white. Results of this study suggest that the participants in the red office made less errors than participants in the white office. Yet, the results also found that the participants preferred to work in the white office environment and considered white to be the most appropriate colour for an office, because white offices seem to be acceptable as the norm and are prevalent, while red was considered to be more distracting. Conversely, when the investigation was conducted in a real workplace, responses showed no significant effect for colour on productivity. For example, Bakker et al.'s (2013) research focused on testing warm colours and cool colours,

represented by red and blue, within a real workplace setting. Fifty-two participants used both coloured rooms in turn and were asked to complete questionnaires two or three days after using the meeting room. The findings reveled that there were no differences between the blue and red environments in relation to either perceived wellbeing or the workers' productivity. The researchers concluded that, in an actual work environment, there are so many contributing factors affecting perceived wellbeing and productivity that measuring the effect of colour alone is extremely difficult. Therefore, to create better work environments, considerable attention should be paid to choosing the colour scheme. An inappropriate colour scheme might have a negative psychological impact on occupants, such as depression, boredom, or stress (Haller 2017).

Other studies have focused on investigating the psychological effects of colour on workers. Stone (2001) for example, conducted an experimental study to evaluate the effect of different colours on satisfaction, mood, motivation, and performance of the participants across a range of different task types. The participants were adult students randomly assigned to one of the tasks/colour pairs: a low or high work requirement, undertaken in a red or blue environment. The environment comprised a workstation surrounded by three partitions, 610 mm high above the workstation desktop, with all three partitions being either dark red or light blue. The results showed that, under these conditions, performance seems to be influenced by environment colour. When the participants worked at a high demand task, their performances were generally inefficient in the red environment compared with the blue one. The red colour was described as distracting by participants, affecting their concentration and reducing their productivity. In regard to mood, positive moods were experienced in the blue open-plan workplace in contrast with the red workplace, because of the calming effects of cool colours and stimulating effects of warm colours. Participant motivation was not shown to be affected by the colour of the workplace.

Colours have an impact on temperature perception; Wang et al. (2018) conducted an experimental study to investigate the impact of colour on thermal perception, satisfaction, comfort level, and heart rate. The experimental study, conducted on 16 participants, used three air temperature conditions and seven wall colours in a chamber. The results indicated that thermal perception and heart rate increased with warm-coloured walls and decreased with cool-coloured walls. In addition, the participants were more comfortable and satisfied with cool colours in a warm environment and more comfortable with warm colours in a cold environment. Colour in workplaces is critical to inducing or reducing occupant's

productivity; therefore, more attention should be paid to investigating in depth the effect of colour on productivity.

2.6 Conclusion

The workplace design evolved over time, from individual and shared office to cubical, open-plan and ABW office layout. These changes were brought on by requirements to enhance creativity, collaboration, and social interaction among co-workers. This chapter established the lack of consensus in literature reviewed with regards to the effects the indoor environment quality has on the open-plan office performance in commercial sector. Some studies confirmed a strong relationship between the collaborative work in the open-plan office and increase in productivity (Clarke, Kenny and Loxley 2015), while other studies disputed these results concluding that the open-plan workplace can impede the interaction among employees (Gaskell 2018; Orel and Almeida 2019; Kim and de Dear; 2013; Bernstein and Turban 2018). Moreover, the review of literature found that the open-plan office can have a negative impact on workers' privacy and control over the workspace, which in turn may reduce the productivity.

Studies concerned with academic open-plan workplace have only recently come to fore due to the delay in adopting open-plan office layout in academic field compared to other sectors. Therefore, the studies do not adequately address this phenomenon comprehensively (Sadick, Kpamma and Agyefi-Mensah 2020; Wilhoit et al. 2016). Accordingly, the open-plan office in academic sector needs deeper investigation and research to overcome the limitation of earlier studies. In addition, due to the unique nature of academic activities which require a high level of concentration and collaboration, the expectations of productivity in an academic setting are different from any other sectors.

The previous literature found a strong correlation between the physical environment and occupants' emotions and motivation, which consequently affect their judgment and behaviour (Weiss and Cropanzano 1996; Ashkanasy et al. 2014). However, the transferring of academics to an open-plan office layout may generate different emotions. This study argues that the impact of mood and motivation within the academic workplace are important factors that should be taken into consideration for optimal work environment as this field is still under-explored area of research. In contrary to previous studies which in general focused on studying and evaluating one or two factors of the indoor environment quality, this study

provides a thorough insight by investigating six indoor environment quality. These factors (temperature, air quality, lighting, sound level, layout and colour) were investigated to understand how these elements altogether effects on workplace performance and identify the most effected factors in academic open-plan workplace.

CHAPTER 3: METHODOLOGY

3.1 Introduction

This study investigates how the quality of the indoor environment of open-plan academic workplaces affects productivity in the Western Australian tertiary education sector. Consistent with the study's research question and objectives (Chapter 1, section 1.2) and in relation to the review of the literature (Chapter 2), an exploratory case study methodology has been employed. This methodology was adopted in order to identify the characteristics and the main drivers behind the increasingly occurring phenomenon of the open-plan academic workplace. Multiple case studies have been selected for this in-depth study, to explore different aspects of academic productivity and different characteristics of open-plan designs to analyse data collected from within each case, and then to analyses the data across the three cases.

This chapter explains the research methodology, the data collection framework, the methodological approach used to collect both the qualitative and quantitative data, the data analysis techniques used, the reasons why particular methods were chosen, and the analyses of these data. The chapter concludes with a discussion of ethical considerations and a summary of chapter contents.

3.2 Philosophy and the Research Design

Researchers utilise a particular philosophy to guide their research (Holden and Lynch 2004). The term research philosophy can be defined as embracing certain strategies in order to support research methodology and design to obtain and analyse data related to the subject of the research (Žukauskas, Vveinhardt and Andriukaitienė 2018; Saunders, Lewis and Thornhill 2007). Research assumptions create a holistic view of how knowledge is viewed. Research assumptions can be divided into two main types: ontology and epistemology. Ontology concerns assumptions about the nature of being and entity (Burrell and Morgan 1979). Epistemology refers to assumptions about knowledge, and concerns how the knowledge is gained; it also determines what can be deemed as acceptable knowledge of good quality. The current study is consistent with epistemology, as it is concerned with providing evaluation of the perceptions and opinions that occupants hold towards their work environment and how they describe their experience. There are three major research

philosophies or paradigms, worldviews, or belief systems that guide researchers: postpositivist, interpretivist, and pragmatist (Tashakkori and Teddlie 1998). Postpositivists believe that there is a single reality which can be measured with scientific methodologies (Bassey 2009; Cohen, Manion and Morrison 2011); therefore, researchers frequently use quantitative methods to measure this reality, such as a questionnaire (Tuli 2010). Postpositivist epistemology suggests that reality can be measured, hence the focus is on reliable tools to measure it (Yin 2014). Postpositivist research maintains a distance from the participants and what is being researched in order to remain objective and is usually connected with quantitative research (Carson et al. 2001). In contrast, interpretivism, the core philosophy of this research, suggests that there is no single reality or truth, and that reality needs to be interpreted by studying phenomena in their natural environment (Neumann 2003). Therefore, the research design for this philosophy uses a qualitative method to interpret participants' perceptions in-depth about their environment. In interpretivist research, the researcher is more personally involved by embedding their opinion in their analyses of the participants' experiences (Creswell 2013; Smith 2019). Pragmatists believe that reality is constantly renegotiated, debated, interpreted. It provides opportunity to investigate what is important to the research and ensure that it is represented in a practical and applied way. The pragmatist believes that the best method to use is the one that solves the research problem and allows development of mixed method approaches by using both qualitative and quantitative method for collecting and interpreting the data. This allows the researcher to be more subjective at times and objective at other times based on the research aims and objectives (Creswell 2013).

Creswell and Plano Clark (2018) suggest that the research aims and questions dictate the method of the study to be undertaken. Accordingly, to answer the research question "How does indoor environment quality impact upon academic productivity in open-plan workplaces"? the researcher needed two types of data: quantitative, to measure the impact of six IEQs on feelings of satisfaction, mood, motivation and perceived productivity in open-plan workplaces; and qualitative, to explore the subjective experiences of the academics in their workplace. A combination of qualitative and quantitative methods (mixed method) was thus employed for data collection and analysis. In this sense, this study employed a pragmatic paradigm, which has often been seen as the foundation of mixed method research to obtain knowledge, using both qualitative and quantitative data in order to find answers for research

questions (Creswell 2013); this approach provides opportunities to investigate what is of importance to the research in a practical way.

3.3 Case Study Research

A case study is a powerful approach to providing a comprehensive overview of a complex problem. Yin (2014) defined a case study as a practical investigation of a contemporary real-life phenomenon that involves complex relationships with unclear boundaries; for example, the study of a complex social phenomenon such as racism. Benbasat et al. (1987) stated that this approach is appropriate when the research and theory are still at an early formative stage, when there is not enough information about the phenomenon. Yin (2014) stated that the case study is well suited to situations in which questions such as why or how can be posed about current topics that the researcher has limited control over. The primary purpose of a case study is to obtain new perspectives that contribute to an existing phenomenon or theory through investigation within a practical setting (Simons 2009). Furthermore, case studies allow the researcher to combine both qualitative and quantitative data, offering a strong strategy for data collection and analysis. However, there are some identified weaknesses with the case study methodology. For example, it can create biases, because it is subjective by design (Hessler 1992), and both the collected data and the subsequent results cannot necessarily be generalised (Cavaye 1996). This study seeks to understand in depth how the new designs for open-plan workplaces for academics need to respond to the complex relationships between the occupants and their environment according to the differences in their academic activities and roles within universities. The traditional academic office was dominant in most universities until the 2010s, when the open-plan workplace design evolved to include a variety of settings focused on greater flexibility.

According to Yin (2014), case studies can be classified into three types of case studies: exploratory, explanatory and descriptive. Each type aims to serve a specific purpose:

- The exploratory type is employed “to identify the research questions or procedures to be used in a subsequent research study, which might or might not be a case study” (Yin 2014, 238).

- The explanatory type is used to examine data in-depth, to explain how and why some sequence of events happened.

- The descriptive type is a realistic description of a real problem, with a focus on the events, characters, ideas, and solutions proposed by the individuals who face the problem.

This research is both explanatory and descriptive, in order to explain how and why the indoor environmental quality within open-plan workplaces influences academics' productivity. It describes workplace features and academic experiences in real contexts, and identifies specific issues related to their productivity. Yin (2014) has distinguished four types of designs for case studies: single or multiple, and embedded or holistic. A single case is usually conducted to provide rich description of a phenomenon, or for theory development or theory testing (Markus 1989). Multiple case studies using a variety of cases support investigation of cases that are literal replications (producing similar results) and theoretical replications predicting contrasting results for theoretical reasons (Yin, 2014). The benefit of multiple case studies rests in helping researchers understand the differences and the similarities between the cases (Baxter and Jack 2008). Multiple case studies enable researchers to analyse the same phenomenon across several different cases (Yin 2014). In addition, multiple case studies help to overcome issues relating to generalisation of the results and can therefore yield stronger findings (Yin 2014). However, research using multiple case studies requires a greater variety of resources, more time, and increased funding.

The other option would be to select between adopting holistic or embedded design, where the first one depends on the application of a single unit of analysis, while the other uses several units of analysis. An embedded case study contains more than one sub-unit of analysis (Yin 2014) and allows the integration of quantitative and qualitative methods in a single study (Yin 2014). Additionally, more accurate and detailed information can be obtained when adopting the use of sub-units. This study employed embedded, multiple case study design to examine more than one case, with each case study focusing on a particular type of academic work, using the same units of analysis for each case. The units of analysis were: a) the influence of IEQs of open-plan workplaces on academic satisfaction, mood, motivation, and overall productivity, employing a quantitative design through a questionnaire; and b) gathering of in-depth information about academic experiences in open-plan workplaces. For the latter, a qualitative research design was employed, using semi-structured interviews to better understand how and why the open-plan workplace influences academics' experience. The next section explains the case study, mixed method methodology combining quantitative and qualitative data.

3.3.1 Case Study Mixed Method Approach

Case studies rely on collecting a variety of quantitative and qualitative data in order to gain in-depth comprehension of the phenomena. Quantitative research is the process of collecting and analysing measurable data and is mainly used to explain the results (Creswell, 2013). In quantitative research, the researcher conducts the investigation in an unbiased and objective manner (Todd et al. 2004). In this research, the quantitative data measures a series of IEQ factors in open-plan workplace. Whereas qualitative research allows the researcher to explore in depth for quality in the data, with the researcher more personally involved (Smith 2019), usually through interviews, focus groups, or observations (Creswell and Plano Clark 2018). When quantitative and qualitative data are combined in one study, this is called mixed methods research design (Ostlund et al. 2011).

Case study and mixed methods integrate well (Yin 2014). Creswell and Plano Clarke (2018, 116) state that integrating case study and mixed methods in one study "provide[s] in-depth evidence for a case(s) or develop cases for comparative analysis". Combining case studies and mixed methods in a systematic way can provide a more complete understanding of the phenomena under investigation (Creswell and Plano Clark 2018). Yin (2014) points out that using mixed method design allows for tackling more sophisticated research problems than case studies alone. According to Carolan, Forbat and Smith (2016), case study and mixed methods research are connected; the data from these methods might support or lead the research, based on the purpose of combining these two methods. There are two primary designs for combining case study and mixed method: mixed methods–case study (MM-CS) and case study–mixed methods (CS-MM) (Guetterman and Fetters 2018).

In CS-MM, mixed method is nested in a larger case study research (Guetterman and Fetters 2018). The use of mixed method design in case study research will help to integrate the qualitative and quantitative data for more in-depth understanding for the case (Yin 2014). In MM-CS, on contrary, the case study is nested in a larger mixed method research. Using this method will help to understand the characteristics of the case study research complexities. The current study used CS-MM, because this study performed a case study using a mixed method for data collection.

The mixed method approach explains quantitative and exploratory data through qualitative research questions (Creswell and Plano Clark 2018; Creswell 2013). Mixed methods allow a more comprehensive understanding of the issue under investigation. According to Creswell and Plano Clark (2018), using mixed methods in the same study enables the researcher to obtain a more complete image of human experiences. Besides providing rich and comprehensive data, use of mixed methods has several advantages, such as triangulation of data by verifying or rejecting results from qualitative data using quantitative data, or vice versa. It also helps to answer the research question that cannot be solved by using one type of data exclusively and improves the validity of research findings (Todd et al. 2004). This study utilised both qualitative and quantitative procedures to collect, analyse and interpret the data to triangulate the data towards a comprehensive understanding of the influence of IEQ factors in open-plan workplaces on academic work (Creswell 2013). In this study, the qualitative and quantitative data were gathered and analysed separately; the two sets of results were then merged together to interpret the data, based on convergent design from Creswell et al.'s (2007) four techniques of designing mixed methods, figure 3-1.

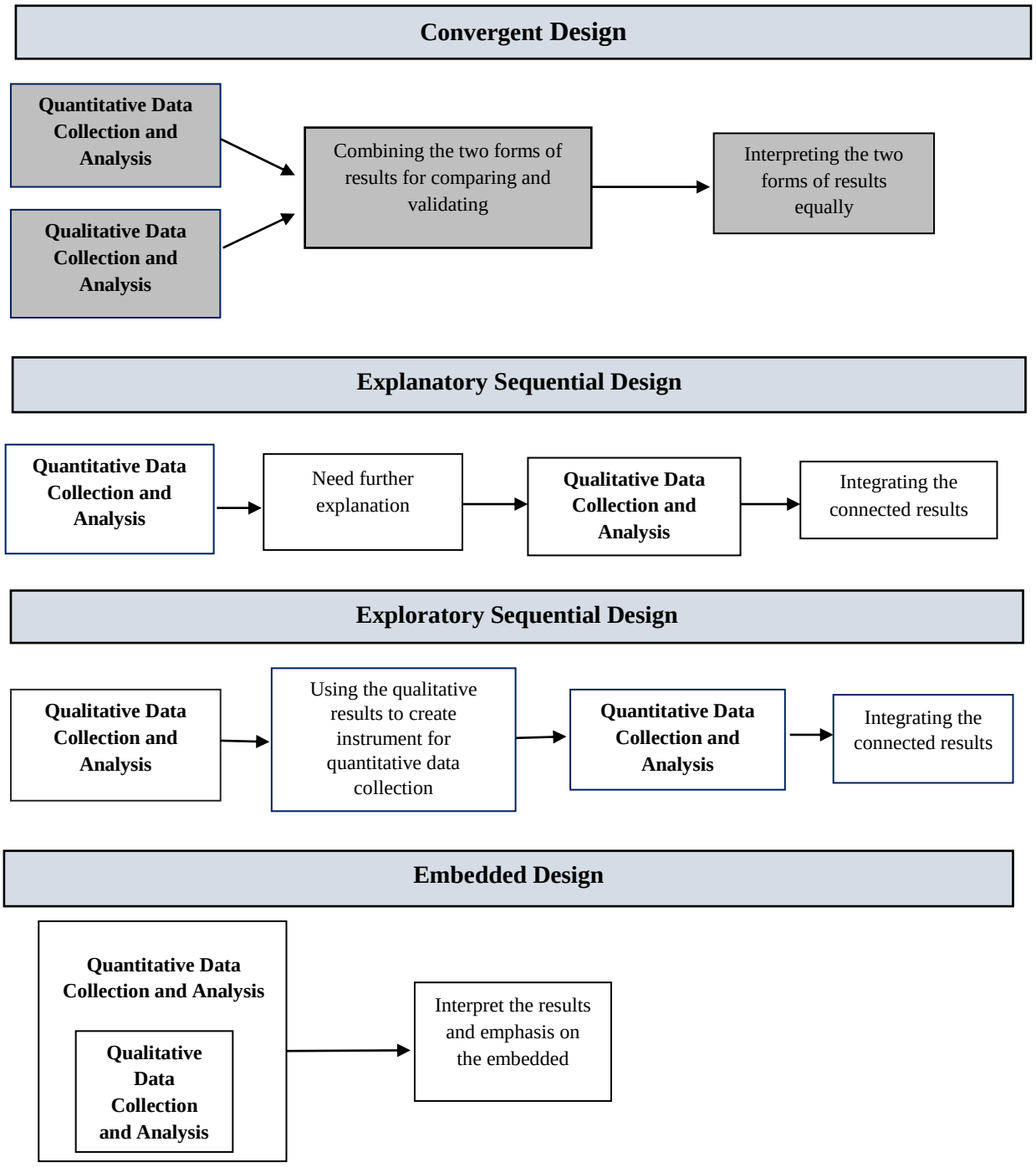

Figure 3-1 Mixed methods design adapted from (Creswell et al. 2007, P.158)

Mixed method techniques can be distinguished by the weighting given for each component of the data. Johnson and Christensen (2017) constructed a more detailed set of mixed methods designs to explain the weighting of each type of data in a study, which is presented in Table 3-1.

Table 3-1 Set of mixed methods designs to explain the priority of qualitative and quantitative data (adapted from Johnson and Christensen 2017, 478).)

Data driven	Concurrent Design	Sequential Design
Equal status	**Qualitative + Quantitative**	**Qualitative** → **Quantitative** or **Quantitative** → **Qualitative**
Qualitatively driven	**Qualitative** + quantitative	**Qualitative** → quantitative or quantitative → **Qualitative**
Quantitatively driven	***Quantitative*** *+ qualitative*	**Quantitative** → qualitative or qualitative → **Quantitative**

Table 3-1 showcases the two design types of mixed method: concurrent design and sequential design, which can be distinguished by the weighting given to both quantitative and qualitative techniques. The table uses bold letters to identify the priority data that leads the research. These techniques help researchers to identify the research design that will provide valid and relevant data to answer the research question. This study adopted a concurrent design-quantitatively driven type of mixed method (the italic row in the table above), which gives quantitative data the priority, with the addition of qualitative data to help verify or reject results from the quantitative data.

As described in detail in Section 3.3.1, this research study collected quantitative and qualitative data on the same day, involving the same participants — academics working in a recently constructed open-plan workplace. The quantitative data were collected via measuring physical environment factors, and conducting a questionnaire relating to the effect of IEQ on their satisfaction, mood, motivation and overall productivity. Qualitative data was then gathered by conducting working environment observations and interviews with academics to explore their experience and perception of their work environment, and how the new workplace design supported their activities. The two set of data were analysed separately before the results were merged during the interpretation stage, as described by Creswell et al. (2007, 15).

In summary, this study aimed to investigate and understand the open-plan workplace environment and its influence on academics comprehensively. Because of the diversity of the factors that comprise the academic work environment, especially with open-plan workplaces,

there is a need for research methodology that provides a holistic understanding of the complexity of research problems. Both case study and mixed methods research provide unique designs for researchers wanting to address complex research issues (Walton et al. 2020). This study, therefore, employed convergent case study-mixed methods (QUANTITATIVE + qualitative) to provide in-depth evidence for the case and help to manage the integration of the two forms of data (Creswell and Plano Clarke 2018).

3.3.2 Triangulation

Using a mixed method approach is more than applying two approaches — quantitative and qualitative. It also enables the data to be triangulated and integrated during the research process (Creswell 2013). Triangulation is suggested as an ideal strategy, using several sources of data or multiple methods to analyse the data, in order to examine a particular phenomenon (Noble and Heale 2019). Therefore, triangulation can increase confidence in the research findings (Walsh 2013; Cohen 2011). When used as part of a case study methodology, the triangulation approach provides the ability to examine the phenomenon from different viewpoints, thus offsetting or counteracting biases, which helps to confirm the validity, thereby contributing to the reliability of the findings (Golafshani 2003). In addition to the multiple methods used for data collection, triangulation can take several other forms. Denzin (2012) identified four forms:

a) Time triangulation involves collecting data at different times;
b) Space triangulation collects data from multiple spaces;
c) Theoretical triangulation uses multiple theories to grow a single viewpoint; and
d) Investigator triangulation is when data is collected by different investigators.

This study incorporated space triangulation, with data being collected from multiple sites. Three different open-plan workplaces were chosen for data collection, two at Curtin University and the third at the Central Institute of Technology. These three places are characterised as contemporary academic open-plan workplaces with a diversity of design settings and a diversity of academic work being undertaken, but with each workplace specialising in a particular type of academic work.

In summary, by using mixed methods for data collection across multiple sites and diverse academic work being undertaken by participants, this study enabled substantial data collection to gain a full understanding of the phenomenon being investigated in this study.

Furthermore, the multiple viewpoints helped to avoid bias and to increase confidence in the research findings.

3.3.3 Case Studies Selection

There are two main strategies for case selection: random and purposeful sampling selection. Random selection is when the case is chosen arbitrarily from a large sample. This strategy is used to create credibility and to ensure objectivity. In contrast, purposeful sampling focuses on particular characteristics of a large sample that are of interest (Creswell and Plano Clark 2003). The current research employed purposeful sampling because this strategy provides results applicable to the research questions and helps identify shared characteristics across the cases. The following are questions that were considered before selecting cases (Miles and Huberman 1994, 34)

- "Is the sampling relevant to your conceptual frame and research question?"
- "Will the phenomenon you are interested in appear? In principle, can they appear?"
- "Does your plan enhance generalizability of your finding, ethics through conceptual power or representativeness?"
- "Can believable description and explanation be produced, ones that are true to real life?"
- "Is the sampling plan feasible?"
- "Is the sampling plan ethical?" (Miles and Huberman 1994, 34)

Furthermore, Yin (2014) stated three main criteria that the selection of cases can be based on: convenience, access, and geographic proximity. The sample for this study took account of the above considerations to purposefully identify samples based on layout and facilities, which include a variety of alternate work settings for the occupants, such as permanent individual workstations, meeting rooms, and some quiet rooms (for work requiring concentration). The size of the open-plan workplaces chosen is medium, accommodating 9-24 occupants, and large, accommodating more than 24 people, to provide rich information relevant to the academic experience. The workplaces were equipped with modern IT and communications technologies. The selected cases represent diverse primary academic work such as research,

teaching and administrative work. In addition, the sample needed to be feasible; that is, readily accessible to the researcher (Yin 2014).

This study took place in three academic open-plan workplaces which are related to tertiary education. The researcher visited the selected tertiary education institutions in Western Australia to meet with their properties departments and establish what type of open-plan workplaces academics were occupying. In addition, information was sought in relation to workplaces that have been designed, built or refurbished to create open-plan layouts between 2010 and 2015, because the flexible workplace concept has become a more common occurrence in western universities in the last decade.

In total, five cases were initially identified as potentially meeting the criteria for this study. However, after initial site visits to investigate and takes photos by the researcher two cases were discounted due to inadequate workplace facilities for contemporary academic work practices. There is no definitive guidance for determining the number of cases to be studied (Pyett 2003), and it has been suggested by Yin (2014) that the number of cases depends on the type of question that the researcher is asking and the convenience of sampling. Therefore, the total number of case studies of open-plan academic workplaces undertaken in this study is three. The three case study samples were selected purposively to reflect the different perspectives of the phenomenon, such as how open-plan offices perform in supporting particular types of academic work; Curtin University Sustainability Policy (CUSP) focuses on research work, Curtin Teaching and Learning (CTL) focuses on administration work, and Central Institute of Technology (CIT) focuses on teaching work; the overall purpose was to increase the explanatory power and ability to generalise the findings (Miles and Huberman 1994).

3.3.4 Participant Sample

The targeted participants were academics who are regularly undertaking the main academic activities of research, teaching, and administration within the selected open-plan workplaces. For the purposes of this study, any support staff occupying the workplace were not included. Approval was obtained from each office manager to have access to the workplaces in order to collect the data. An invitation email was sent to academic staff, inviting them to participate in both the questionnaire and interview for each case study. The invitation was accompanied by an information sheet providing the research background, procedures, and significance of the study. The researcher arranged appointments via email

with all academics who had agreed to participate, in order to discuss and clarify any issues or questions. In total, 73 academics agreed to participate in both the questionnaire and interview. Table 3-2, below, represents the distribution of participant numbers across each case study.

Table 3-2 Participant numbers across the three case studies (Rashid 2015).

Case study	Total number of academic staff	Number of participants in this study
CUSP open-plan workplace	23	19
CTL open-plan workplace	23	20
CIT open-plan workplace	60	34
Total number	**106**	**73**

3.4 Quantitative Method

This study adopted a quantitatively driven concurrent design method, which gives quantitative data the priority (Schoonenboom and Johnson 2017). The quantitative method was designed to generate knowledge and understand a phenomenon by collecting numerical data (Schoonenboom and Johnson 2017). This method allows researchers to explore numeric patterns by conducting complex statistical analysis such as averages and percentages to demonstrate relationships among the data and to enable comparison across different cases. Two types of data, collected through questionnaires and physical environment measurement, were used.

3.4.1 Questionnaire

The questionnaire is a practical and quick data collection instrument for collecting information (Sarantakos 2012) and was employed in this research because it allowed the researcher to gather information from a large population in a short period of time in an affordable way (Sarantakos 2012). In addition, questionnaires are a practical way to gather data because they allow questions to be managed in a variety of ways. The design of the questionnaire survey used in this research aimed to explore each participant's self-rated evaluation of the effects of six indoor environment quality factors within their open-plan workplaces on their satisfaction, mood, motivation, and perceived productivity. This study adopted key indoor environment quality factors from the occupant indoor environmental

quality (IEQ) Survey created by The Centre for the Built Environment (CBE 2019). The survey measures workers' satisfaction and productivity in relation to the essential factors in the workplace.

Prior to commencing the data collection, a draft questionnaire was piloted with five academics who were known to the researcher and who were working in an open-plan workplace (but not in any of the case study workplaces). Consequently, some changes were made to the questionnaire. The researcher delivered a hard copy of the revised questionnaire to each of the case study participants at his or her workplace, and then left the participant to complete it. The questionnaire was divided into six IEQ sections; thermal comfort, air quality, light, sound level, layout, colour, and overall productivity; each section considered the degree of satisfaction, mood and motivation scale. Each section was aligned to two or more of the research objectives (Table 3-3): In addition to participant background, demographic information was also recorded, including gender, age group, academic field, how long they had been working in the current open-plan workplace, and the type of academic work in which the participant was involved. The full questionnaire can be found in Appendix 3.

Table 3-3 Structural design of questionnaire for the current study.

Artificial lighting	How does academic open-plan workplace influence: satisfaction, mood, motivation and overall productivity?	Objectives 1, 2, 3 and 4
Sound		Objectives 1, 2, 3 and 4
Air quality		Objectives 1, 2, 3 and 4
Thermal comfort		Objectives 1, 2, 3 and 4
Layout		Objectives 1, 2, 3and 4
Colour		Objectives 1, 2, 3 and 4
Overall productivity	How is occupant's productivity impacted by: artificial lighting, sound, air quality, thermal comfort, layout and colour?	Objectives 4 and 5

The IEQ factors that follow were adopted and adapted for this study from the CBE survey are briefly described below:

Temperature: is one of IEQ factors that has a significant influence on the comfort and productivity of the occupants. The temperature level determines the nature of that effect, whether it is positive or negative, on the occupant's concentration, mood, and motivation to subsequently influence their overall performance. According to Australian standards, optimal temperature degrees range from 20 °C–24°C (AS 1668.2-2012(2026)), but this range was found to be subject to individual occupants' factors such as gender, age, and season (Kang et al. 2017). Moreover, studies revealed that there is a correlation between thermal comfort and occupants' work activities (Tanabe et al. 2007).

Air quality: is an important factor that relates to satisfaction of the occupants in open-plan offices. Studies demonstrate that a reduction in occupant's productivity as a result of discomfort stems from poor indoor air quality (Cho et al. 2019; Al Horr et al. 2016). The concentration of CO2 and air fresh are a crucial element that impact on an occupant's satisfaction; for example, odour could result in various adverse feelings (Bluyssen 2010).

Lighting: light has a significant impact on open-plan workplace occupants. Lighting illuminance is subject to the influence of the type of work that occupants are engaged with (Villa and Labayrade 2016). Some studies show that providing an appropriate lighting environment is necessary to fulfil both the physical and the psychological needs of the occupants and enhance their performance (van Bommel and van den Beld 2016).

Sound level: is one of the IEQ factors that takes part in determining the quality of open-plan offices. Level of noise is a common issue that the occupants complain about, and which has a negative impact on their satisfaction, productivity and health (Lee et al. 2015). There are many noise aspects inside the open-plan office caused by irrelevant speech between occupants and machine noise, which contribute to the overall noise level that distracts attention and reduces productivity (Kaarlela-Tuomaala et al 2009). The quality of the acoustic environment is evaluated by determining two crucial elements, the noise level and sound privacy in the open-plan office.

Layout: of open-plan has a significant effect on occupants' satisfaction and productivity. It may support and facilitate communication cohesion and cooperation between occupants, but on the other hand, it may cause lack of privacy among occupants and increasing sound level and interruption, besides reducing space in the personal workstation (Kang et al 2017; Sadick et al. 2020). The special density which can be defined as the area per occupant in the office is the unit that measures and evaluates open-plan quality in terms of the layout.

Colour: Colour was found to be one of the physical environment qualities that has a significant impact on occupants' productivity in the workplace. Several studies have been conducted to evaluate the effects of colour on occupants' productivity and mood in a workplace setting (Sorokowski et al. 2014; Baniani and Yamamoto 2015. However, more investigation is required for better understanding of this impact of colour on academic satisfaction, mood, motivation, and productivity in open-plan workplaces.

3.4.1.1 Degree of satisfaction

Data regarding satisfaction with the environment was collected by asking how participants assessed the building performance; when users feel satisfied with the environment, it is considered to be performing well (Samani et al. 2018). The questionnaire on occupant satisfaction with the indoor environment was designed based on the Centre for the Built Environment's (CBE) satisfaction survey. The CBE was started in 1997 under the National Science Foundation (NSF) Industry/University Cooperative Research Centre (I/UCRC) program to assess perceived satisfaction and performance of buildings. The CBE occupant satisfaction survey has an extensive track record in numerous settings, including offices, hospitals, schools, and research centres. Over two decades, the CBE survey has proven reliable in measuring satisfaction in a variety of case studies, regardless of location, size or design (Heinzerling et al. 2013). For this study, the questions about satisfaction used the following structure, in accordance with the CBE occupant satisfaction survey: "How satisfied are you with… in your workstation?" The satisfaction response used a 5-point Likert scale ranging from "Not at all" to "Extremely satisfied". Each satisfaction question was followed by further questions aimed at diagnosing the source of dissatisfaction if they were dissatisfied with the environment, or alternatively, the respondent could choose "I am happy" (Moezzi and Goins 2011).

3.4.1.2 Mood evaluation scale

Mood evaluation provides data to assess how an IEQ factor impacts on occupants' mood, based on the role mood plays in behaviour in the workplace (Lan and Lian 2009; Stone and English 1998; Wang and Boubekri 2011). The evaluation of the impact of each IEQ on mood was designed based on the profile of mood states (POM) self-report mood scale. As discussed in detail in the literature review (Section 2.4.2.3), this scale has been widely used to evaluate the impact of IEQs on mood in the workplace (McNair et al. 1971). The mood scale adopted covers six different states: annoyed, confused, unhappy, fatigued, energetic and nervous.

Each state employed a 5-point Likert response scale, ranging from “Not at all” to “Extremely”. Each question about mood followed the structure: “What mood response do you associate with the overall… in your work area during the last week, including today?”

3.4.1.3 Motivation evaluation scale

Motivation evaluation was designed to collect data about how the IEQs of open-plan workplaces facilitate or undermine individuals’ sense of willingness and enthusiasm to perform a task. The evaluation questions of the impact of IEQ on motivation were adopted from Lan, Lian, and Pan’s (2010) study. They found that motivation and productivity in the workplace can be affected by the indoor physical environment; for more detail, see Section 2.4.3. Motivation is evaluated based on the willingness of staff to perform tasks as well as their enthusiasm to perform tasks. The questions relating to motivation were structured as “Rate the effect of… in your workplace on your willingness to perform tasks?” and “Rate the effect of… in your workplace on your enthusiasm to perform tasks?” The motivation responses used a 5-point Likert scale ranging from “Not at all” to “Extremely”.

3.4.1.4 Measurement of occupant productivity

As a concept, productivity is multidimensional, and thus, there are multiple ways to conceptualise and measure it. Sutermeister (1976) defined productivity as an output per employee hour, with quality considered. The researcher emphasised that both time and quality are more relevant than simply the rate of productivity. However, Hameed and Amjad (2009) stated that the reduction in the rate of part- or full-time absence from work has a positive impact on productivity.

In this study, a worker’s productivity is considered as the ability to complete the required work within an appropriate time, while also meeting the standards for accuracy on a daily basis within the work environment. In some cases, researchers have measured an increase in the productivity of organisations as being when there is less absenteeism, fewer employees leaving early, and employees taking fewer breaks. These measurements are effective when applied to group productivity within a team. For measuring an individual’s productivity within a workplace, a number of studies use self-report productivity measurement methods based on the occupant’s self-assessment (Ramos et al. 2019; Hjalmarsson and Dåderman 2020; Hameed and Amjad 2009). The subjective assessment measurement used to assess an individual’s perceptions and attitudes may identify a particular input such as motivation or

obstacles that would be difficult to identify by using an objective method (Haapakangas et al. 2018). This study has therefore adopted a self-rated report as a mechanism for evaluating the effect of IEQ factors on the academics' perceived productivity. The question relating to productivity was structured as "How would you weight the impact of… on your productivity?" The collected data were documented on a 5-point Likert scale ranging from "Not at all" to "Extremely". In addition, the survey questions were extended to explore comparative experiences of traditional workplaces and open-plan workplaces, if the participants had experienced both. The productivity questions were structured as "How do you rate your productivity in the open-plan/individual office?"

3.4.2 Physical Measurements

The physical environment measurements were conducted in each of the selected workplaces to establish whether the indoor environment conditions were within comfort tolerances prescribed by the Australian Standards. Environmental monitoring refers to the physical measurement of the basic IEQ parameters, including lighting illuminance, sound level, thermal conditions (temperature/relative humidity) and air quality (carbon dioxide [CO2] concentration). For each of the three open-plan environments studied, the physical measurements were taken in autumn during the morning and afternoon. Primarily, the physical measurements were taken to draw comparisons between the IEQs of each of the three case studies and the recommended Australian standards for occupant comfort. In addition, the physical measurements were used to evaluate potential IEQ-related sources of dissatisfaction, mood and motivation fluctuations, and productivity. The physical measurements were taken and recorded between 9:30 am and 12:00 noon, and then between 2:00 pm and 5:30 pm.

Prior to conducting the measurements, site visits were undertaken to inspect each of the open-plan workplaces to identify the appropriate locations (areas) for placement of the series of instruments used to take the measurements. The areas were selected based on the recommendation of the National Australian Built Environment Rating System (NABERS 2015), which includes recommendations for proximity to windows, ventilation systems and workstations, as well as instrument height. Four instruments were used to measure lux, humidity, CO2 concentration, and temperature and sound levels. Some training was required and provided to the researcher by Curtin University's Facilities Department to enable the researcher to appropriately use the four instruments. Three devices were borrowed from the

Physics Department at Curtin University to measure illuminance, sound and temperature, and the fourth was purchased directly by the researcher to measure CO_2 concentration and humidity. The instruments measuring temperature, relative humidity, CO_2 concentration, and sound levels were deployed near the workstations at a height of 1.1 m. This height is the occupant's breath zone when they are seated. NABERS (2015) recommends that these readings are taken at the location of the workstation chair. However, as the individual workstations were occupied during the time of measurement, this was not possible. The environmental measurements were recorded continuously. A hand-held lux meter was used on the workstations' surfaces to measure the level of lighting at each workstation. Details of the equipment used can be found in Appendix 5.

3.5 Qualitative Data: Semi-structured Interviews and Researcher Observations

Face-to-face interviews with academics were used to investigate in depth what lies behind people's decision-making and perceptions, and to capture the more nuanced, subjective, and less quantifiable aspects of the occupants' experiences in the open-plan workplace environments (Hammarberg, Kirkman, and de Lacey 2016). Two types of interviews are commonly defined: structured and semi-structured interviews. In structured interviews, the participants respond to prepared closed-ended questions, while semi-structured interviews allow participants to freely express their thoughts about the research questions. They enable interaction and discussion between the interviewer and participants, to gain their judgements, perceptions and experiences (Patton 1990; Yin 2014). As the interview process in this study aimed to evaluate and understand in depth what lies behind the participants' perceptions by providing opportunities for academics to describe their experiences, it was decided to adopt comprehensive, semi-structured interviews. The face-to-face interviews enabled the researcher to gather more detailed information regarding the suitability of the open-plan workplace for academic activities. These interviews were conducted with the academics after completion of the questionnaire. The interview questions were designed to facilitate interactive conversations between two parties in order to explore and investigate issues that were raised during the meeting in a holistic manner. Each interview was recorded using a high-quality digital recorder to enable the interviewer to fully concentrate on the interviewee while also ensuring an accurate record (Yin 2014). Table 3-4 shows the topic areas covered during the interview. A full version of the interview questions can be found in Appendix 4.

Table 3-4 Structural design of interview for the current study

Artificial lighting	How does the academic open-plan workplace influence: satisfaction, mood, motivation and overall productivity?	Objectives 1, 2, 3 and 4
Sound		Objectives 1, 2, 3 and 4
Air quality		Objectives 1, 2, 3 and 4
Thermal comfort		Objectives 1, 2, 3 and 4
Layout		Objectives 1, 2, 3and 4
Colour		Objectives 1, 2, 3 and 4
Overall Productivity	How is occupant's productivity impacted by: artificial lighting, sound, air quality, thermal comfort, layout and colour?	Objectives 4 and 5

After the interviews, the researcher recorded observations of the workplace in terms of the layout, location of the workstations, workstation personalisation, proximity between workstations, access to windows and daylight, direct exposure to sun, colour scheme, and fluctuations in occupancy levels. In addition, photographs of each of the workplaces were taken to develop a better understanding of the academics' experiences in relation to their environments.

3.6 Research Framework and Procedures

The research procedures conducted in this study comprise four main stages:

1. A review of the literature to examine studies that focused on understanding the effects of IEQ on an occupant's productivity in open-plan workplaces. This included studies looking at environmental satisfaction and the psychological effects of IEQ on occupants. Results from the literature review were used to conceptualise a framework that enables an informed evaluation of productivity in the open-plan workplace.
2. Undertaking a mixed methods design for data collection and analysis. The data collection started with quantitative data by taking physical measurements of IEQ in

specific areas in each case study. Next, a questionnaire survey was conducted with academic participants working in an open-plan environment. Data collection continued with gathering qualitative data through semi-structured interviews with the same participants directly after they completed the questionnaire.

3. Separate analysis of the qualitative and quantitative data in line with Creswell and Plano Clark (2011). Quantitative statistical analysis of the questionnaire was carried out using SPSS software. The thematic analysis was used for analyzing the results from the semi-structured interviews.
4. Both the quantitative and qualitative results were integrated after analysing the data sets separately; the results were merged together during the interpretation stage (Creswell and Plano Clark 2011). The research framework used in this study is shown in Figure 3-2.

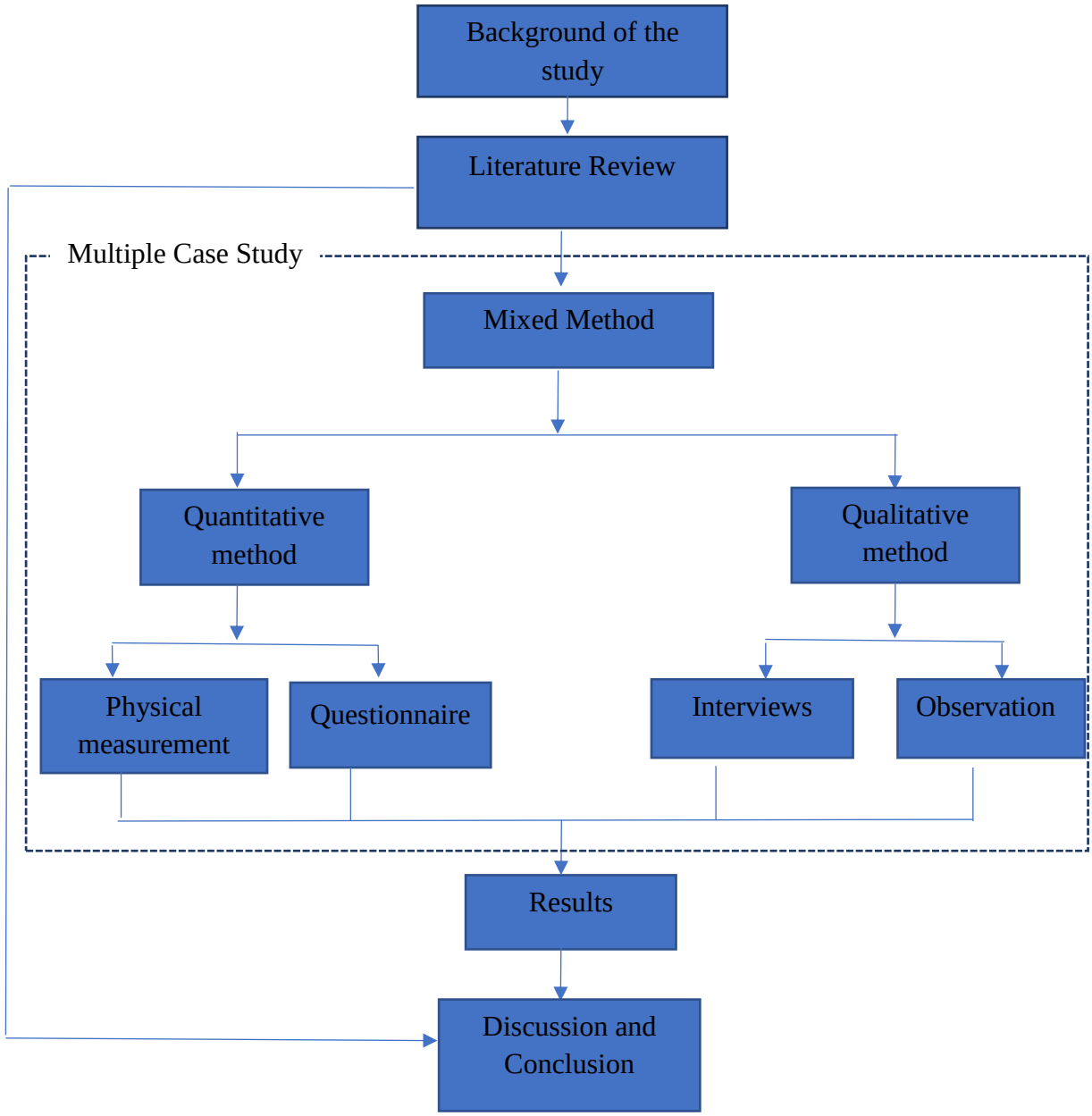

Figure 3-2 Research framework for the current study (Rashid 2020)

3.7 Data Analysis

Data analysis is the interplay between researchers and the data; it is a process of breaking down the data and putting it back together in an organised and logical structure (Strauss and Corbin 1990). This section describes how data were reorganised to provide an understanding of the experiences of academics working in their open-plan workplace environments and how the workplaces affected their productivity.

3.7.1 Quantitative Data Analysis

The quantitative data gathered from the questionnaire were organised and the analysis was accomplished using the "Statistical Package for Social Sciences (SPSS) version 22.0" software. The SPSS performed analyses of the responses and provided descriptive statistics of the data. The descriptive analysis was then used to develop an understanding of the data, including the mean, minimum, and maximum of the respondents' demographic information, including age group, gender, years of working in open-plan workplaces, and qualifications. In addition, the descriptive analysis was used to analyse the impact of the six indoor environmental quality factors (temperature, air quality, lighting, sound level, layout, and colour) on the academic participants' satisfaction, mood, motivation, and productivity. The results were then visually screened to fully understand the distribution of data, as well as to identify any outlying results or anomalies. For demographic information a Pearson chi-squared test χ^2 was used to determine whether there is a statistically significant difference between the expected frequencies and the observed frequencies in categories (Plackett 1983). In this study, the test was utilised to analyse the relationship between a categorical variable (gender, age) and an ordinal variable (satisfaction, mood and motivation). Fisher's exact test (Mehta and Patel 1983) was used instead of Pearson's chi-squared test to examine years of experience working as an academic due to the small cell sizes.

The statistical reliability of the mood and motivation constructs were tested using Cronbach's alpha (CA) coefficient test (Sekaran 2003) in order to assess the overall consistency of the POMS mood scale (annoyed, confused, unhappy, fatigued, energetic, and nervous) (McNair et al. 1971) and the motivation questions (willingness and enthusiasm) (Lan, Lian and Pan 2010). The following section (3.7.2) describes the detailed results of this test. The Spearman rank correlation coefficient (Morgan et al. 2004) was subsequently adopted as a non-parametric test to assess the statistical dependence between two variables (perceived productivity on the one hand and the other variable is satisfaction, mood and motivation each separately) by determining the direction and strength of the monotonic relationship between them. The rate of change in monotonic variables occurs according to whether the constant increase or reversible decrease is linear or non-linear; that is, the rate of change might be the same or different for both variables. (Morgan et al. 2004). This coefficient was applied to investigate how the respondents' perceived productivity related to their satisfaction, mood, and motivation.

3.7.2 Statistical Reliability of Mood and Motivation

Reliability refers to the degree of consistency of participants' responses across the items (internal consistency). The purpose of a reliability test is to reduce any errors and provide consistent results. Cronbach's Alpha (CA) test was chosen to examine the mood scale (six items) and motivation (two questions) reliability using the SPSS software program. The test is not a statistical test; it measures the internal consistency of the data. Cronbach's alpha is frequently used to measure reliability of research instruments used by researchers (Sekaran, 2003). Cronbach's alpha test was used to illustrate the validity of the mood groups and motivation questions and assert the legitimacy of the analysis. Different values for alpha have been suggested in the literature; however, according to Nunnally (1978, 244), the generally agreed level of good internal consistency is above 0.70, while results that fall below this mark are considered unreliable and need further investigation. Therefore, in this research, the alpha should exceed 0.70 to indicate internal consistency. All staff responses to mood and motivation for each IEQ in all three workplaces were subjected to Cronbach's Alpha test.

3.7.2.1 Mood scale

To determine whether the six mood items load on to a single factor, exploratory factor analysis (EFA) was performed for three case studies and all IEQs. The Cronbach's alpha test results for the impact of thermal comfort and lighting on mood for CUSP and thermal comfort and colour for CIT generated scores below the recommended threshold of 0.70, as illustrated in Table 3-5.

Table 3-5 Cronbach's alpha test results for mood construct for the current study.

CUSP-IEQ	Cronbach's Alpha	No. of Items in the mood scale
Thermal comfort	0.654	6
Air quality	0.849	6
Lighting	0.588	6
Sound level	0.821	6
Workplace layout	0.817	6
Colour	0.659	6
CTL-IEQ		
Thermal comfort	0.637	6
Air quality	0.815	6
Lighting	0.727	6
Sound level	0.794	6
Workplace layout	0.828	6
Colour	0.026	6
CIT-IEQ		
Thermal comfort	0.919	6
Air quality	0.893	6
Lighting	0.843	6
Sound level	0.833	6
Workplace layout	0.832	6
Colour	0.938	6

Further investigation of the low alpha values involved respectively removing each of the separate mood responses (annoyed, confused, unhappy, fatigued, energetic and nervous) before re-estimating Cronbach's alpha for each of the 5-item scales. Tables 3-6, 3-7, 3-8 and 3-9 show that the highest alpha-values were generally obtained when the 'energetic' item was

removed from the scale. These results indicate that the remaining five mood items can be averaged to reflect a uni-dimensional mood construct.

Table 3-6 Mood responses associated with thermal conditions CUSP

Mood response associated with thermal conditions	Scale mean if item deleted	Scale variance if item deleted	Corrected item - total correlation	Cronbach's alpha if item deleted
Annoyed	8.11	7.877	.690	.465
Confused	8.79	12.175	.410	.617
Unhappy	8.11	7.322	.795	.405
Fatigued	8.11	9.766	.515	.560
Energetic	8.47	14.263	-.122	.789
Nervous	8.95	13.386	.247	.656

Table 3-7 Mood responses associated with lighting levels CUSP

Mood response associated with lighting levels	Scale mean if item deleted	Scale variance if item deleted	Corrected item - total correlation	Cronbach's alpha if item deleted
Annoyed	7.74	5.205	.764	.354
Confused	7.84	5.585	.769	.384
Unhappy	7.68	5.228	.660	.386
Fatigued	7.21	5.509	.444	.483
Energetic	7.42	9.702	-.356	.863
Nervous	7.89	6.988	.394	.533

Table 3-8 Mood responses associated with thermal conditions CTL

Mood response associated with thermal conditions	Scale mean if item deleted	Scale variance if item deleted	Corrected item - total correlation	Cronbach's alpha if item deleted
Annoyed	6.80	4.905	.835	.326
Confused	7.45	10.155	.484	.627
Unhappy	6.80	5.537	.769	.384
Fatigued	6.65	5.818	.501	.543
Energetic	7.30	11.379	-.206	.742
Nervous	7.50	10.895	.000	.664

Table 3-9 Mood responses associated with colour CIT

Mood response associated with colour	Scale mean if item deleted	Scale variance if item deleted	Corrected item - total correlation	Cronbach's alpha if item deleted
Annoyed	5.90	1.674	.000	.028
Confused	5.80	1.221	.256	-.221[a]
Unhappy	5.80	1.221	.256	-.221[a]
Fatigued	5.85	1.713	-.153	.092
Energetic	5.25	.829	-.172	.571
Nervous	5.90	1.674	.000	.028

3.7.2.2 Motivation

The 2-item motivation questions measured two aspects of motivation relating to willingness (1 item) and enthusiasm (1 item). All the data for the three workplaces was input into SPSS and Cronbach Alphas were generated across the two items for each of the six quality factors. As illustrated in Table 3-10, all alpha-values were above the recommended threshold of 0.70, which suggests that the willingness and enthusiasm scores can be summed for each participant to produce a reliable measure of motivation.

Table 3-10 Cronbach's alpha test results for motivation contract for the current study

CUSP-IEQ	Cronbach's Alpha	No. of Items in motivation questions
Thermal comfort	0.924	2
Air quality	0.962	2
Lighting	0.903	2
Sound level	0.924	2
Workplace layout	0.971	2
Colour	0.973	2
CTL-IEQ		
Thermal comfort	0.817	2

3.7.3 Qualitative Data Analysis

Qualitative data analysis consists of describing the phenomenon studied, the development of the conceptual classification, and the identification of the connection between these concepts (Silverman 2001; Richards 2005). A series of steps constitute the core of the data processing.

Firstly, all the data collected throughout the study (from interviews, open-ended questionnaire answers and the researcher's observational memos) were transcribed, organised and classified, and saved for analysis. After that, the data were saved in a Microsoft Word document.

The second step was to read through the data several times to form a general view about the investigated phenomena. This procedure was an important step in the early stages of data analysis, because it identified key points that were subsequently utilised to initiate the first step of analysis.

The last step was to initiate thorough analysis of the coding procedure. Strauss (1987, 27) emphasised the significance of the coding process, pointing out that "the excellence of the research rests in large part on the excellence of the coding". The coding process provides analytical tools for managing a large amount of raw data systematically and helps researchers

to consider the alternative meaning of the phenomena to build a theory (Strauss 1987). Three stages of coding were conducted in this study: open coding is the first stage of the qualitative analysis process to label the initial themes from the data; axial coding, wherein the researcher draw connections between the data into logical categories (Mehmetoglu and Altinay 2006); and the last stage is selective coding, where integration and refining the categories is done in a systematic, cohesive, and comprehensive way. A thorough discussion of these stages is provided in the following section.

Qualitative data analysis using software such as Nvivo has been criticised in the literature, particularly relating to concerns about disengagement from the data, meaning that relying on software to analyse data could result in the researcher focusing on the technical capabilities of the program instead of gaining the necessary depth of understanding of the data through detailed data investigation (Cope 2014). For this study, the software was not used to auto-code; instead, the researcher chose to identify emerging themes manually. Using the software in this study helped the researcher to organise the raw data, enabling the development of a profound data understanding and identification of the themes without disconnecting from the source of data.

The three case studies were analysed separately; three files were created, identified by the name of each of the three case studies, and all files were imported into Nvivo 10. The researcher followed the three stages defined above in order to connect the labelled themes to their contexts and finally, the supporting evidence was selected in a logical manner.

Before the collapsing of themes, a list of the complete codes was generated. Codes were iteratively refined, moved, merged and deleted, based on evolving themes and their attributes. Coding categories were examined for their utility, salience, credibility, uniqueness, heuristic value and feasibility, internal and external reasonability, and inclusivity (Patton 1990).

3.7.3.1 Open Coding

The researcher went through two steps to conduct open coding. Firstly, the interview transcripts were read several times and broken down into key points reflecting the interviewees' main ideas about their experiences within their open-plan workplace environments and how the indoor environment quality was conceptually represented. Basically, during this stage the researcher starts to create tentative categories that summarise masses of participants' words and establish properties of each code. Code names were diverse

and broad at this stage. For example, in the second step of open coding, the researcher looked for similarities among the codes, particularly those sharing commonly defined properties to group the codes into categories. In this step, the number of codes was reduced to facilitate managing the data. The aim of this step in this study was to generate a list of more focused themes concerning the interviewees' experiences of the influence of the indoor environment quality in their open-plan workplace environments. This process of categorisation resulted in 15 main categories across all three case studies. An example of this consolidation process is shown in Table 3-11, which highlights where groups of codes related to academic open-plan workplace characteristics were grouped under a single code, 'academic workplace'.

Table 3-11 Example of the first step of the open coding process for the current study

Open codes	**Properties**	**Participant's words**
Office layout	Advantages and disadvantages of open-plan	*This type of office. Everyone can see me. Too many papers. Storage space. Individual office better. Collaboration. Diversity in setting. Surrounded by other people. Interaction. Sit in the corner position. People would be able to look. I think this sort of office is very good for business. You have to get out of there and into the room. Surrounded by other people. It is hard to be in open-plan. I can't get students. Nothing confidential.*
It depends on the type of work	Different academic work requirements work well in specific situations.	*Academic job is quite diverse. For some part of work, it is suitable in terms of writing — those sorts of things — it has definitely decreased. You need quiet time. Busy and noisy, you have to get out of there and into the room to make calsl. A lot of academic work is about thinking. Good for social interaction. Just wear headphones so I block out when I need. Works well for group meeting. Teamwork.*
Colleagues' conversations	Words have nothing to do with work	*People saying hi. You can't go in there and talk to people. Constantly have people coming and going through reception. Nothing stops people from seeing and interrupting you. Talking about clothes. News about friends.*

3.7.3.2 Axial coding process

Once the data was in a manageable code structure, it was developed systematically, using the key themes identified through the literature review as guidance in main and sub-categories to add depth and to identify emerging relationships between categories. For example, the office layout code was developed into a more comprehensive theme and evolved to become 'comfort/discomfort' which included all the emerging factors involved in how an open-plan workplace layout can affect workers' comfort.

3.7.3.3 Selective Coding Process

The last step of the qualitative data analysis process focused on integrating and refining the categories and sub-categories to form a comprehensive network. Through this process, the researcher developed a better understanding of the data across all three case studies. This final step involved reviewing and refining the outcomes regarding the research questions, finalising the categories, and determining how the findings are presented to obtain accurate image of the studied case. This stage was crucial to ensure that those findings were demonstrated in a rational way and the aspects of the studied case were clearly revealed. See Table 3-12.

Table 3-12 Example of the three steps of coding for the current study

Open coding	Axial coding	Selective coding
Office layout, workstation location and size, uncomfortable environment, temperature affects in a bad way, environment stops people from working.	Comfort/discomfort	Distraction and concentration difficulties
It depends on the type of work. Deep thinking work. Academic staff needs. Academic performance depends on the type of work. Intense work needing a lot of concentration. Overheated. Distracts thinking. Interruptions.	Concentration work	
Colleagues' conversational noise. Disadvantages of open-plan. Causes delays in academic work. Quaint office. Distractions from noise. Informal interaction. Sound privacy. Meetings. Social relationships.	Noise	

The three detailed coding processes resulted in six themes representing the academic experience and perceptions about their open-plan workplace environments and ensured that the research question could be responded to comprehensively. The researcher used these six themes to analyse the qualitative data, extracted from multiple individual interviews and the open-ended questionnaire responses across all three case studies.

The themes included many factors related to the productivity of the workers, such as the physical environment of the workplace and the psychological and social aspects. These themes are: distraction and concentration difficulties, suitability of the workplace, control, feeling, privacy and communication. Each theme is described below:

- **Distraction**: this theme includes the codes of the impact of open-plan workplace environment on the academics' ability to concentrate and work without distraction.
- **Suitability of the workplace:** the suitability of the workplace arrangements for academic work and how the physical workplace environment supports the academic activities.
- **Control**: this theme includes all the psychological and physical factors in an open-plan office that would positively or negatively influence the feeling of ownership and empowerment over the workspace allocated to each individual.
- **Feeling**: the theme comprises responses to a variety of psychological aspects and moods/emotions that have an impact on the academic in open-plan workplaces. This theme includes both negative and positive responses.
- **Privacy:** includes all codes concerned with providing a private visual and sound environment for the academics and their work.
- **Communication:** this theme concerns all factors that affect an academic's ability to conduct informal interactions among colleagues in the workplace.

3.8 Research Trustworthiness

This study followed the criteria set by Guba and Lincoln (1989) in order to ascertain the degree of credibility and establish validity of the research. These criteria will be discussed in detailed in the following section.

3.8.1 Credibility

Credibility is defined as the techniques used to prove the degree of trustworthiness between research finding and reality (Guba and Lincoln 1989). In addressing credibility, this study used a triangulation of different methods, including the use of multiple data collection instruments, to provide a rich set of data across multiple sites. In addition, the iterative examination of previous research findings was used to measure congruency with results from previous similar studies.

3.8.2 Transferability

Transferability can be defined as the ability to apply research results to similar situations (Guba and Lincoln 1989). To meet this criterion, a sufficient description of the methodology adopted as well as the data collected are required to enable the transfer to similar settings. The description should include detailed information about the phenomena that have been examined, including where and how the data were collected. Use of direct quotes from participants is another technique utilised to allow transfer of research results to similar situations.

3.8.3 Dependability

Dependability can be achieved by providing a detailed report of the study, for the reader to "explore process, judge the decisions that were made and understand what salient factors in the context led the researcher to the decisions and interpretation made" (Guba and Lincoln 1989, 242). This study provides details regarding the cases, methods of collecting the data, and the analysis process.

3.8.4 Confirmability

Confirmability is one of the criteria used to exclude subjectivity, to guarantee that research findings are rooted in appropriate contexts, and that these are not based on the researcher's own perspectives (Guba and Lincoln 1989). In this research, confirmability was achieved through triangulation of multiple sources of evidence, to alleviate investigator bias.

3.8.5 Ethics Approval

The ethical issues of this research project were carefully considered and deemed to pose no threat to any persons or groups within society. The purpose of the research was clarified, and each contributor was provided with a comprehensive information sheet. Participants were

never directly or indirectly pressured or forced into their contributions. The ethics application form for approval to conduct research involving humans (Form C) was submitted to the human research ethics committee in compliance with Curtin University's guidelines. In addition, the ethics application was screened by the Curtin survey team because some of the targeted participants for this study were employees of Curtin University. All data collected for the study were stored electronically and securely on Curtin University servers. Data will be kept for not less than seven years. The data will be available to researchers and the committee overseeing the research. After a period of seven years, the data will be destroyed.

3.9 Chapter Summary

Below is a summary table of the aspects of the research procedure (Table 3-13).

Table 3-13 Summary of approaches to the research process for the current study

Aspects of the Research	Process
Methodology	Case Study-Mixed Method (CSMM)
Research design	Multiple case study
Research method	Mixed method: Quantitative (questionnaire and physical environment measurements). Qualitative (semi-structured interview, and environment observations)
Data analysis/interpretation	Concurrent Design — quantitatively driven Statistical analysis using SPSS software program for questionnaire data. Identification of themes. Cross-case analysis for qualitative data
Ethical issues	Informed consent, confidentiality

This research aimed to explore how the indoor environment quality can impact upon academic productivity in an open-plan workplace. A case study methodology was utilised to obtain a deep record of viewpoints in regard to the investigated workplaces. This chapter discusses the philosophy of the research design as well as the methodology suitable for conducting research of this complexity. Quantitative and qualitative data were examined for their role in this research. The quantitative data included physical measurements and a

questionnaire; the qualitative data included interviews and observations. The chapter explains the criteria employed for selecting samples and participants, and the different steps of quantitative and qualitative data analysis and interpretation are explained. Finally, the chapter emphasises research trustworthiness and reports how ethical issues were addressed in the study. The next chapters will present the findings of this research.

CHAPTER 4: CASE STUDIES ANALYSIS AND RESULTS

4.1 Introduction

This research has examined three open-plan academic workplaces in Perth, Western Australia. This chapter presents analysis and findings data collected using a case study-mixed method. The collection method was designed to explore academic staff experiences in an open-plan workplace and, in particular, how the indoor environment quality, including aspects of the design, affects worker's productivity. The research analysis was designed to enable the researcher to address the research question:

"How does indoor environment quality impact upon academic productivity in the

open-plan workplace?"

This chapter presented the results for each of the three-case studies CUSP, CTL and CIT respectively. Each case study displays:

-Case study description: This section features illustrated photos of the interior space taken by the researcher and an in-depth description of each of the three case studies. This includes an overview of the workplaces, number and demographic information of occupants and academic activity in the workplaces, as well as a detailed description of the physical workplace environments - the office layout including workstations, lighting and HVAC system (Heating, Ventilation and Air Condition).

- Indoor environment quality measurements: This section summarises the results of the IEQ measurements for each of the three case studies: CUSP, CLT and CIT open-plan workplaces. A hand-held device (see Appendix 5) was used to collect data on temperature (ºC), relative humidity (%), carbon dioxide concentration (ppm), light (lux) and acoustics (dB). The measurements were taken in identified areas within each of the workplaces. The selected areas were based on recommendations provided by National Australian Built Environment Rating System (NABERS 2015). These areas were selected in order to cover as much of the office environment as possible and to obtain an accurate representation of morning and afternoon IEQ (see section 3.4.2). The physical environment measurements were undertaken to establish whether the physical indoor environment conditions were within comfort standards stipulated by the Australian Standards. In addition, the physical

measurements were used to evaluate potential IEQ-related sources of dissatisfaction, mood and motivation fluctuations, and productivity.

-Statistical analysis of the questionnaire: the data from the questionnaire were analysed in relation to means, percentages and frequencies to explore the impact of IEQ on academic in the three open-plan workplaces. Surveyed academics were asked to rate their perception of satisfaction, Mood, Motivation and productivity in relation to each of the six IEQ factors (thermal comfort, air quality, overall lighting, sound level, office layout, and colour) on a five-point Likert scale from 'Not at all satisfied' (1) through to 'Extremely satisfied' (5). The data were analysed using the SPSS software package.

To explore whether the impact of IEQ on satisfaction, motivation or mood affects academic staff perceptions of productivity, the Spearman rank correlation coefficient was adopted as a non-parametric test to investigate the relationship between satisfaction, mood, and motivation and workers' perceived productivity (p-value *< 0.05 and **< 0.01).

The literature suggests that the impact of IEQ on satisfaction, mood, motivation, and productivity can vary according to the demographic variables of the population sample (Kwallek 1990). The section examines whether, the age, gender or number of years' working as an academic significantly influenced the responses of academics regarding the IEQ of their workplaces. The resultant tables are shown in Appendix 6,7and 8.

-Semi-structure interview: this section presents the findings revealed by qualitative analysis of the data collected using a semi- structured interview method. The in-person interview was designed to investigate academic staff experiences in the open-plan workplace, particularly to explore how occupant satisfaction, mood, motivation and productivity were affected by IEQ factors. Since the interview process in this research aimed to enrich the case study with additional occupant experiences that build on the findings of the questionnaire, the interviews were conducted with the academic staff participants immediately after completing the questionnaire. The questions that directed the interviews were designed to be clear and flexible in order to explore in-depth issues raised during the interviews. After a series of steps of data processing, six themes were identified: Distraction and concentration difficulties, Suitability of the workplace, Control over environment, Feelings, Privacy, and Communication.

4.2 Case Study One: Curtin University Sustainability Policy (CUSP) Institute

4.2.1 Overview

The CUSP workplace is an open-plan environment located on the ground floor of building 209 at the Curtin University 'Bentley campus' Perth, Western Australia. In 2014, the workplace was refurbished by Curtin's Properties, Facilities and Development department. The resulting workspace was occupied by 26 staff members, 23 academics and, three general or support staff.

4.2.1.1 Participants

Of the 23 academics, 19 were available to participate in this study. Table 4-1 provides a summary of the participants' demographics.

Table 4-1 Demographics of the CUSP workplace participants (Rashid 2015).

Age group	Male	Female	Total
>50 years	3	7	**10**
31-50 years	3	6	**9**
Total	**6**	**13**	**19**

4.2.1.2 Academic Activity in the Workplace

At the time of this study, CUSP was classified as a multidisciplinary research institute, comprising of a team of academics focused on sustainability policy. Staff within CUSP are responsible for supervision of Higher Degree by Research students, and delivering a Masters by coursework in Sustainability and Climate Policy. CUSP academics were expected to teach, both on campus and online, undertake both research and administrative work, undertake phone conversations and to attend meetings with colleagues. A large proportion of the work required collaboration with other staff members for purposes of conducting research. Figure 4-1, below, describes academic work undertaken in CUSP.

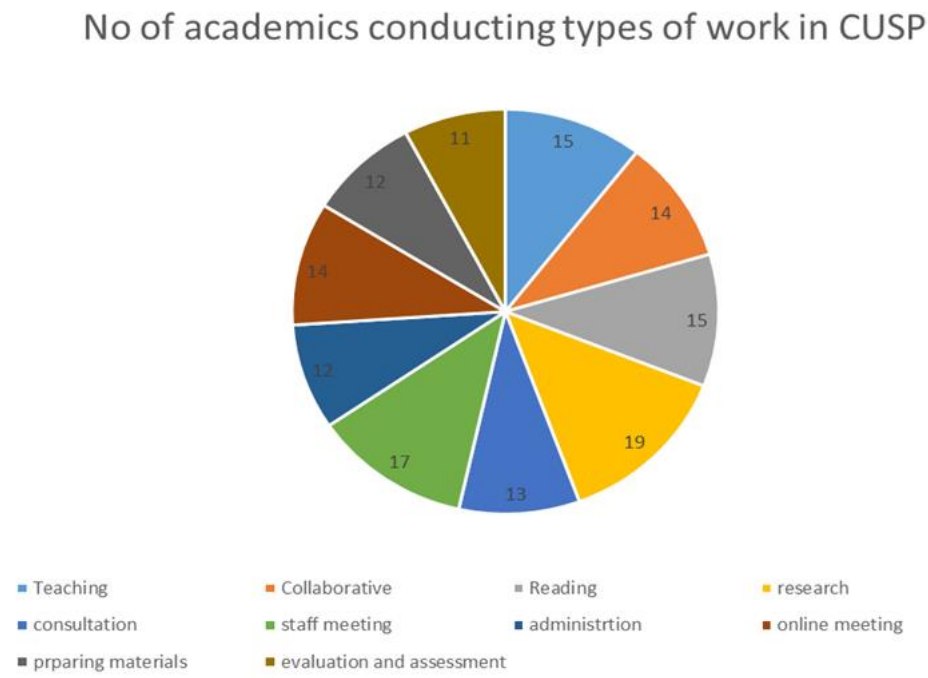

Figure 4-1 Number of academics conducting types of work (Rashid 2015).

It was noted that academics spent much of their working hours (8 am–5:30 pm) outside of the open-plan workplace, either teaching or attending meetings elsewhere on campus, or working from home. The researcher's observations recorded that the occupancy average for a working day was between 26% and 43%, except on the weekly meeting days, when the workplace was fully attended by all staff.

4.2.1.3 Open-plan Layout

Figure 4-2 shows the floor plan of the CUSP workplace layout. The workplace has two entrances from the north and the other from the south side. The north entrance is full-length glass, designed to allow daylight into the indoor environment and to give a sense spaciousness within the workplace. The reception area is situated in front of the south entrance. The building has an open office layout, with two separate small meeting rooms that both house a maximum of four persons and are located in the Centre of the open-plan workplace (Figure 4-3). These rooms are heavily used, on a daily basis, to hold meetings with colleagues or to make phone calls when a degree of confidentiality is required. In order to ensure maximum room availability to all staff, reservations must be made in advance.

Neither of the meeting rooms have direct access to daylight. This also has the added benefit of helping to figure out whether the room is empty or not (Figure 4-3). In the middle

of the north section of the workplace, there is another, larger meeting area that can accommodate up to ten people and is equipped with a large screen, used for weekly meetings and for conducting seminars and presentations (Figure 4-4). Bookshelves with plant beds above to form a visual barrier of approximately 160 cm in height on two sides serve to partly separate the meeting space from the main open-plan area. This barrier helps to define the space and give visual privacy. This area can be busy, and at times noisy, which causes a distraction for those who are not involved in meetings (Figure 4-4).

Figure 4-2 Floor plan of CUSP workplace (Rashid 2015).

Figure 4-3 Small meeting room (Rashid 2015).

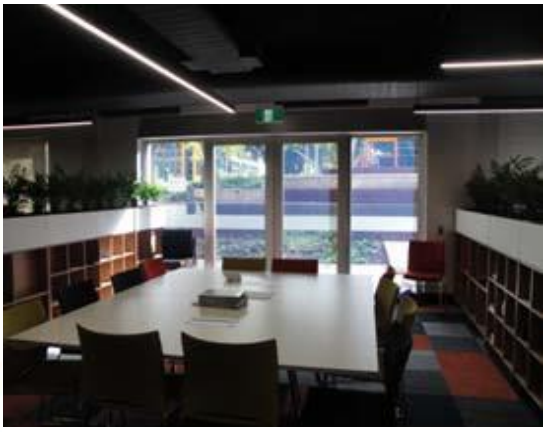

Figure 4-4 Large meeting area (Rashid 2015).

The workplace environment also includes booth seating for a casual meeting or a short break, located near the printing area on the west side of the workplace. As this area is vacant most of the time it causes the least amount of noise (Figure 4-5). The workplace manager does not have a separate office. The building has one storage room. All walls that face the workstations are painted white. The floor of the workplace is covered by dark grey, light grey and orange carpet, while the ceiling is black.

Figure 4-5 Booth seating for casual meeting (Rashid 2015).

4.2.1.4 Workstation Layout

The CUSP open plan office accommodates 23 permanent workstations. Workstations are lined up in rows of three. Some workstations face each other, and some face the opposite direction. (Figure 4-2)

At the side of each workstation, there is a small storage cabinet (90 cm x 40 cm x 60 cm), and another cabinet which is organised along the side of each row of workstations. However, some workstations were poorly organised and were stacked with piles of accumulated papers and books. This stacking is likely due to the insufficient amount of storage allocated for each workstation. These workstations and storage cabinets are white and separated from each other by a partition that protrudes 40 cm above desk height to the side of each chair. This provides a little privacy from the next workstation while also letting light through. The front partition is approximately 60 cm from the desk level to enhance visual privacy while working at the desk. Ultimately, the workstations and their partitions give a sense of territory (Figure 4-6 and 4-7). Pot plants have been distributed throughout the office. Plant beds have been distributed in the office, adding beauty as well as enhancing visual privacy. Some staff have decorated and personalised their working space for a sense of ownership.

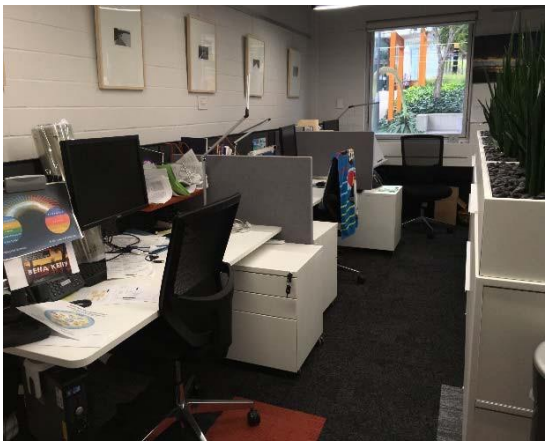

Figure 4-6 Workstation design arrangements in the workplace (Rashid 2015).

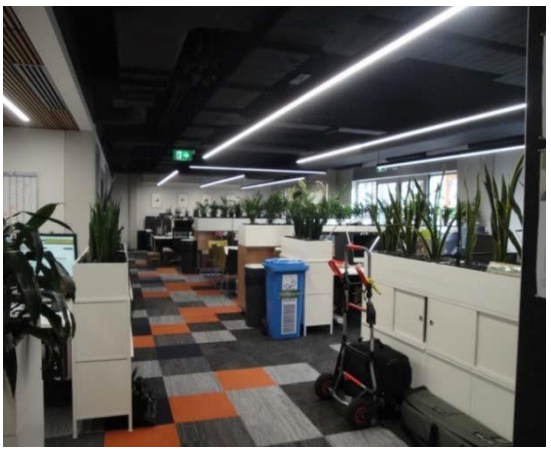

Figure 4-7 Workstation design arrangements in the workplace (Rashid 2015).

4.2.1.5 Lighting/windows

The CUSP working space is lit by LED strips, white/warm energy-saving light tubes, suspended on the ceiling above the workstations (Figure 4-8). The light (the amount of the illuminance (Lux)) above the presentation area can be adjusted by manual control. In addition to artificial lighting, the office has a set of windows along each of the north and south sides of the building and glazing in the middle of the west wall, allowing the daylight into the office. However, the mid-day sun glimmering from the north side causes discomfort in vision during

the first hours of work each day, forcing staff who sit near the windows to use the blinds to avoid the reflection of sunlight on their desktops.

4.2.1.6 HVAC System

The HVAC system controls ventilation and air conditioning. The office has a centrally controlled A/C system for the entire workplace. The circular ventilation diffusers are distributed uniformly to cover the whole workplace. The occupants can not turn the AC on/off.

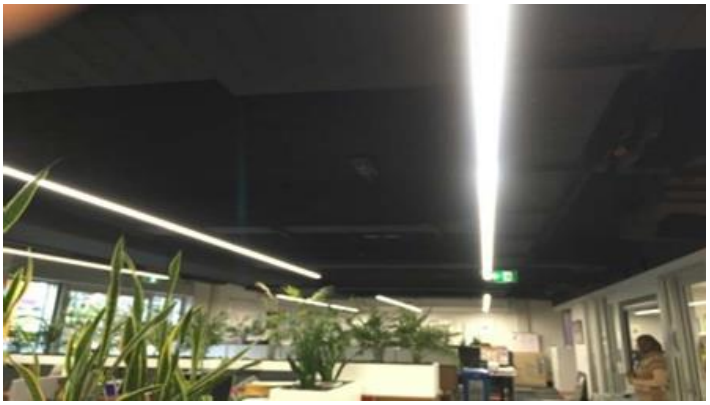

Figure 4-8 Lighting Distribution (Rashid 2015).

4.2.1.7 Summary of Case Study One Overview

Table 4-2 summarises the CUSP workplace description including occupancy, type of academic activities and environmental characteristics.

Table 4-2 A summary of CUSP-academic open-plan workplace characteristics (Rashid 2015).

Case Study	Occupancy	Academics' activities performed by CUSP	Environment
Case study 1: Curtin University Sustainability Policy Institute (CUSPI) – open-plan workplace on Curtin Bentley Campus	Total number for occupants is 26 staff: 23 are academic staff and 3 are support staff	-Focus on conducting research for publication and deep-thinking work -Supervision of postgraduate students -Meetings-face-to-face and online -Teaching preparations and reading	-Thermal comfort AC and automatic ventilation system - Air quality: limited access and control to fresh air. -Lighting: Uniform light distribution and local light, with plenty of daylight access -Layout: Variety of setting designs (two small meeting rooms, one large meeting area and siting for casual interaction) -Few storage shelves and 140 cm high partitions from the floor -Grey partitions and black ceiling -Carpet

4.2.2 Quantitative Results for CUSP

This section presents the analysis and findings of quantitative data (IEQ quality measurements and questionnaire) collected using a mixed method. The quantitative collection method was designed to explore indoor environment quality measurement and academic staff perceptions in relation to how IEQ impacts on occupants' satisfaction, mood motivation, and productivity in the open-plan workplace.

4.2.2.1 Indoor Environment Quality Measurements

This section summarises the results of the IEQ measurements for CUSP open-plan workplace. The measurements were taken in three designated work areas indicated in (Figure 4-9).

Figure 4-9 Identified spots for physical measurements in CUSP (Rashid 2015).

Temperature

The average temperatures in the CUSP open-plan workplaces were measured in each of the three selected areas. In accordance with Australian Standards, the recommended temperature range for occupant comfort is 20-24ºC (AS/1668.2-2012). There was inconsistency in temperature across the three areas shown in am and pm readings except for area 2. This fluctuation was within half a degree. However, the three measured areas were within the Australian standards recommendation (Figure 4–10).

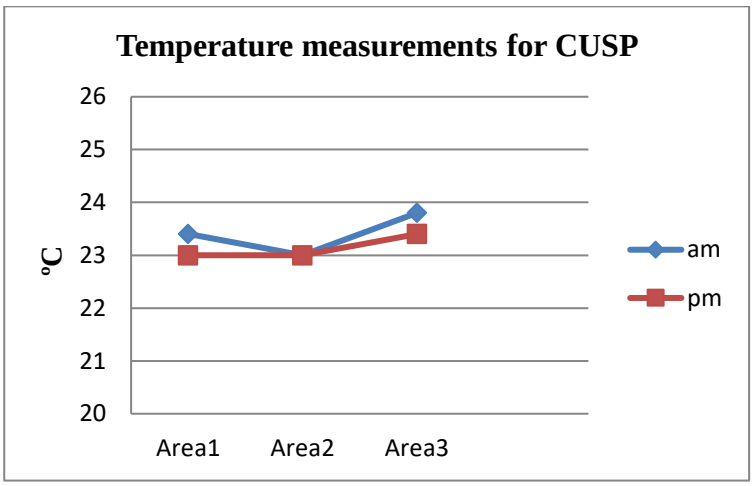

Figure 4-10 Temperature measurements for CUSP (Rashid 2015).

Humidity Percentage Fluctuations

The amount of humidity is depending primarily on the temperature of the air because warmer air holds more humidity than cooler air (ASHRAE 2010). The recommended range for relative humidity in the workplace is between 40% and 60% (AS/NZS 1668.2-2012). The average relative humidity recorded was within 1% across all areas during the morning hours, but there was a drop of 3% in the afternoons in area 1 and 2 (Figure 4.11). The relative humidity level in workplaces was within the recommended comfort level for workplaces in accordance with Australian Standards (AS 1668.2-2012 (2016) but, at the lower end of the spectrum.

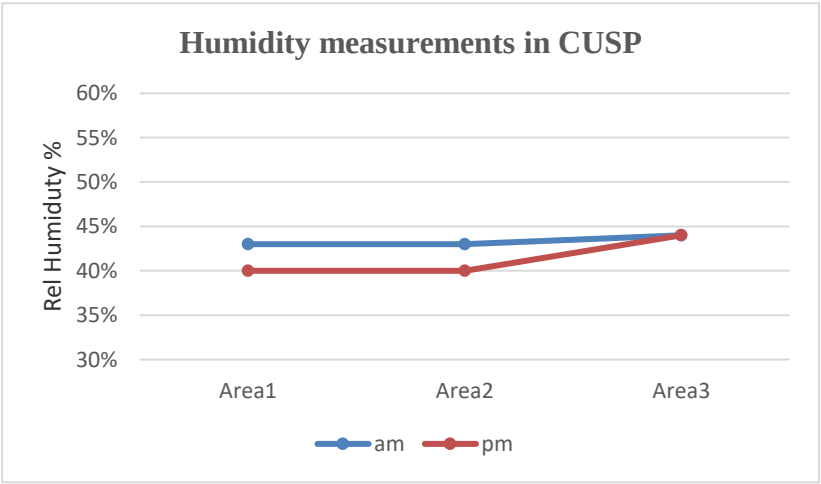

Figure 4-11 Humidity measurements for CUSP workplace (Rashid 2015).

CO_2 Concentration

Carbon dioxide (CO_2) concentrations indoors have been associated with air quality (Seppanen, Fisk, and Lei 2005). CO_2 can be affected by many aspects of the indoor environment, including the ventilation rate, sick building syndrome, the furniture and equipment, and the number of occupants (Varjo et al. 2015). According to standards Australia the CO_2 concentration level above 800 ppm is indication of unacceptable work environment (AS/1668.2 2012). The CO2 readings for the CUSP showed similarity to some extent between area 1 and 2 while the reading of area 3 came different also, the morning and afternoon readings for all areas were similar as shown in Figure 4-12. The measured CO_2 levels were within the acceptable Australian Standards for comfort in all three areas.

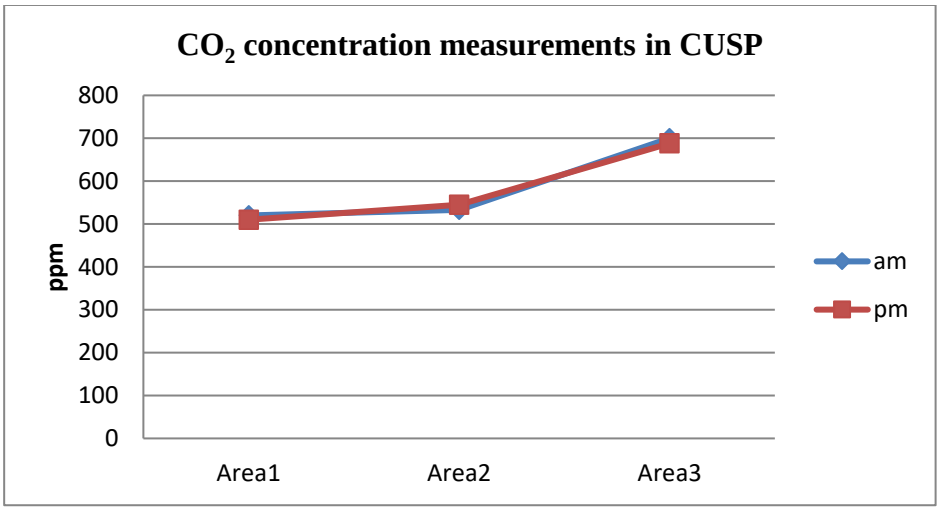

Figure 4-12 CO_2 concentration measurements for CUSP workplace (Rashid 2015).

Artificial Light Measurement

Lighting illuminance (lux) was measured by recording horizontal lux readings on an 'average' sunny autumn day, with internal lights switched on. Horizontal illuminance is the light landing on a horizontal surface, such as a desk or keyboard; it is important for reading and desk-based tasks. According to Australian Standards, the acceptable horizontal lighting level for office work is 320-600 lux, and the acceptable vertical lighting level is 160-240 lux (AS/NZS 1680.2.2:2008 2002). The results of the recordings are shown in Figure 4–13, there

was difference in the results between areas 1 and 2, and area 3. Area 3 showed incompliance with the standers, across both morning and afternoon reading. The high readings for area 3 was because it was close to the external windows.

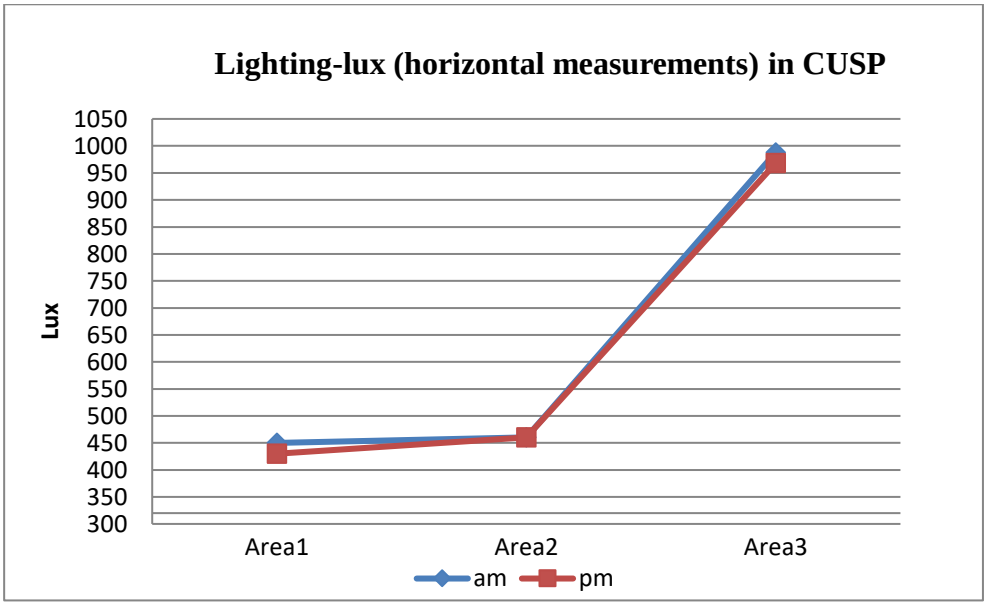

Figure 4-13 Lighting measurements for CUSP workplace (Rashid 2015).

Sound Level

The Australian Standard for sound level recommends a level in the range of 43-47 Db (AS/NZS 2107:2000). Generally, the measurement of sound level can be difficult to obtain accurately, due to it being easily altered by somebody speaking or a nearby door closing.

The data collection from the three work areas demonstrate that CUSP has optimum sound levels within the standard range for a.m. and p.m. readings (Figure 4-14). Area 1 in the evening and area 3 in the morning reached the maximum level of 47dB.

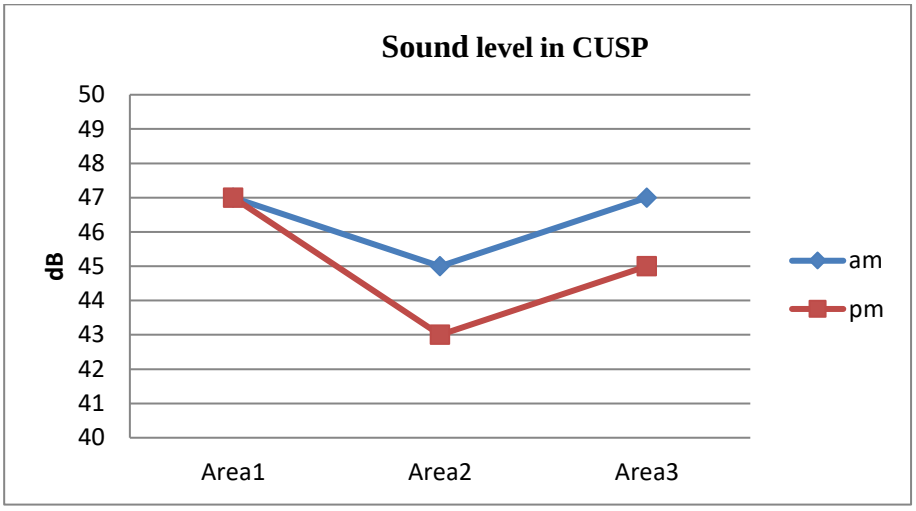

Figure 4-14 Sound level results for CUSP workplace (Rashid 2015).

4.2.2.1.1 Summary of Indoor Environment Quality Measurements for CUSP

All physical readings of the CUSP workplace were taken on a single day in March and June in 2015. The timing was selected to align with the teaching semester, so that the number of occupants of the workplace was complete or almost complete. The results showed that the indoor environment quality for the three workplace areas within CUSP is compliant with Australian Standards except light measurement in area 3 recorded 988 lux, while 600 lux is maximum range for general and screen-based office tasks. The measurement results of the indoor environment showed slight inconsistencies across the different areas and work hours. This process of analysing the recorded physical measurement in different areas in CUSP was helpful to obtain a fuller picture of the microclimates within each of the office environments. However, the results obtained in this study were constrained by the accuracy of the hand-held devices used for the recordings (see Appendix 5).

4.2.2.2 Statistical Analysis of the Questionnaire

4.2.2.2.1 Indoor Environment Quality and the Impact on Satisfaction

Occupants' satisfaction was investigated in regard to the six IEQ factors and table 4-3 and figure 4-15 show the results for the mean score and number of respondents of satisfaction across the participants respectively. Satisfaction with an IEQ was considered high when most of

the participants chose highly or extremely satisfied. Conversely, participants not satisfied with IEQ were deemed to be those who rated it as 'Not at all satisfied', or 'Slightly satisfied'.

The academic staff in CUSP were most satisfied with the colour of their office spaces (mean rating = 3.28) with 58% of respondents rating their satisfaction level with colour as either highly or extremely satisfied. Of those that were not satisfied with the colour (31.5%), when they asked to provide comments on what they particularly disliked, most of them remarked that the dark colour for the ceiling created an uncomfortable contrast with the overhead lighting. Staff were also satisfied with the lighting conditions, with an average mean rating of 3.26 and a total of 47% of the occupants responding as satisfied. Of the 21% of participants that were unsatisfied with the lighting, 4 out of 19 stated that the glare from the morning sun on the computer's screen caused discomfort. Of interest, all 21% of the not satisfied staff were in the same age group, that is, over 50.

Conversely, the sound levels and air quality within the CUSP workplace were perceived as the least satisfactory environmental factors. The mean score for the sound level was 1.95, with 73% of the respondents rating the sound as not satisfactory. The problems identified included noise from other staff conversations (17/19), lack of acoustic privacy (9/19), and noise from the ventilation system (3/19). Two of the participants who were highly satisfied with the sound level also noted that, while they enjoyed the interaction with their colleagues, the office was occasionally too noisy, especially during the weekly staff meetings. The mean satisfaction level with air quality was 2.47, with 47% rating this aspect as not satisfactory. While a larger number of participants stated during the interview that having limited control over access to fresh air (11/19) and air movement (5/19) made them uncomfortable in their work environment.

Table 4-3 Numbers of respondents and mean score of satisfaction for CUSP (Rashid 2015).

IEQ	Not at all satisfied	Slightly Satisfied	Moderately satisfied	Highly satisfied	Extremely satisfied	Mean
Thermal comfort	2 (10.5%)	5 (26.3%)	6 (31.5%)	6 (31.5%)	0	2.8
Air quality	5 (26.3%)	4 (21%)	6 (31.5%)	4 (21%)	0	2.4
Lighting	2 (10.5%)	2 (10.5%)	6 (31.5%)	7 (36.8%)	2 (10.5%)	3.2

Sound level	8 (42.1%)	6 (31.5%)	3 (15.7%)	2 (10.5%)	0	1.9
Layout	6 (31.5%)	3 (15.7%)	4 (21%)	6 (31.5%)	0	2.5
Colour	4 (21%)	2 (10.5%)	2 (10.5%)	9 (47.3%)	2 (10.5%)	3.2

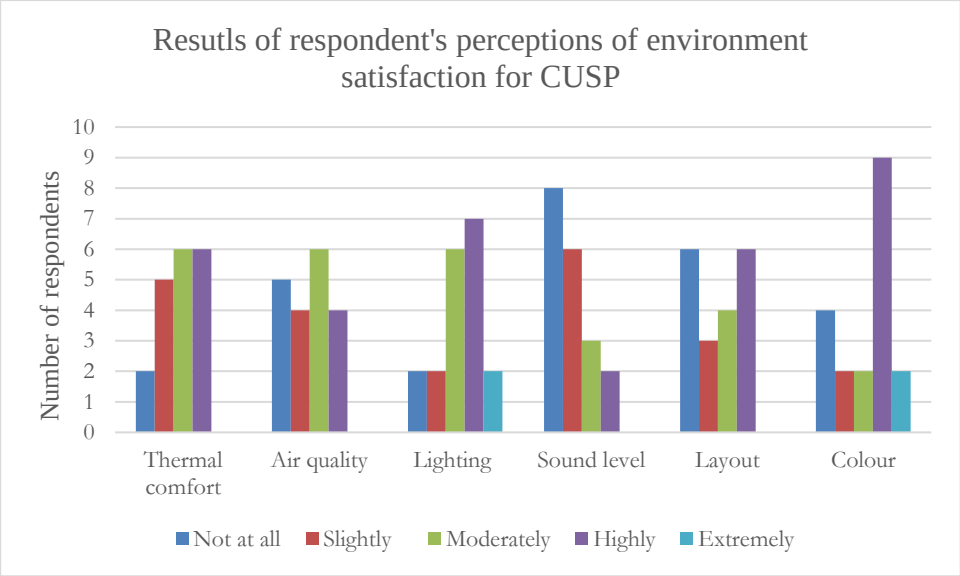

Figure 4-15 Results of the respondents' perceptions of environment satisfaction for CUSP (Rashid 2015).

4.2.2.2.2 Impact of Indoor Environment Quality on Mood

(EFA) test was used in order to load the six POMS mood responses into a single factor. The results below present the mean scores for the mood scale for CUSP workplace and six IEQ (Figures 4-16). The results indicate that the IEQ factors are not strongly associated with the occupant's mood. However, sound level has the highest mean compared with the other IEQ, with an average rating of 2.3. Colour (1.2) followed by lighting (1.4) within the workplace were perceived as the lowest mean in the workplace.

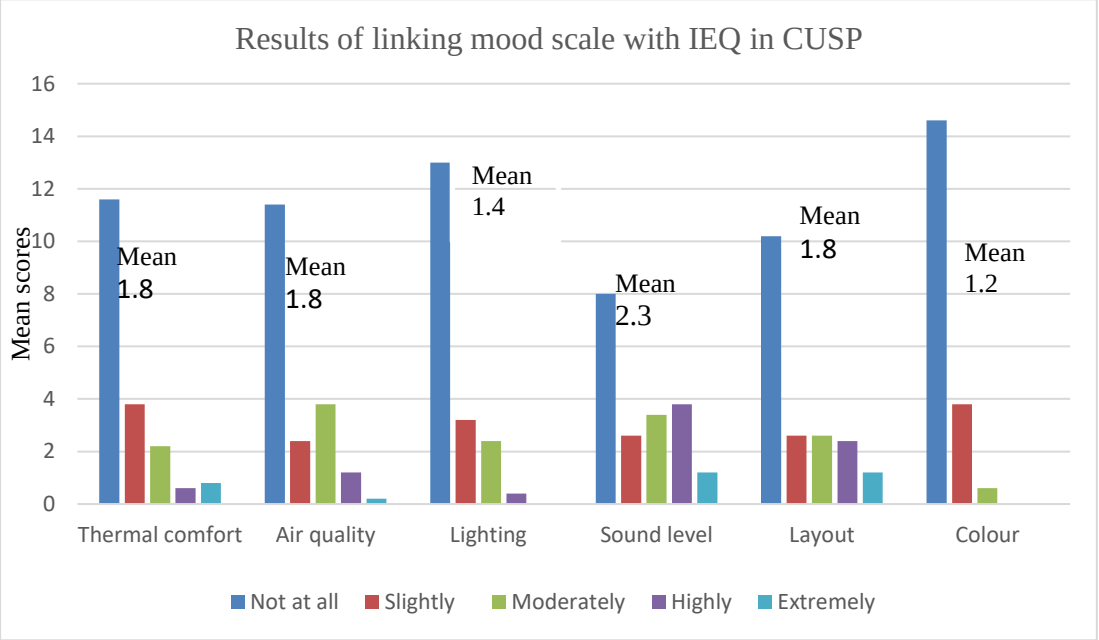

Figure 4-16 Results of the respondents' perceptions of mood for CUSP (Rashid 2015).

4.2.2.2.3 Indoor Environment Quality and the Impact on Motivation

The participants were asked to rate the effects of the six monitored IEQs on their motivation through two questions about 'enthusiasm' and 'willingness' to do tasks, responding on a five-point Likert scale from 'No effect at all' (1) through to 'Extremely affect my motivation' (5). The mean of the two questions for each participant was calculated. A significant effect of an IEQ on staff motivation was deemed to be for those participants who rated an average of four or above, that is, highly or extremely affected. Conversely, participants whose motivation was not deemed to be affected by an IEQ were those who rated it as two or below, that is, 'not at all' or 'slightly affected'.

Figure 4-17 represents the average means of the ratings for each IEQ in the CUSP workplace. In relation to motivation, the results showed a significant effect for IEQ on occupants' motivation to perform tasks. The academics' motivation was most affected by the layout of their office spaces; 11/19 respondents rating their motivation as either highly or extremely affected by layout, with a mean of (3.5), followed by sound level (3.2) and light (3). Conversely, colour within the workplace environment was perceived as the least affecting factor in their motivation to work. The mean score for colour was (2.4), followed by thermal comfort (2.5).

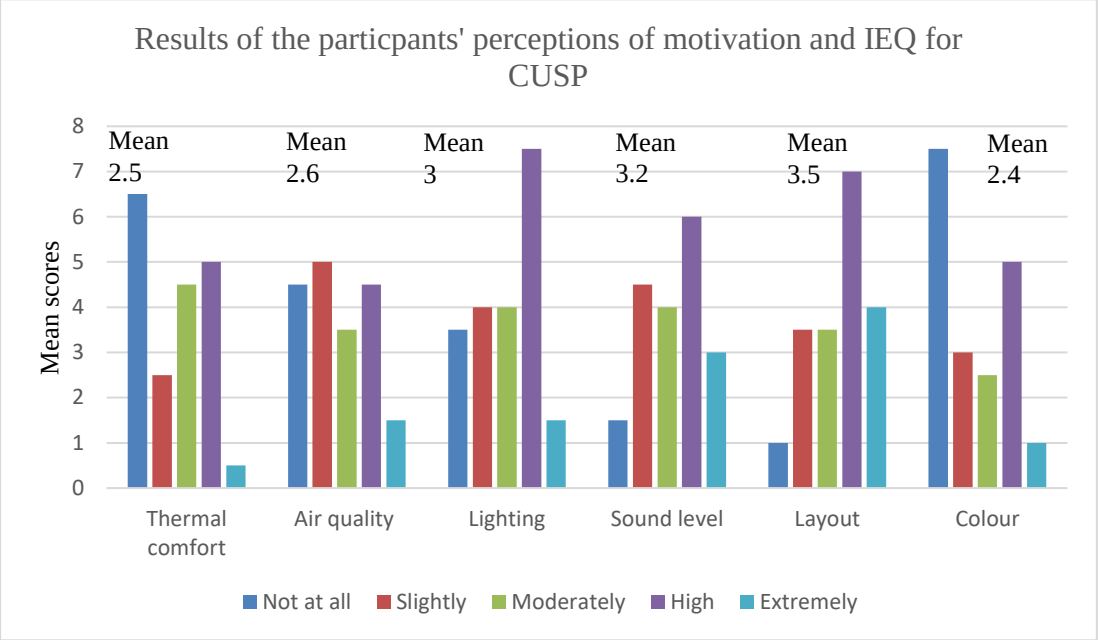

Figure 4-17 Results of the respondents' perceptions of motivation for CUSP (Rashid 2015).

4.2.2.2.4 The Impact of Indoor Environment Quality on Staff Productivity

The participants were asked to rate their perceptions of their productivity in their open-plan workplaces using a five-point Likert scale, from 'Not at all productive' (1) through to 'Extremely productive' (5). A summary of the results is shown in Table 4-4.

Table 4-4 Productivity in CUSP workplace (Rashid 2015).

	Not at all productive	Slightly productive	Moderately productive	Highly productive	Extremely productive
CUSP	0	7(36.8%)	3(14.7%)	9(47.3%)	0

Almost half of the CUSP (47.3%) respondents perceived their productivity as highly productive. In order to understand the relationships between each of the six IEQs and worker-perceived productivity, the participants were then asked to weight the impact of each IEQ on their productivity on a five-point Likert scale from 'Not at all' (1) through to 'Extremely' (5).

Productivity in CUSP

Table 4-5 and figure 4-18 represents a summary of the results of the impact of each IEQ on perceived productivity in the CUSP workplace. It shows that sound level was rated as having

the greatest negative impact on staff's productivity. In this workplace, almost three-quarters of the participants (73.6%) rated sound level in their office as having a high negative impact on their productivity, with only one person rating sound as having little impact on their productivity in their workplace. The next highest IEQ result was that of layout, with 68.3% of the participants rating this as having a high impact and only two persons rating layout as having little impact on their productivity; a possible explanation can be brought down to differences in personal preferences. Moreover the 47% of the participants rated light as highly and extremely effected their productivity. In contrast, colour was found to have the least impact on productivity, with more than half of the respondents rating colour as having little impact (52.5%) among the six IEQ.

Table 4-5 Numbers of respondents and mean score of perceived productivity for CUSP (Rashid 2015).

IEQ	**Not at all**	**Slightly**	**Moderately**	**Highly**	**Extremely**	**Mean**
Thermal comfort	3 (15.7%)	4 (21%)	3 (15.7%)	5 (26.3%)	4 (21%)	3.1
Air quality	3 (15.7%)	5 (26.3%)	3 (15.7%)	5 (26.3%)	3 (15.7%)	3
Lighting	4 (21%)	1 (5.2%)	5 (26.3%)	4 (21%)	5 (26.3%)	3.2
Sound level	0	1 (5.2%)	4 (21%)	6 (31.5%)	8 (42.1%)	4.1
Layout	0	2 (10.5%)	4 (21%)	4 (21%)	9 (47.3%)	4
Colour	7 (36.8%)	3 (15.7%)	5 (26.3%)	4 (21%)	0	2.3

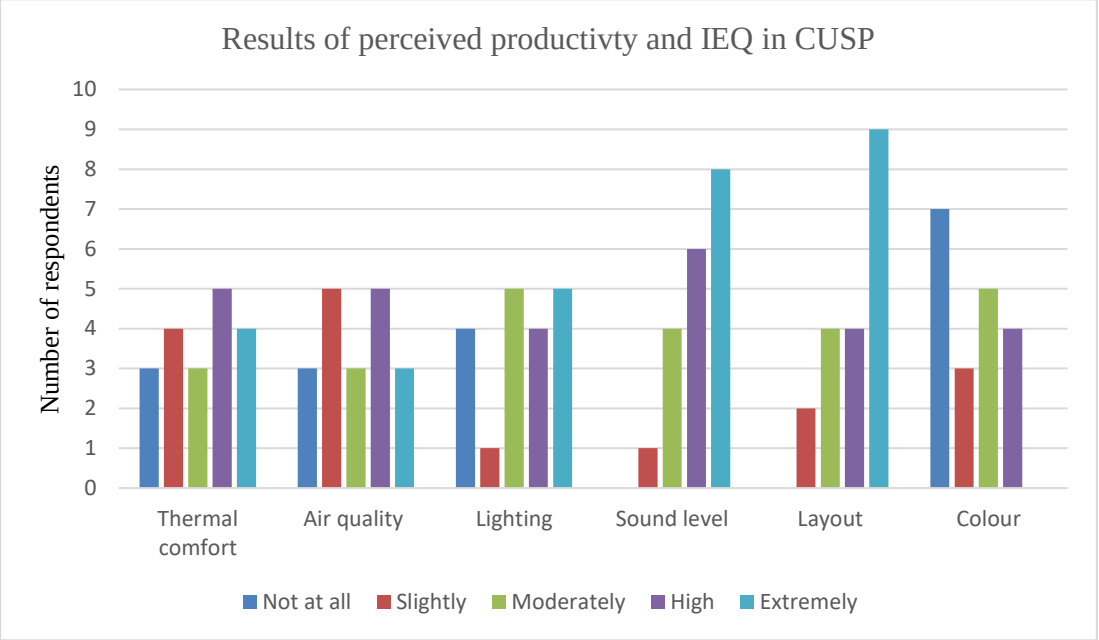

Figure 4-18 Results of the respondents' perceptions of own productivity for CUSP (Rashid 2015).

4.2.2.2.5 Relationships of Productivity with Satisfaction, Mood, and Motivation

The Spearman correlation coefficient has been used to determine whether an occupant's satisfaction, motivation and mood in regard to each IEQ factor has a relationship with perceived productivity (p-value *< 0.05 and **< 0.01)[2]. The results showed a significant negative relationship between the impact of sound level and workplace layout on their perceived productivity and their degree of satisfaction, as can be seen in Table 4-6. In other words, when satisfaction is high or extremely high with sound level and workplace layout, the impact of that factors on productivity is very small (i.e., 'not at all' or 'slightly'). The correlation coefficient related to sound level is -0.538 and in relation to layout is -0.504, while the correlations with lighting, air quality, thermal comfort, and colour showed no significant relationships with perceived productivity (p-value < 0.05)

[2] * Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.05 level (2-tailed).

Table 4-6 The correlation between productivity and satisfaction in CUSP workplaces for the current study

Building				How would you rate the impact of the following indoor environment? quality factors on your productivity at work?					
				Lighting	Sound	Air	Thermal	Layout	Colour
CUSP	Spearman's rho	Satisfaction - Lighting	Correlation coefficient Sig. (2-tailed)	0.199 0.415					
		Satisfaction - Sound level	Correlation coefficient Sig. (2-tailed)		-0.538* 0.018				
		Satisfaction - Air quality	Correlation coefficient Sig. (2-tailed)			-0.152 0.535			
		Satisfaction - Thermal comfort	Correlation coefficient Sig. (2-tailed)				-0.381 0.108		
		Satisfaction - Office layout	Correlation coefficient Sig. (2-tailed)					-0.504* 0.028	
		Satisfaction - Colour	Correlation coefficient Sig. (2-tailed)						-0.303 0.222

The results demonstrated that there is a significant positive relationship between mood and productivity in relation to office layout. Higher levels of mood associated with the office layout are related to higher levels of productivity, as can be seen in Table 4-7. The impact of layout on mood and perceived productivity is 0.624, while other IEQ factors showed no significant relationships. The correlation coefficients for mood and perceived productivity in relation to thermal comfort, lighting, air quality and colour were, respectively, 0.863, 0.628, 0.464 and 0.480.

Table 4-7 The correlation between productivity and mood in CUSP workplaces for the current study

Building				How would you rate the impact of the following indoor environment? quality factors on your productivity at work?					
				Lighting	Sound	Air	Thermal	Layout	Colour
CUSP	Spearman's rho	Mood - Lighting	Correlation coefficient Sig. (2-tailed)	-0.119 0.628					
		Mood - Sound level	Correlation coefficient Sig. (2-tailed)		0.384 0.104				
		Mood - Air quality	Correlation coefficient Sig. (2-tailed)			0.179 0.464			
		Mood - Thermal comfort	Correlation coefficient Sig. (2-tailed)				-0.042 0.863		
		Mood - Office layout	Correlation coefficient Sig. (2-tailed)					0.624** 0.004	
		Mood - Colour	Correlation coefficient Sig. (2-tailed)						0.173 0.480

There are significant positive relationships between motivation and productivity in relation to sound, air quality, thermal comfort, layout, and colour. Higher levels of motivation associated with sound, air quality, thermal comfort, layout, and colour are related to higher levels of productivity, as can be seen in Table 4-8.

Table 4-8 The correlation between productivity and motivation in CUSP workplaces for the current study

Building				How would you rate the impact of the following indoor environment? quality factors on your productivity at work?					
				Lighting	Sound	Air	Thermal	Layout	Colour
CUSP	Spearman's rho	Motivation - Lighting	Correlation coefficient Sig. (2-tailed) N	0.427 0.077 18					
		Motivation - Sound level	Correlation coefficient Sig. (2-tailed) N		0.627** 0.004 19				
		Motivation - Air quality	Correlation coefficient Sig. (2-tailed) N			0.734** 0.000 19			

		Motivation - Thermal comfort	Correlation coefficient Sig. (2-tailed) N				0.877** 0.000 19		
		Motivation - Office layout	Correlation coefficient Sig. (2-tailed) N					0.669** 0.002 19	
		Motivation - Colour	Correlation coefficient Sig. (2-tailed) N						0.679** 0.001 19

4.2.2.3 The Impact of Demographic Variables for CUSP workplace

The current study used a Pearson chi-squared test χ^2 (Plackett 1983) to examine whether there is a relationship between two categorical variables: demographic information (age and gender) and satisfaction, mood and motivation each of the six IEQ factors. However, due to the small cell sizes in years of experience working as an academic (cells are less than 5) the chi-squared test was considered unreliable therefore, Fisher's exact test (Mehta and Patel 1983) was alternatively used to analysis this small cell size. The resultant tables are shown in Appendices 6, 7 and 8.

Age

In this study, age had no significant impact on satisfaction for any of the IEQ factors in the selected workplaces. Similarly, it was concluded that age groups had (under 50 years, 50 years old and over 50 years) no significant effect on mood and motivation for each of the six IEQ factors (Appendix 6).

Gender

Gender (male and female) had no significant impact on satisfaction for any of the IEQ factors in the selected workplaces. Similarly, gender and its impact on mood for each of the six IEQ factors returned no significant relationship (Appendix 7). However, Pearson chi-squared test χ^2 found that females had reported a greater impact on their motivation to perform tasks for colour in their environments than males ($\chi^2[4] = 10.71$, $p = 0.030$)

Years of Experience Working as an Academic

Fisher's exact test results showed no significant impact on satisfaction, mood and motivation for any of the IEQ factors in the selected workplaces in relation to years of working as an academic (< 1 year, 1–3 years, > 3 years) (Appendix 8).

4.2.2.4 Summary of Quantitative Results

The results of the questionnaire in CUSP case study shows that the IEQ in open-plan workplace have a significant impact on the feeling of satisfaction, motivation and perceived productivity. Particularly, sound level was the most common factor identified to have a negative impact among the six IEQ.

The results show that sound level and air-quality had a strong negative impact on participants' satisfaction. Additional quantitative analysis showed that most of the participants identified noise from background conversations and lack of acoustic privacy as the most common reasons for dissatisfaction with sound levels. For air quality, lack of fresh air and air movement were the most common reasons for dissatisfaction. The participants were most satisfied with the colour and light, which might be due to the colour scheme of the office being based on the neutral colors (white for the walls and workstations, black for the ceiling and gray with orange for the flooring. Kwallek and Lewis (1990) found that participants preferred working in a white office environment compared to other colours, due to white-coloured offices being more acceptable and prevalent.

Similarly, sound levels were found to have a negative impact on participants' mood. In particular, high sound levels made academics annoyed and unhappy with the environment, while colour and light in the workplace were perceived as the least associated with mood in the workplace. However, the results of the average mood ratings for each IEQ indicate that the IEQ factors are not strongly associated with participants' mood.

Both sound levels and layout had significant negative impacts on participants' motivation and perceived productivity. Perceived productivity was strongly affected by sound levels and layout of the workplace. However, almost half of respondents perceived their productivity in open-plan workplace as highly or extremely productive. This means that many of the academic still perceived their productivity as high even though layout and sound were negatively rated as factors affecting their productivity. Conversely, colour within the

workplace environment was perceived as the factor least affecting their motivation to work and perceived productivity. That suggested that academics who were engaging in deep thought were less satisfied, motivated and productive with high sound levels caused by colleagues' conversations noise. This indicates that academic research work requires a higher level of sound and visual control over the environment.

Spearman correlation results found out that relationship of productivity with satisfaction, mood and motivation were signification in terms of sound and layout for satisfaction, layout for mood and all IEQ except light for motivation. Fisher's exact test stated that age groups, gender and years of experience working as an academic had no significant impact on satisfaction and mood for any of the IEQ factors However, females reported a greater impact on their motivation to perform tasks for colour than males

4.2.3 Results of Semi-structured Interviews with Academics

After a series of data coding process which, will be applied similarly for all three case studies, six themes were identified and explained in detail in this section: Distraction, Suitability of the workplace, Control over environment, Feelings, Privacy, and Communication.

Distraction in the CUSP workplace

55% (10/19) of the CUSP participants stated that distraction is a big disadvantage of their open-plan workplace. Distraction constantly has a big impact on participants' performance, and it interferes with their abilities to concentrate on their tasks, particularly when these tasks need deep thinking or high levels of concentration. The participants noted that the open-plan nature of their environment was interrupted that all staff were considered 'available' for conversations at all times. One research academic noted that this scenario played both ways:

> *People interrupt me all the time and I interrupt other people. So, it's not just one, you know, it goes both ways. Because you see somebody and it's like they're easy prey. You know you can just go over and as soon as you have a thought about wanting to speak to them you can go over and speak to them, rather than making an appointment or trying to knock on their door and ask if it's convenient. (CU10)*

While there were advantages in the availability of staff, this constant distraction also has an impact on ability to concentrate, particularly on research related tasks. For example:

... It's an advantage for meeting and greeting but it's a disadvantage for doing concentrated work, such as writing a paper…. (CU3)

In addition, 80% (15/19) of the participants believed that the noise levels contributed to a bad working atmosphere, leading to reluctance to collaborate with colleagues. The distraction usually happened on specific days, particularly when the office was fully occupied. One participant noted:

It's too noisy sometimes, 'especially on Wednesday; it's not private enough. (CU12)

Similarly, 60% (11/19) of the participants believed that the layout of the open-plan workplace, and the requirement to support different types of activity, also contributed to the academic staff's exposure to distractions. For example:

...we had a meeting this morning; we all sat here. I thought that was pleasant and very nice. But it may have disturbed other people… and the reason we sat there was because there were nine of us in the meeting. So, we didn't have any other space that accommodated nine people." (CU7)

In addition, location of the workstation plays a significant role in affecting the office workflow. Almost a third, 31% (6/19) of the participants stated that workstations located in the main traffic zone were prone to visually distract staff, and some workstations near to air-conditioning outlets caused staff to feel uncomfortable due to noise and room temperature, ultimately making them want to leave the workplace early. However, one of the participants mentioned that the IEQ of the workplace comes into effect as a package and some qualities do not work independently.

... Don't know, I think they combine. I think maybe if the light is low and the air is getting a bit stuffy — the sound — I normally just wear headphones so I block out. (CU18)

Suitability of the CUSP workplace

Almost half 47% (9/19) of the CUSP participants thought that an open-plan workplace was suitable for particular types of work and not for others. For example, an open-plan workplace supports academic staff in collaboration and interaction with their colleagues. However, an open-plan workplace is not suitable for deep thinking and writing. For example:

With some, productivity in some cases has increased, I guess, but productivity in terms of writing — those sorts of things — it has definitely decreased. So yeah, it's not as cut and dried as an increase or a decrease. Because I think the types of work we do, you do need interaction with people for collaboration, but then to actually do the outputs and stuff, you need quiet time. (CU12)

On the other hand, 31% (6/19) of the participants indicated that an open-plan office is suitable for all kinds of academic tasks and is a more productive environment than any other office. They suggested that there were advantages in the diversity of their open-plan workplace, such as the big meeting room and two separate smaller meeting rooms to provide an opportunity for collaborative work and easy interaction among staff. One explained further:

Without that (diversity in seating) our open plan wouldn't work because it would be far too busy and noisy. With it, the opportunity for just working surrounded by other people, getting things done like your emails or reading something, writing something can happen. But as soon as anyone rings up or comes to visit you, you have to get out of there and into the room. (CU2)

Conversely, 21% (4/19) of the participants stated that the open-plan workplace does not support their entire work, because they need a workplace that can achieve a balance between communication and level of sound or visual privacy. For instance:

A lot of academic work is about thinking and it's about interaction with students and other people. When you're all in together and you're all trying to do that, some are trying to think, and others are trying to interact; then everyone together — it doesn't work. (CU5)

Control in the CUSP workplace

21% (4/19) of CUSP participants believed that control over the physical environment in open-plan workplaces is a problem, leading to an uncomfortable and unhappy work environment. The inability of staff to control air-conditioning systems, window openings and workstation levels of noise creates a less productive work environment. For example:

A lot of the time our climate is good enough to be able to open doors and windows and just breathe the fresh air. I would like to be able to do that but it's not clever enough — our system is not clever enough. So, a more smart system of being able to

open and close doors and windows — indoor-outdoor experience of architecture is, for me… very important to feel fresh and pleasant — those cultures that do that well like in Bali, in Broome, and increasingly the new architecture in Perth does that — but we can't even keep our doors open for more than a few seconds before it beeps at you and goes off and sets an alarm. We would have a much more collegial and productive research environment if we could manage doors and windows ourselves. (CU10)

However, the rest of the staff did not mention control over the physical environment as a problem facing the staff in their workplace.

Feelings in the CUSP workplace

Of the academic staff employed at CUSP, 40% (8/19) believed that the high level of noise and the layout of their workplace were affecting their feelings towards their work environment negatively, causing an increase in frustration, bad temper and annoyance. Participants noted that the small space allotted for each workstation and its storage spaces, and the presence of an open presentation area, were the main factors affecting their feelings negatively. One person explained how they could be negatively affected:

…probably the noise again. I guess it can be both 'annoyed' and 'unhappy'. You know, like yesterday we had some exciting news and so that part of it can be positive because you hear, you know what's going on. We do work in close-knit groups so it's nice — you get to know what's happening in people's lives and things like that, so it becomes more than just work. But I guess then, when you are trying to concentrate, it can be very annoying and make you feel very annoyed or unhappy, I guess. Then the other one I think is the constant interruptions [that] can make you very unhappy and annoyed. (CU15)

However, 35% (7/19) of the participants expressed that their interactions with colleagues in their open-plan workplace contributed to a pleasant atmosphere, a feeling of happiness, motivating staff to stay and work until late hours in the open-plan workplace, which in turn increased their productivity. Only 10% (2/19) of the participants stated that their mood could be affected by what happened inside the workplace.

For example, in terms of feeling happiness with the open-plan workplace:

I enjoy coming to work… When you enter you see who's here and you have a little good morning to people on the way past. It's positive, I like it…. *(CU6)*

In terms of the academics' motivations to stay and work late in their workplace, one participant said:

I think all the factors that you listed about air quality, about light, about artificial light, about temperature — they all play a role. I couldn't separate them out. Mostly I feel very comfortable in this setting and it invigorates and motivates me. The only issue I find is that the air conditioning is sometimes too cold, and you can't really control it. *(CU10)*

Privacy in the CUSP workplace

60% (11/19) of staff stated that the open-plan design provided a comfortable level of visual privacy, through partitions, greenery and workstation locations. For example:

The greenery, the plants — I don't know if that's an issue of it being open plan but I think that helps to give it a bit more privacy and makes it feel, yeah, just very nice. *(CU4)*

It is okay, I'm happy that I have the corner position. I don't think I'd be as comfortable in an open-plan office if I was in a place where people would be able to look over my shoulder as they're walking past and all that sort of thing. So, I think it works for me because of the corner position; just because it feels like you have more privacy and are able to concentrate on your work without the sense of people looking over your shoulder or walking past and — just disturbed less. *(CU1)*

For 42% (8/19) of the participants, a lack of visual and sound privacy impacted upon their productivity. The layout of the open-plan workspace and absence of high physical partitions between workstations led the staff feeling unprotected, working in an unsecure work environment, and distracted. One person explained:

This place has no privacy …. Privacy is important because you need … confidentiality on what [you] are doing, and with constant disruption you're losing your line of thought and it's almost like starting over and over again on the same task. *(CU2)* ***Communication in the CUSP workplace***

77% (15/19) of the participants stated that communication among workers is a big advantage that helps to improve the team's productivity and makes them work happily. The open-plan workplace enhances the idea of teamwork by enabling the staff to sit near each other, without high partitions, and to have communications. For example:

> *The other big advantage is that I hear what people are involved in, I know what other people are doing, I know what I can help with or where I can get involved. My colleague who sit[s] next to me — we're working on a lot more collaboration than we would otherwise because I'm aware of what she's doing and she's aware of what I'm doing. Otherwise, we may not be aware of each other's work… (CU5)*

On the other hand, 21% (4/19) pointed out the difficulties of communicating with each other in open-plan spaces because of the distraction it causes to others working in the same office. However, not all staff work in the office every day. For example:

> *… you have a good interaction with people, because you just informally cross paths or whatever. But as I say at another level, counter-intuitively, in a sense, you lose some of that interaction because actually quite a few people choose not to come as frequently because they work more from home or whatever. So in a sense it sort of works against each other. It's a bit of an ironic thing. (CU14)*

Additionally, one participant made it clear that communication does not necessarily improve productivity. It sometimes causes distraction. For example,

> *Well, for me, when I'm really focused, I'm deep, deep thinking. Like, analysis of data or really deep stuff — I can actually do it better in a coffee shop than I can do here. Because in a coffee shop it's noisy but there are not people I know, I'm left alone, I'm in my own zone. So it's not so much noise — because I can do that in a coffee shop and I'm just in my bubble, nobody will come and talk to me or bother me and I can concentrate and not get disturbed. (CU5)*

4.2.3.1 Summary of Qualitative Results

The participants engaged in semi-structured interviews individually with the researcher for five–ten minutes. They were asked about their experiences in the open-plan workplace, as a way of exploring how occupants' satisfaction, mood, motivation and productivity were affected by the physical work environment. The academics all stated that distraction is a big issue in their open-plan workplace. They reported that distraction has a constantly negative impact on their ability to concentrate on their tasks, especially when the tasks need deep thinking and high levels of concentration. The main reasons for the distraction are noise levels that come from other staff conversations and staff movement, with the open-plan layout aggravating the problem of distraction. The participants stated that there is a perception that all staff were considered to be 'available' for conversations at all times in open-plan layout, and they agreed that their workplace layout did not support different types of activity, especially deep-thinking work. Moreover, many believed that the open-plan workplace affected their feelings negatively, causing frustration, bad temper and annoyance. The participants noted that the open presentation area, and the small size of the storage spaces allotted for each workstation, were the main causes of negative feelings. The layout of the open plan led the staff to feel unproductive working in an unsecured work environment, due to lack of privacy. However, the results showed that the open-plan workplace provide a good opportunity for communication among workers, which helped to improve the team's productivity and make them work happily. The open-plan workplace enhances the idea of teamwork by enabling the staff to sit near each other, without high partitions.

4.2.4 Conclusion and Discussion for CUSP Workplace

The CUSP workspace was occupied by 26 staff members, 23 of whom were academics, with the remaining three classifieds as general or support staff. A large part of the academic work requires writing, research, and deep-thinking.

The quantitative results agreed with the qualitative results that sound was the big problem in open-plan workplace, although the physical measurements for sound were within the acceptable Australian Standards for comfort. The quantitative results show that sound level is the most impactful factor influencing academics' productivity, feeling of satisfaction, mood, and motivation. The quantitative results are consistent with the qualitative results in relation to sound level as the main source of distraction, discomfort with the environment,

and have a negative impact on occupants' feelings, which in turn negatively affect the speed of work completion and staff desire to stay behind to accomplish the work inside the workplace. This finding aligns with previous studies by Vassie and Richardson (2017), Di Blasio et al. (2019), and Jahncke et al. (2011). For example, Jahncke et al. (2011) investigated the effect of two different noise levels on mood and cognition in a simulated open-plan workplace. The study found that in the noisy open-plan workplace, participants were tired, and their moods were negative. However, academic work is different in terms of complexity, diversity, and requirements, which makes it difficult to compare with other works.

The quantitative and qualitative results are also consistent in terms of open-plan layout. The results show that the open-plan workplace layout produced a significant negative impact on the academics' productivity and motivation. The occupants responded that the ability to concentrate in open- plan workplace was very difficult and cause more difficulties in implementing their academic work such as writing and deep thinking which need high concentration. The academic in CUSP added that individual workplace would be better for their type of work and open-plan layout did not support diversity of their academic work patterns. Moreover, the participants identified that workstations situated near the hallway and the partition height did not provide visual and sound privacy eventually causing frustration and bad temper. This is in alignment with the existing literature in relation to workplace space-planning and layout (Kang, Ou, and Mak 2017; Kim and de Dear 2013). Kang Ou and Mak (2017), for instance, found that open-plan layout causes distraction and does not support the academic activities. However, half of the participants showed that they were still productive in an open-plan layout. This was supported by the qualitative results, which indicated that half of the participants found that the open-plan workplace was suitable for particular types of work; for example, an open-plan workplace supports academics with collaborative work and social interaction among colleagues. However, it is not suitable for deep thinking and writing tasks. This finding is in line with a previous study by Dimotakis, Scott, and Koopman (2011) which confirmed that positive social interaction among occupant in workplace generates positive feeling and the negative interaction leads to negative feeling. This outcome suggests that academic workplace needs a layout that support concentration work and both formal and informal interaction for better productivity.

The quantitative results indicated that air quality was a significant factor negatively influencing feelings of satisfaction, specifically, a lack of fresh air and air ventilation. Furthermore, some participants indicated that the inability to control air-conditioning systems and window openings created annoyance and a less productive work environment. The literature supports this finding, indicating that there is a relationship between both air quality and a feeling of satisfaction (Kang, Ou, and Mak 2017; Ai et al. 2016). This suggests that academic research work requires higher standards for fresh air in order to stimulate a higher level of concentration, thinking and creativity than other types of academic work.

The correlation coefficients between satisfaction and motivation, with productivity and in relation to sound level and workplace layout are significantly similar to Vischer and Wifi (2017) and Samani et al. (2018) research findings which suggest that satisfaction with the physical workplace environment evaluates occupants' performance. The correlation was also strong in relation to mood and productivity in terms of layout. Küller, Mikellides, and Janssens (2009) demonstrated that both mood and performance of workers were enhanced in a multi-coloured environment. Figure 4-19 shows the main findings for CUSP workplace.

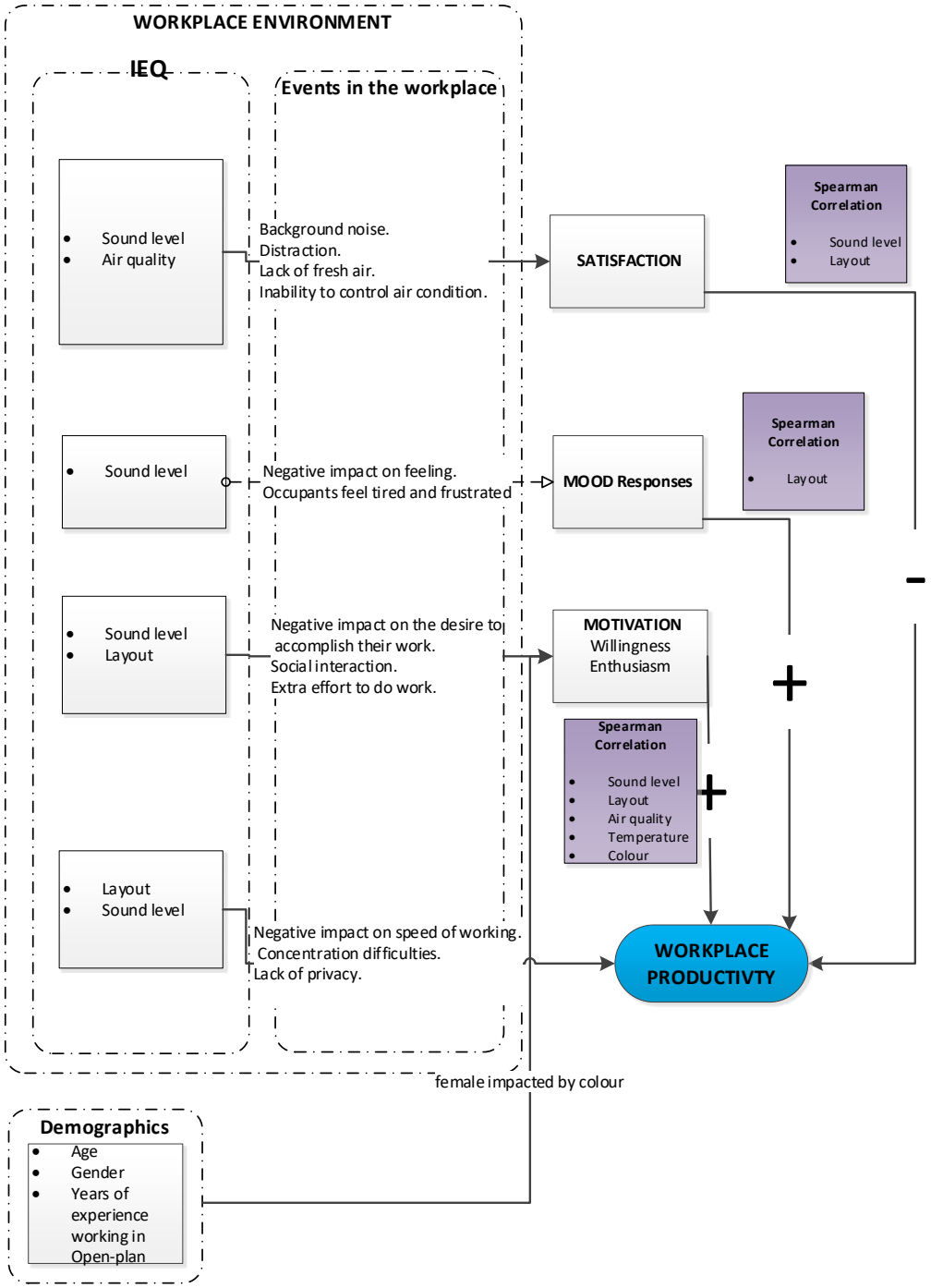

Figure 4-19 Outcomes of CUSP workplace (Rashid 2018).

4.3 Case Study Two: Curtin Teaching and Learning (CTL)

4.3.1 Overview

The Curtin Teaching and Learning (CTL) office is an open-plan workplace located in the basement level of building 105 at Curtin University's Bentley campus, Perth, Western Australia. In 2014, the CTL workplace was refurbished by the Curtin's Properties and Facilities Development. The building was occupied by approximately 68 staff members: 23 academics, 40 general, and 5 administration staff.

4.3.1.1 Participants

Of the 23 academics, 20 participated in this study. Table 4-9 provides a summary of the participant demographics.

Table 4-9 Demographic of the CTL workplace participants (Rashid 2015).

Age group	Male	Female	Total
>50 years	3	12	15
31-50 years	2	3	5
Total	5	15	20

4.3.1.2 Academic Productivity in the Workplace

The essential role of Curtin Teaching and Learning is to develop the quality of teaching and learning practice at Curtin University, supporting excellence in course and learning design, assessment practices and policies, quality learning, and learning engagement.

The academic staff are expected to work as a team. Usually, one or two academic staff members lead a group of general staff. A large part of the job requires the use of computers for general administrative work, collaborative work, meeting attendance, research and reading, and some academics in CTL are work-loaded to teach and/or supervise Higher Degree by Research students. Occupants of this open-plan work place are allocated permanent work stations. Here, the academics are required to attend their workplace on a daily basis for

eight hours, five days per week. During the data collection, the researcher observed the attendance percentage to be about 91%. At various times, most of the academics will be required to leave their desks to attend meetings. CTL academics spend most of their time in their workplace. Figure (4-20) below describes academic work in CTL.

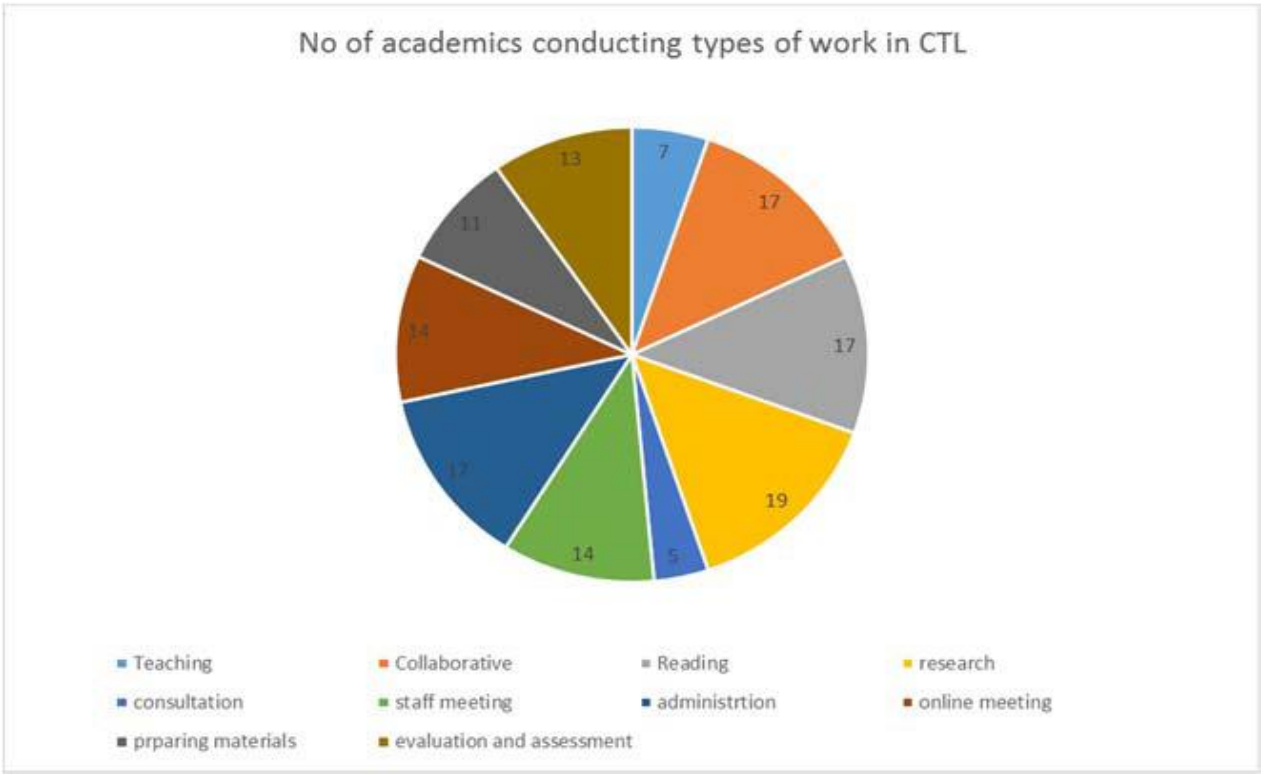

Figure 4-20 Number of academics conducting different types of work (Rashid 2015).

4.3.1.3 Open-plan Layout

Figure 4-21 shows the floor plan for this workplace layout. The workplace has one main entrance situated on the east side, with a glazed door through which to reach the workplace via the reception area. The reception area is located in the front of the main entrance and isolated from the open-plan area by a partition of long wooden strips. Visitors are not allowed to enter without permission from the office. The building has an open- plan office layout with six separate meeting rooms, each room equipped to accommodate six to seven people. The presence of these rooms supports the collaborative work between team members and minimises potential noise inside the open-plan workplace. Reservations must be made in advance. Each one of the six meeting rooms is in a different colour: orange, green or blue.

Figure 4-21 Floor plan for the CTL workplace (Rashid 2015).

Figure 4-22 Meeting room accommodates eight persons (Rashid 2015).

Figure 4-23 Meeting room accommodates six persons (Rashid 2015).

In addition, the workplace has three quiet rooms equipped with a desk, chair, table lamp, a small table and one or two seats. There are not enough of these rooms in relation to the number of occupants and their particular responsibilities in this workplace. For example, when these rooms are fully occupied some of the staff have to leave the workplace and go outside to use their personal phones in order to hold discreet work-related conversations. The academic participants emphasised the importance of having a meeting and a quiet room to enhance and achieve their work properly. As with the meeting rooms, each one of the quiet rooms has been painted a different colour: orange, green or blue with the intention being to give the user the opportunity to choose the most comfortable and motivating colour (Figures 4-22,4-23,4-24 and 4-25). The colours were chosen according to a questionnaire conducted among users of the workplace before the office was refurbished by Curtin University's Properties and Facilities department.

Figure 4-25 Quiet room, in orange colour, for work requiring concentration (Rashid 2015).

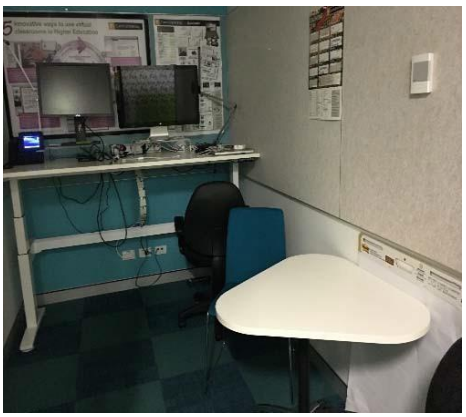

Figure 4-24 Quiet room, in blue colour, for work requiring concentration (Rashid 2015).

The workplace manager occupies an individual office that is partially separated from the open-plan workplace, and which overlooks the workplace through a glazed door, to facilitate monitoring of the workflow. The north side of the workplace have a view of a common room, isolated from the workplace by a glass partition that reaches the ceiling; the opposite side of this common room is also made of glass. The view beyond the glass is of a garden, allowing the daylight to penetrate the indoor environment and it gives a sense of spaciousness (Figure 4-26 and 4-27).

Figure 4-26 North side of the workplace overlooking the common room (Rashid 2015).

Figure 4-27 Opposite side of the common room, allowing daylight to enter the workplace (Rashid 2015).

The common room, which is used by staff during lunch breaks, for socialising, and sometimes for informal meetings between colleagues, has storage cabinets, a fridge, sink, dining tables, casual sofas, and bookshelves (Figure 4-28).

Figure 4-28 Common room for informal interactions (Rashid 2015).

The workplace also has a storage room. Walls and ceilings of the workplace are painted white. Along the south side is a planter wall with plants, to simulate the external environment and provide a pleasant feeling. However, at certain times of the year, these plants become uncomfortable due to attracting insects (Figure 4-29). The floor of the workplace is covered by a beige carpet.

Figure 4-29 Planter wall on the south side of the workplace (Rashid 2015).

4.3.1.4 Workstation layout

The office has a total of 63 sets of workstations for full-time staff and 6 hot desks for part-time staff. Workstations are organised in "team enclosure style", with four- or six-person workstations situated in a group and surrounded by a green-coloured privacy partition up to a height of 135 cm from the floor (Figure 4-30). This design actively supports the team without any interruptions stemming from other teams and offers optimal team workflow. Each

workstation is L-shaped, white-coloured and provided with storage cabinets, a telephone and a line connected to the telecom system. The amount of storage is appropriate because most work is stored on the computer (Figure 4-31). Pot plants are also located on top of storage cabinets at a height of 160 cm and uniformly distributed within the workplace. Some staff have decorated and personalised their working space.

Figure 4-30 Team enclosure design for workstations (Rashid 2015).

Figure 4-31 Individual workstation design (Rashid 2015).

4.3.1.5 Lighting/windows

The CTL workplace is lit by fluorescent, white/warm tubes situated in the ceiling. The light is distributed uniformly (Figures 4-32 and 4-33). There is also a task light for each workstation. The local illumination (lux) can be manually controlled to give occupants the opportunity to choose the most comfortable amount of light. The office suffers from the absence of windows in most parts. This situation gives rise to some staff feeling discomfort and strain. On the west side of the room, a set of windows provides daylight and some outside views to add some comfort to the environment. The windows cannot be opened or closed, and no window blinds are installed (Figure 4-32). In addition, a glass partition between the common room and the workplace allows natural light into the office space, especially during sunny days.

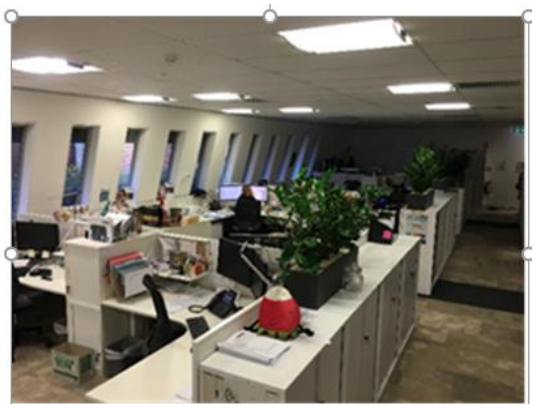

Figure 4-32 Set of windows in west side of the workplace (Rashid 2015).

Figure 4-33 Uniform lighting distribution (Rashid 2015).

4.3.1.6 HVAC System

Office ventilation and air conditioning is via a centrally controlled A/C system that cools and heats the entire workplace. The ventilation diffusers are uniformly distributed in the ceiling. The occupants have no control over the temperature. Some of the occupants mentioned that there are some days when the office is very hot, forcing them to go outside to obtain some fresh air and then come back to work again.

4.3.1.7 Summary Case Study Two Overview

Table 4-10 summarises the CTL workplace description including occupancy, type of academic activities and environmental characteristics.

Table 4-10 Summary of CTL workplace characteristics (Rashid 2015).

Case Study	Occupancy	Academics' activities performed by CTL	Environment
Case study 2: Curtin Teaching & Learning (CTL) — open-plan workplace on Curtin Bentley Campus	Total number for occupants is 63 staff: 23 are academic staff and 40 are support staff	-Concentration on office work: collaborative and administrative -Research and Teaching preparations: postgraduate and online teaching -Reading	-Thermal comfort AC and automatic ventilation system -Air quality: limited access to fresh air -Lighting: Uniform light distribution and local light, with very little daylight access (basement level) -Layout: Variety of setting designs: small room for concentration tasks, meeting

			room, common room for informal interaction. -Workstation layout: "team enclosure style" for four- or six-person workstations situated in a group, surrounded by partition 120 cm high from the floor -Moderate amount of storage shelves -Some green partitions and some white -Reception area isolated from the open-plan area by a partition -Carpet

4.3.2 Quantitative Results for CTL

Same steps conducted in CUSP were followed for CTL to analyse the Quantitative date including physical measurements and questionnaire.

4.3.2.1 Indoor Environment Quality Measurements

The section represents the results for the IEQ measurements for CTL open-plan workplaces. The measurements were taken in identified areas (Figure 4-34).

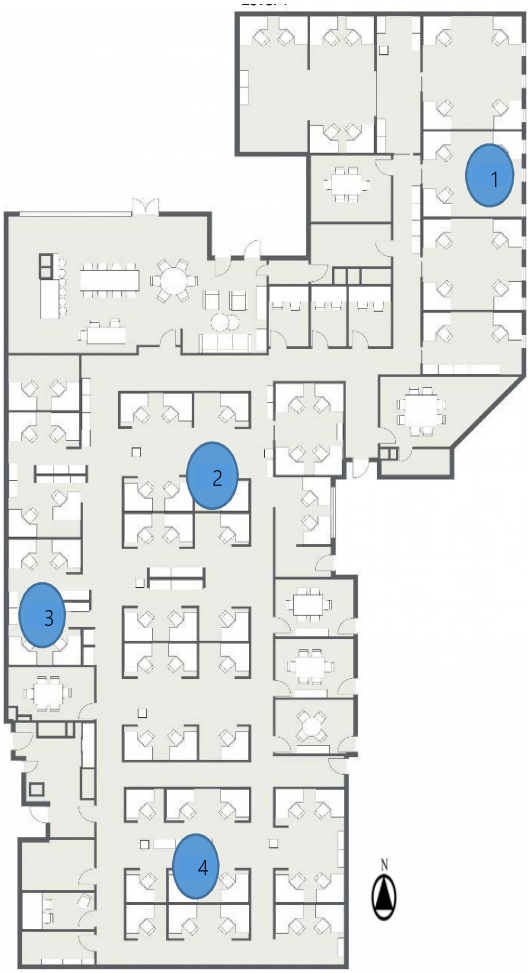

Figure 4-34 Identified spots for physical measurements in CTL (Rashid 2015).

Temperature

The average temperatures in the open-plan workplaces were measured in each of the selected areas. The recommended temperature range for occupant comfort is 20-24ºC (AS 1668.2-2012 (2016)). There were some inconsistencies in temperature across the areas. This fluctuation was within one degree between area 1 and area 3. However, in general the temperature readings were compliant with the comfort standards for workplaces. Figure 4-35

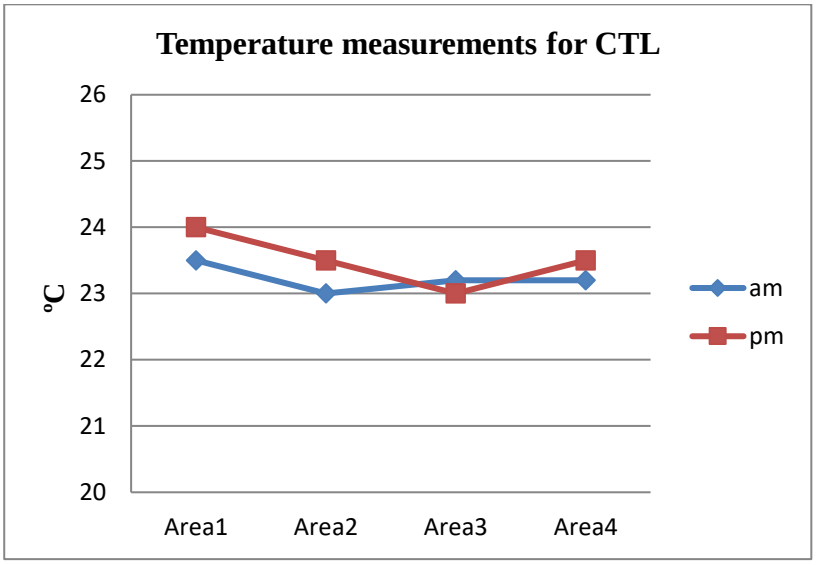

Figure 4-35 Temperature measurements for CTL (Rashid 2015).

Humidity Percentage Fluctuations

The recommended range for relative humidity in the workplace is between 40% and 60% (AS/ 1668.2-2012). The results were within 2% across areas 1, 2 and 3 for the a.m. and p.m. readings. However, area 4 was noted as recording an increase in the percentage for both the a.m. and p.m. readings, reaching 55% in the a.m. and 50% in the p.m. (Figure 4-36). The relative humidity level was within the recommended comfort level for workplaces, according to AS.

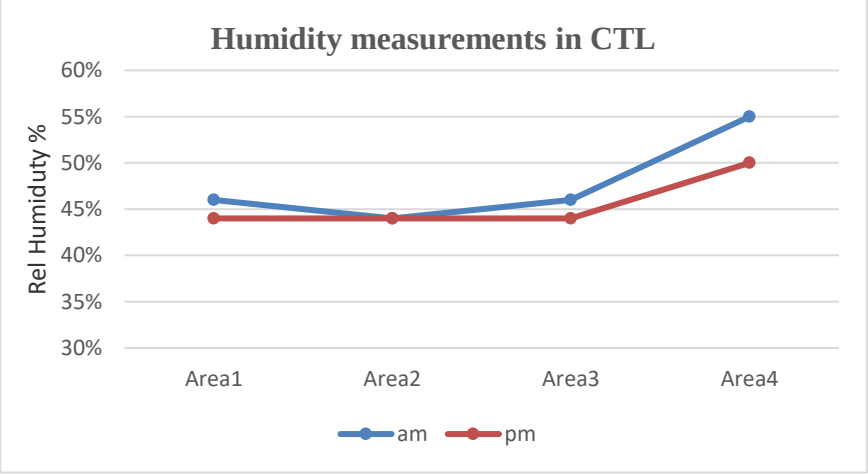

Figure 4-36 Humidity measurements for CTL workplace (Rashid 2015).

CO_2 Concentration

Carbon dioxide (CO_2) concentrations indoors have been associated with perceived air quality and health issues (Seppanen, Fisk, and Lei 2005). The average measurement for CO_2 level was recorded in all designated areas. The CO_2 readings showed some consistency between areas 1, 2, and 3 however, area 4 recorded big different (Figure 4-37). The morning and afternoon readings were similar in CTL. The measured CO_2 levels were within the acceptable Australian Standards for comfort which is below 800 ppm (AS/1668.2 2012).

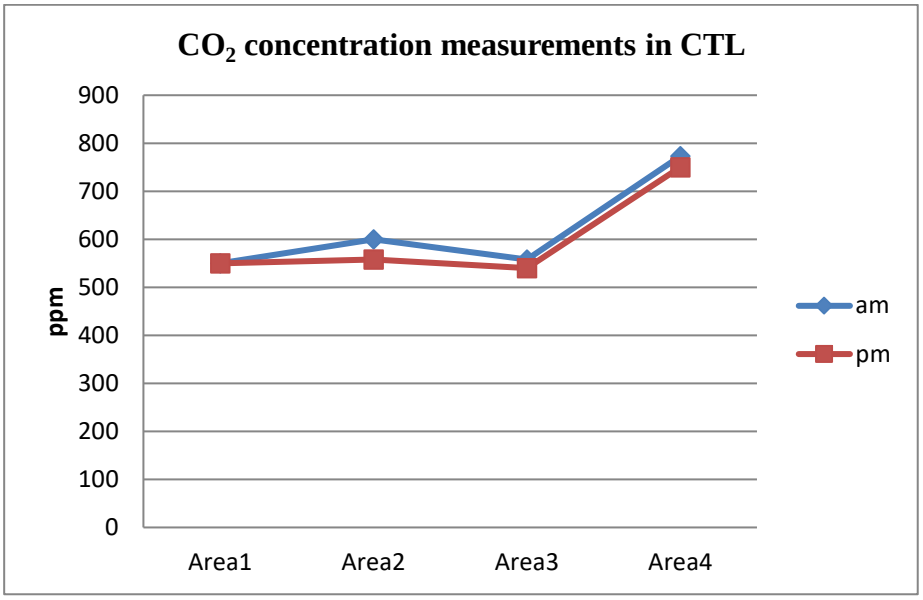

Figure 4-37 CO_2 concentration measurements for CTL workplace (Rashid 2015).

Artificial Light Measurement

Lighting illuminance (lux) was measured by recording horizontal lux readings on an 'average' sunny autumn day, with internal lights switched on. Horizontal lighting levels for general and screen-based office work is 320-600 lux (AS/NZS 1680.2.2:2008). The results of the recordings are shown in Figure 4-38. It can be noted that one area (area 3) within the CTL workplace fell below the recommended minimum horizontal illuminance, with a recording of 306 lux during the morning and afternoon. The reason for that was lack of daylight due to the CTL is located in the basement.

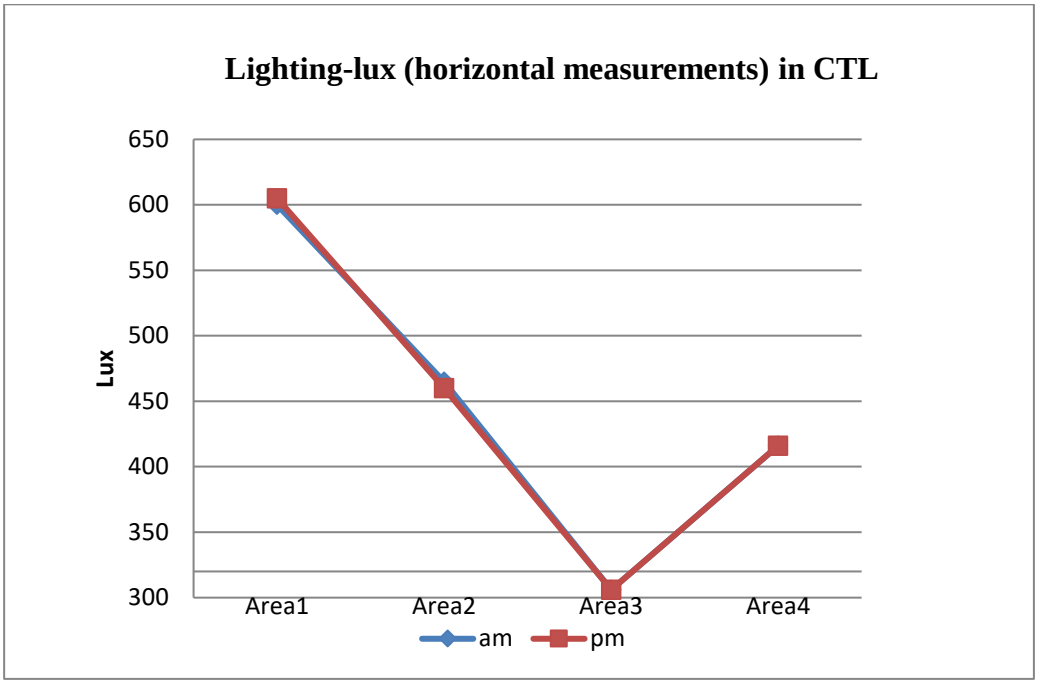

Figure 4-38 lighting measurements for CTL workplace (Rashid 2015).

Sound Level

The Australian Standard for sound level recommends a level in the range of 43-47 Db (AS/NZS 2107:2000). Generally, the measurement of sound level can be difficult to obtain accurately, due to it being easily altered by somebody speaking or a nearby door closing. The data collection spots demonstrated CTL had optimum sound levels within the standard range for a.m. and p.m. readings. Figure 4-39

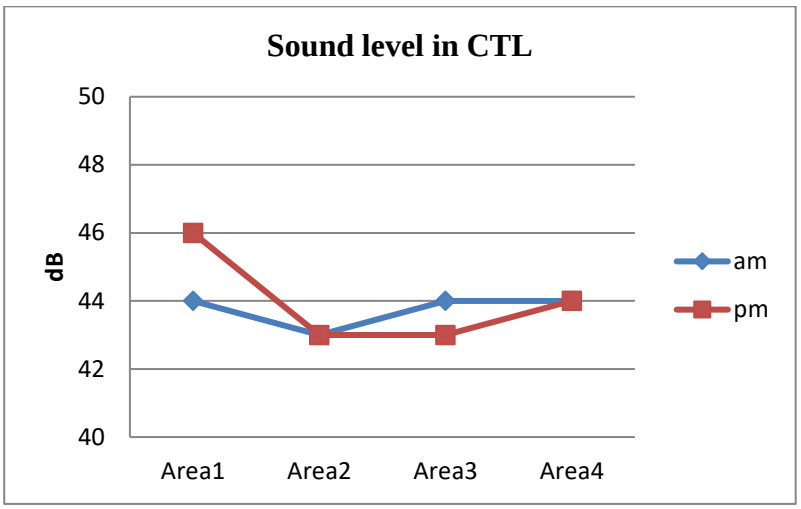

Figure 4-39 Sound level results for CTL workplace (Rashid 2015).

4.3.2.1.1 Summary of Physical Measurements

Five physical readings were taken on a single day in March and July for CTL workplace in 2015. The timing was selected to align with the working semester that the number of occupants of the workplace is complete or almost complete. The results showed that the indoor environment quality for the workplaces was compliant with Australian standards. However, there was exceptions in area 3, which was under-lit comparing with Australian Standards (Figure 4-38). The reason for that is due to CTL workplace being in the basement receiving limited amount of day light. The measurement results of indoor environment, while compliant, also showed inconsistencies across the different areas and the different work hours.

4.3.2.2 Statistical Analysis for the Questionnaire

4.3.2.2.1 Indoor Environment Quality and the Impact on Satisfaction

Occupants' satisfaction was investigated in regard to the six IEQ factors and table 4-11 and figure 4-40 show the results for the mean score and the number of respondents of satisfaction across the participants respectively. The academic staff in CTL were mostly satisfied with the IEQ factors. 70% of respondents rated themselves as being highly or extremely satisfied with the colour, lighting (60%), air quality (50%), and thermal comfort (50%). Two respondents rated their satisfaction with colour as 'not at all' or 'slightly not

satisfied' (2/20), and both identified the colour scheme as "clinical". A total of 60% of the staff were satisfied with the lighting. Despite the lack of natural daylight in this basement workplace, only one of the participants (5%) was found to be not at all satisfied with this aspect.

Half of the participants (50%) were either highly or extremely satisfied with air quality. Of the 35% who were dissatisfied, 7/20 recorded the need for more fresh air and air movement as root causes. The thermal comfort results showed that 50% of participants were satisfied while 25% of participants (5/20) were dissatisfied, the participants stated that the temperature was sometimes too cold in the summer and too hot in the winter. And 4/20 were dissatisfied with the humidity, commenting that they needed to adjust their clothing layers because they could not control their workstation's temperature.

The workplace layout and sound levels within the workplace were perceived as the unsatisfactory environmental factors, with 45% of the respondents rating the workplace layout as not satisfactory. The main reasons given for this were the lack of privacy (13/20), the need to consider other workers when interacting with co-workers in the workplace (8/20), and the lack of available storage for each workstation (7/20).

Of the 15% (3 people) that were satisfied with the layout, all were allocated workstations located in a corner, giving them privacy in their workplace while still allowing them to do collaborative work. The results also showed that 40% (8 people) rated the sound level as unsatisfactory, with only 3 (15%) indicating they were satisfied with the sound levels. Reasons given included noise of other staff conversations (9/20) and lack of acoustic privacy, especially when they needed to make confidential phone calls (9/20). (See Figure 4-40 and Table 4-11)

Table 4-11 Numbers of respondents and mean score of satisfaction for CTL (Rashid 2015).

IEQ	Not at all	Slightly	Moderately	Highly	Extremely	Mean
Thermal comfort	1 (5%)	4 (20%)	5 (25%)	10 (50%)	0	3
Air quality	5 (25%)	2 (10%)	3 (15%)	9 (45%)	1 (5%)	3.5
Lighting	1 (5%)	0	7 (35%)	8 (40%)	4 (20%)	3.7

Sound level	4 (20%)	4 (20%)	9 (45%)	1 (5%)	2 (10%)	2.4
Layout	4 (20%)	5 (25%)	8 (40%)	2 (10%)	1 (5%)	2.8
Colour	1 (5%)	1 (5%)	4 (20%)	9 (45%)	5 (25%)	3.5

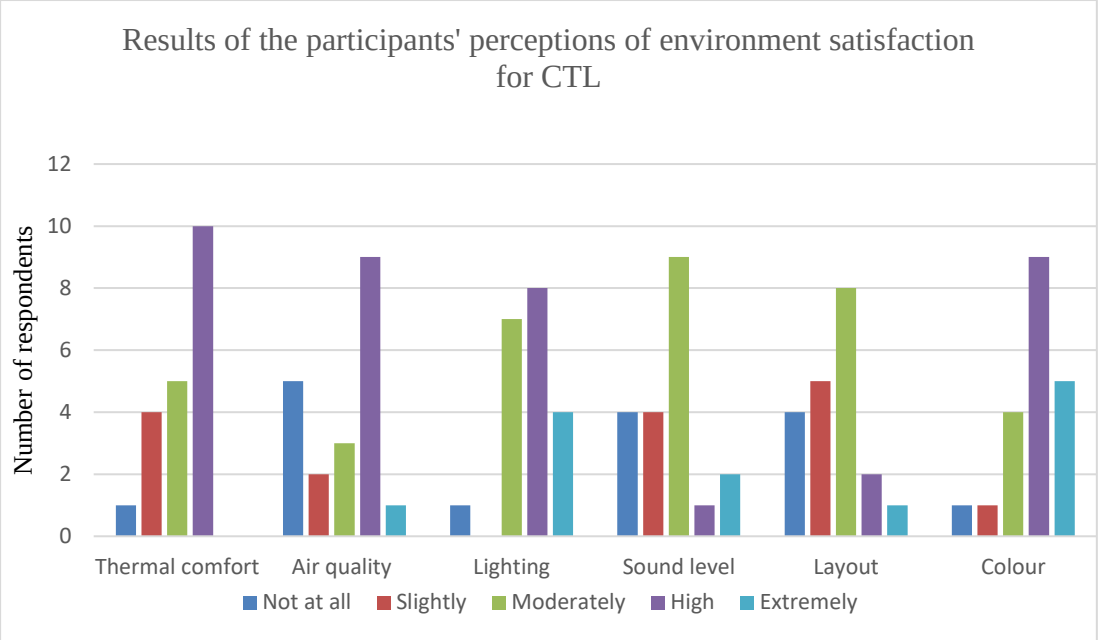

Figure 4-40 Results of respondents' perceptions of environment satisfaction for CTL (Rashid 2015).

4.3.2.2.2 Impact of Indoor Environment Quality on Staff Mood

Figure 4-41 shows the results for the mood average ratings in the CTL workplace for each IEQ. The results indicate that the IEQ factors are not strongly associated with the occupant's mood. However, an academic's mood is most associated with the sound level (1.9) compering to the other factors. Conversely, colour (1) followed by lighting (1.5) were perceived as being least associated with the mood in the workplace.

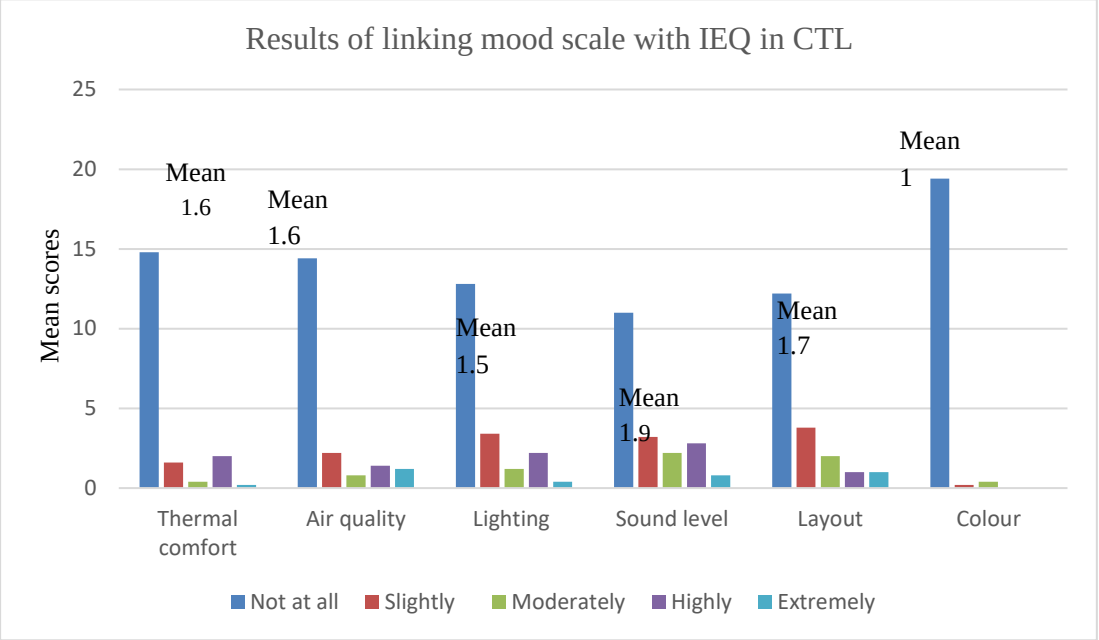

Figure 4-41 Results of the respondents' perceptions of mood for CTL (Rashid 2015).

4.3.2.2.3 Indoor Environment Quality and the Impact on Motivation

Figure 4-42 represents the average mean ratings for the CTL workplace in terms of each IEQ. The motivation results showed no significant effect for IEQ on occupants' motivation (willingness and enthusiasm). The motivation of academic staff was most affected by the lighting of their office spaces compared to other IEQ factors, with an average of 2.8, possibly because they depend on artificial lighting due to the lack of daylight. Conversely, colour within the CTL workplace was perceived as being the least influential factor on motivation in the work environment. The mean score for colour was 2.2.

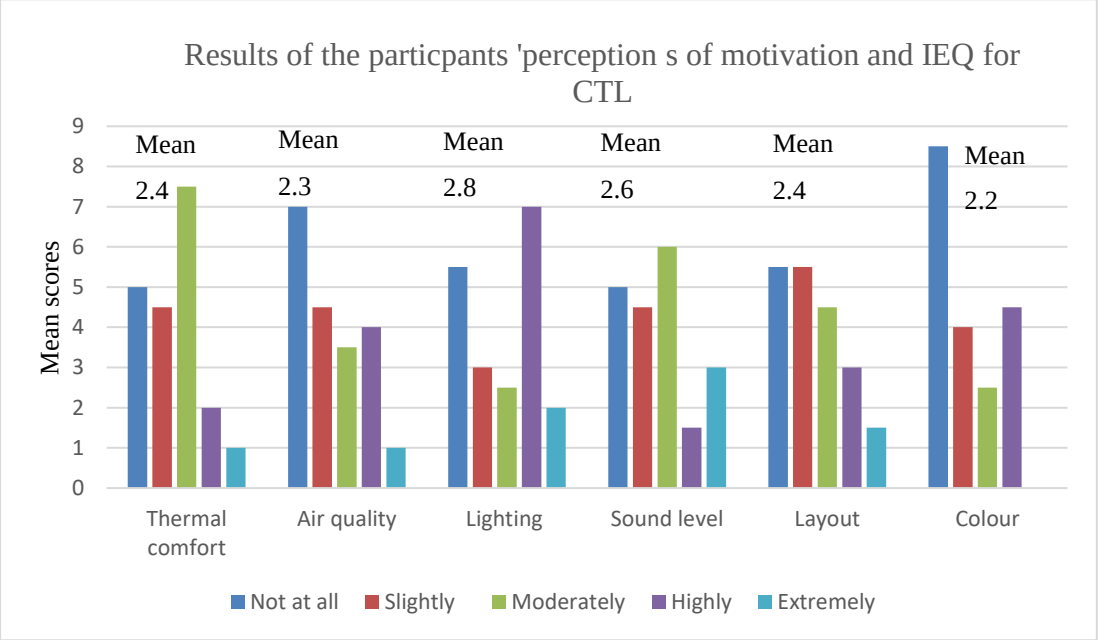

Figure 4-42 Results of respondents' perceptions of motivation for CTL (Rashid 2015).

4.3.2.2.4 The Impact of Indoor Environment Quality on Staff Productivity

The participants were asked to rate their perceptions of their productivity in their open-plan workplaces using a five-point Likert scale, from 'Not at all' (1) through to 'Extremely' (5). A summary of the results is shown in Table 4-12.

Table 4-12 Productivity in CTL workplace (Rashid 2015).

	Not at all productive	Slightly productive	Moderately productive	Highly productive	Extremely productive
CTL	1 (5%)	2 (10%)	8 (40%)	7 (35%)	2 (10%)

45% of the respondents perceived their productivity as highly or extremely productive. Conversely, 15% of CTL perceived themselves as either not at all or only slightly productive in their open-plan workplace. In order to understand the relationships between each of the six IEQs and worker-perceived productivity.

Productivity in CTL

Table 4-13 and figure 4-43 represents the number of respondents and mean scores for the weight of the impact of each IEQ on staff productivity in CTL workplace. More than half

(55%) of the participants rated the sound level, layout and (45% rated) thermal comfort as the factors that most affected their productivity. However, a small percentage, 15% (three people) for sound level, 30% (six people) for layout and 30% (six people) for thermal comfort responded that IEQs were 'not at all' or 'slightly' affecting their productivity in the workplace. On the other hand, 50% of the participants reported that colour had no effect on their productivity (Figure4-43 and Table 4-13).

Table 4-13 Numbers of respondents and mean score of perceived productivity for CTL (Rashid 2015).

IEQ	Not at all	Slightly	Moderately	Highly	Extremely	Mean
Thermal comfort	3 (15%)	3 (15%)	5 (25%)	7 (35%)	2 (10%)	3.1
Air quality	6 (30%)	1 (5%)	4 (20%)	7 (35%)	2 (10%)	2.9
Lighting	3 (15%)	4 (20%)	6 (30%)	5 (25%)	2 (10%)	2.9
Sound level	1 (5%)	2 (10%)	6 (30%)	4 (20%)	7 (35%)	3.7
Layout	4 (20%)	2 (10%)	3 (15%)	6 (30%)	5 (25%)	3.3
Colour	5 (25%)	5 (25%)	6 (30%)	3 (15%)	1 (5%)	2.5

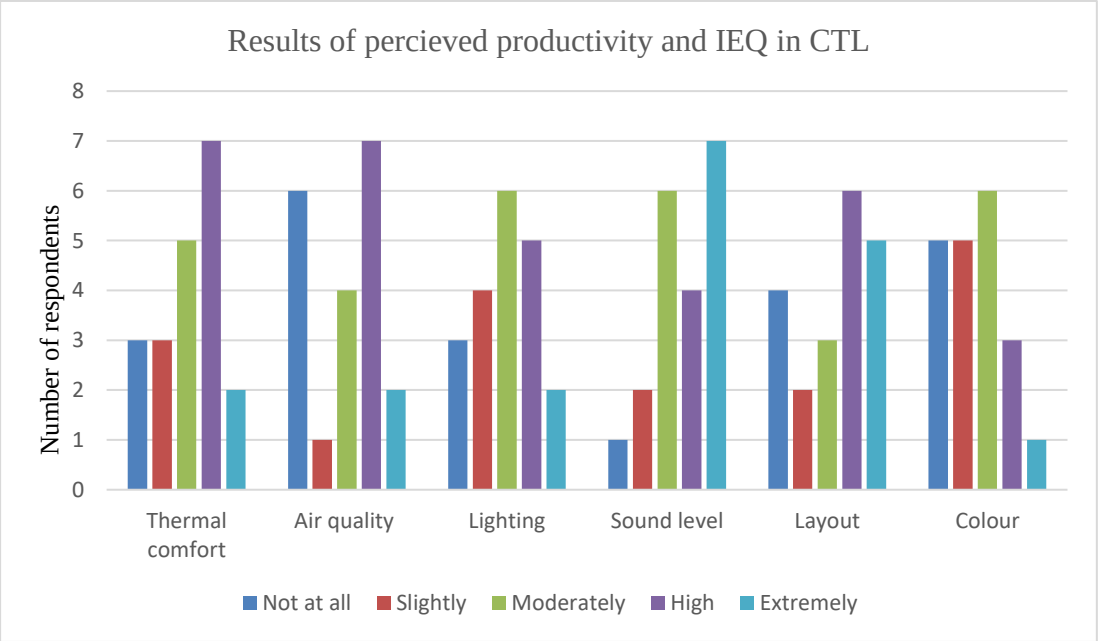

Figure 4-43 Results of the respondents' perceptions of own productivity for CTL (Rashid 2015).

4.3.2.2.5 Relationships of Productivity with Satisfaction, Mood and Motivation

The Spearman correlation coefficient has been used to determine whether an occupant's satisfaction, motivation and mood in regard to each IEQ factor has a relationship with perceived productivity (p-value *< 0.05 and **< 0.01)[3]. The results showed a predominantly negative relationship between the impact of each IEQ factor on their perceived productivity and their degree of satisfaction with sound level and workplace layout, as can be seen in Table 4-14. That means that when satisfaction is high or extremely high with sound level and workplace layout, the impact of these factors on productivity is very small (i.e., 'not at all' or 'slightly'). The correlation coefficients between satisfaction and perceived productivity, in relation to sound is -0.503; and in relation to layout is -0.535. The correlations with lighting, air quality, thermal comfort and colour showed no significant relationships with perceived productivity (p-value < 0.05) (Table 4-14).

Table 4-14 The correlation between productivity and satisfaction in CTL for the current study

Building				How would you rate the impact of the following indoor environment? Quality factors on your productivity at work?					
				Lighting	Sound	Air	Thermal	Layout	Colour
CTL	Spearman's rho	Satisfaction - Lighting	Correlation coefficient Sig. (2-tailed)	0.049 0.837					
		Satisfaction - Sound level	Correlation coefficient Sig. (2-tailed)		-0.503* 0.024				
		Satisfaction - Air quality	Correlation coefficient Sig. (2-tailed)			-0.346 0.135			
		Satisfaction - Thermal comfort	Correlation coefficient Sig. (2-tailed)				-0.143 0.549		
		Satisfaction - Office layout	Correlation coefficient Sig. (2-tailed)					-0.535* 0.015	
		Satisfaction - Colour	Correlation coefficient Sig. (2-tailed)						0.032 0.894

* Correlation is significant at the 0.05 level (2-tailed).

[3] Correlation is significant at the 0.05 level (2-tailed).
** Correlation is significant at the 0.05 level (2-tailed).

The results demonstrated that there is a significant positive relationship between mood and productivity in relation to sound level, air quality and office layout. Higher levels of mood associated with the sound level, air quality and office layout are related to higher levels of productivity, as can be seen in Table 4-15. The Spearman correlation coefficients for air quality, sound level, and layout (0.641, 0.608 and 0.493 respectively). However, the correlation of colour, lighting and thermal comfort showed no significant relationships with perceived productivity (p-value < 0.05)

Table 4-15 The correlation between productivity and mood in CTL workplaces for the current study

Building				How would you rate the impact of the following indoor environment? quality factors on your productivity at work?					
				Lighting	Sound	Air	Thermal	Layout	Colour
CTL	Spearman's rho	Mood - Lighting	Correlation coefficient Sig. (2-tailed)	0.301 0.197					
		Mood - Sound level	Correlation coefficient Sig. (2-tailed)		0.608** 0.004				
		Mood - Air quality	Correlation coefficient Sig. (2-tailed)			0.641** 0.002			
		Mood - Thermal comfort	Correlation coefficient Sig. (2-tailed)				0.441 0.051		
		Mood - Office layout	Correlation coefficient Sig. (2-tailed)					0.493* 0.027	
		Mood - Colour	Correlation coefficient Sig. (2-tailed)						0.007 0.978

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.05 level (2-tailed).

Table 4.16 shows that there are significant positive relationships between motivation and productivity in relation to lighting, sound, air quality and colour. Higher levels of motivation associated with lighting, sound, air quality and colour are related to higher levels of productivity. The correlation coefficients of colour, air quality, lighting, and sound were, respectively, 0.718, 0.661, 0.661 and 0.603. While, in relation to thermal comfort and layout, showed no significant relationship with productivity (0.378 and 0.377, respectively)

Table 4-16 The correlation between productivity and motivation in CTL workplaces for the current study

Building				How would you rate the impact of the following indoor environment? quality factors on your productivity at work?					
				Lighting	Sound	Air	Thermal	Layout	Colour
CTL		Motivation - Lighting	Correlation coefficient Sig. (2-tailed)	0.661** 0.002					
		Motivation - Sound level	Correlation coefficient Sig. (2-tailed)		0.603** 0.005				
		Motivation - Air quality	Correlation coefficient Sig. (2-tailed)			0.661** 0.002			
		Motivation - Thermal comfort	Correlation coefficient Sig. (2-tailed)				0.378 0.100		
		Motivation - Office layout	Correlation coefficient Sig. (2-tailed)					0.377 0.101	
		Motivation - Colour	Correlation coefficient Sig. (2-tailed)						0.718** 0.000

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.05 level (2-tailed).

4.3.2.3 The Impact of Demographic Variables for CTL workplace

To investigate the relationships between demographic information (age and gender) and satisfaction, mood and motivation a Pearson chi-squared test χ^2 (Plackett 1983) was used. After that, Fisher's exact test (Mehta and Patel 1983) has been adopted as an alternative to the previous test due to the small cell sizes in years of expertise as an academic (cells are less than 5) (Mehta and Patel 1983).

Age

In this study, age had no significant impact on satisfaction for any of the IEQ factors in the selected workplaces. Similarly, it was concluded that age groups (under 50 years, 50 years old and over 50 years) had no significant effect on mood and motivation for each of the six IEQ factors (Appendix 6).

Gender

Gender (male and female) had no significant impact on satisfaction for any of the IEQ factors in the selected workplaces. Similarly, gender and its impact on mood for each of the six IEQ factors returned no significant relationship (Appendix 7). However, females reported a greater impact on their motivation to perform tasks for colour in their environments than males

($\chi^2[4] = 10.71$, $p = 0.030$).

Years of Experience Working as an Academic

Fisher's exact test results showed no significant impact on satisfaction, mood and motivation for any of the IEQ factors in the selected workplaces in relation to years of working as an academic (< 1 year, 1–3 years, > 3 years) (Appendix 8).

4.3.2.4 Summary of Quantitative Results for CTL

The results of the questionnaire in the CTL case study show that the IEQ in this open-plan workplace had a significant impact on feelings of satisfaction and perceived productivity, but no significant association with mood and motivation. The results indicate that sound and layout were the most common factors with a negative impact among the six IEQ. The open-plan layout and sound level had a strong negative impact on participants' satisfaction and perceived productivity. Furthermore, quantitative analysis identified that the main reasons given for dissatisfaction with the layout were the lack of privacy, the need to consider other workers when interacting with co-workers in the workplace, and the lack of available storage for each workstation. For sound level, the reasons given were noise from other staff conversations and lack of acoustic privacy, especially when they needed to make confidential phone calls. It can be concluded that the IEQ elements that negatively affect the feeling of satisfaction can be the same as the elements that negatively affect productivity. This could indicate that academics focusing on administrative work requires a higher level of sound reduction and a supportive layout to be satisfied and more productive.

The participants were ether highly or extremely satisfied with the colour, light, air-quality and temperature, which rated 50% and over, despite that CTL is located in basement area with lack of natural daylight and area 3 was under-lit according to Australian standards. This may be because the type of work activities the participants do in the workplace do not require a high level of concentration like research work does. However, light had the most

impact on motivation to complete tasks compared to other IEQ elements. In general, the academics rated their productivity as highly or extremely productive when asked to rate their perceptions of productivity in open-plan workplaces. This suggests that, with the negative impact of open-plan layout and high sound level, the academics make a greater effort to adjust to their work environment so that they can complete their work in any circumstances. However, that may have a bad effect on workers' general health and desire to complete their job. The Spearman's rank correlation coefficient showed a strong relationship between satisfaction with sound and layout and perceived productivity. Mood and motivation had a strong correlation with IEQ factors: air quality, sound level and layout for mood and colour, air quality, lighting and sound level for motivation and perceived productivity. Demographics information stated that age groups, gender and years of experience working as an academic had no significant impact on satisfaction and mood for any of the IEQ factors However, females reported a greater impact on their motivation to perform tasks for colour than males

4.3.3 Research Results and Analysis — Qualitative Data (Semi-Structured Interviews)

Similar to the case study one, a semi- structured interview data were analysed and six themes obtained from thematically analysis process. The six themes are: Distraction, Suitability of the workplace, Control over environment, Feelings, Privacy, and Communication.

Distraction in the CTL workplace

Half (50%; 10/20) of the CTL participants believed that distraction was a big disadvantage of their open-plan workplace. Staff conversations and movement around the office creates a continuously distracting environment. As a result, the participants believe that individual offices would be less distracting and more productive. For example:

> *Oh, the most effect is the noise. So I think that's the biggest thing that affects my work and my mood. It's the sound. (CT19)*

> *I think it's distractions from noise and movement, people walking and up and down — in terms of noise. Sometimes, other people are having a telephone conversation— very distracting. (CT6)*

However, 25% (5/20) of participants found that the temperature inside their workplace was the main reason for distraction. The staff indicated that the temperature in summer is usually low, while in winter it is too high, and that has a negative impact on their concentration, causing distraction and eventually creating an uncomfortable environment.

> *... it's extremely cold or too hot. So what happens is, in summer, it's way too cold and we have to wear winter clothes and then the opposite happens in winter — it gets overheated; that distract[s] my thinking. (CT14)*

In contrast, about 25% (5/20) of the participants believed that their open-plan workplace provided a productive and distraction-free environment. They mentioned that the presence of small meeting rooms in their workplace controls the noise and facilitates their work. For example:

> *Not that much. We try to keep our noise very low and this room [small meeting room] is very helpful. (CT3)*

Suitability of the CTL workplace

Most of the CTL participants (70%; 14/20) thought that their open-plan workplace was suitable for routine business functions but not for academic purposes; they stated that academic work needs a private, secure and quiet office. Therefore, the open-plan workplace reduced their productivity. For example:

> *I don't think it does. I think this sort of office is very good for business-as-usual type work, for where people have got very routine administrative functions and that sort of stuff. (CT12)*

However, 33% (6/20) had a contrary point of view. They believed that the open-plan workplace was suitable for academic work because they could manage to switch off the outside noise and do their work. Also, the meeting rooms and the coffee room were more suitable for providing a level of privacy to complete deep reading, online calls and phone calls. Two participants explained their work practices:

> *It is suitable. If I need to make a work phone call, I can make a phone call and not everybody hears the conversation here [in the small meeting room]. (CT7)*

I do my Skypes from there. I do my webinars. I just put the headphones on. I probably drive other people mad but no one's ever said anything. (CT19)

Control in the CTL workplace

In the CTL workplace, 30% (6/20) of the participants mentioned that control over their physical environment would empower the staff to be more productive and encourage them to do their tasks. The participants found it was hard to take control of their workplace because it is a big working environment and accommodates a large number of occupants, so it is hard to understand every one's needs. Also, they stated that an uncontrollable physical environment can affect eye and general health in a bad way. For example:

In [an] individual office I can close the door and work to my — if I want to put some music on, I can do that. I can work away to my liking, satisfaction. Open plan — I have to put earphones on to cover up the noise if I want to play music. Then no one can talk to me because I'm covered with earphones. So I guess, for me, the productivity thing means I'm in control of the environment when I'm in a private office. In this case I'm not in control of the environment — less control anyway." (CT12)

I find, as I'm getting older, that my eyesight is struggling, so I need to control the light to… not affect me more — too much glare on my desk. (CT13)

Feelings in the CTL workplace

The results showed that 45% (9/20) of the CTL employees felt annoyed and discouraged in their open-plan workplace because the layout does not support their work as academic staff. In particular, the participants noted that the constant level of noise and lack of privacy can change the occupant's mood to annoyance and unhappiness with the work environment. In addition, one participant found it very annoying to have to book and move to an individual meeting room for quiet and private work:

… would be feeling annoyed when I can't find somewhere to have a private conversation with somebody who needs to talk to me. That's when I might be a bit annoyed about it but never really any more than that… Then I need to very quickly find a room that's available with a phone so that I can ring them back and have that conversation in privacy. That's something that's quite annoying when you have to do

that, especially if you then have to hunt quite awhile before you can find a room. I remember there was one time when I had that problem when I ended up ringing them back on my mobile phone from the garden outside rather than using one of our phones because I couldn't find one because they were all busy. (CT18)

On the contrary, 25% (5/20) of the academic staff felt happy and comfortable with their work environment. They believed that colour and being close to each other can enhance their mood. For example:

I am very happy that I've got a team in my immediate surroundings that work really well with me and they're very respectful of me and my time and space. (CT12)

Yeah, I think it's mostly comfortable. I like it. It's nice. I don't have that many problems. (CT13)

A minority of the participants (13%; 3/20) stated that the mood can go both ways, positively and negatively, depending upon the people you work with and the level of distraction. One explained it this way:

I guess that depends on who you're working with. So if you're working around people that — when they interrupt you it's light and interesting and that sort of thing but it's not terribly disruptive — that's fine. But if it's negative and draining and that sort of interruption, then that can have an impact on your work effectiveness in the environment. (CT2)

Privacy in the CTL workplace

The majority of CTL academic staff (85%; 17/20) demonstrated the importance of privacy in enhancing their productivity. The open-plan workplace did not support their activities due to the lack of privacy, creating an unproductive and uncomfortable environment. In the CTL workplace, lots of the work requires making phone calls, usually about sensitive issues related to other staff members or students. This kind of work needs to be secure and private. For example:

Because that's what I used to have, privacy. Lack of privacy causes me to be uncomfortable. (CT20)

If I need to make a work phone call, I can make a phone call and not everybody hears what the conversation is. Now, I find if I have to make a phone call I usually have to do it on my mobile. So I delay it because I have to go outside. Sometimes I may miss the call for a day or two because, if I phone another staff member, everybody can hear the conversation. (CT12)

Communication in the CTL workplace

Many (60%; 12/20) of the academic staff in CTL stated that communication is a big advantage in an open-plan workplace. They found that the tearoom facilitated interaction and communication in regard to their academic work and social life. For example:

It's good in the sense that we can interact with each other. We can see each other. We can access each other. There's no restriction. So, kind of easy access to everybody. (CT4)

However, 40% (8/20) stated that the open-plan design does not support communication. The staff have to be quiet for the consideration of others in the same workplace. One person explained:

Interaction is quite minimal and restricted because you can't speak loudly. It will interfere with other people around you, so we don't really achieve the benefits of sitting closely to each other. (CT11)

4.3.3.1 Summary of Qualitative Results for CTL

The results from the interview highlight issues that affect participants' experience in the open-plan workplace. The CTL participants believed that distraction was a big disadvantage of their open-plan workplace. They identified that sound from staff conversation and movement around the office creates a continuous distraction in their environment. Some of the participants found that temperature inside their work environment in summer is usually low, while in winter it is too high, and that leads to a negative impact on their concentration, causing distraction and eventually creating an uncomfortable environment. This is due to human differences and preferences for room temperature, as well as their proximity to the air-conditioning outlets. The open plan office was a source of annoyance and unhappiness, and the participants felt discouraged because the layout in their open-plan workplace does not support the diversity of their academic role. In particular, the participants noted that the

constant level of noise and lack of privacy can change the occupant's mood so that they become annoyed and unhappy with the work environment. Similarly, the majority noted the importance of privacy in enhancing their productivity, as they conducted a lot of work that need to be secure and private, such as, making sensitive phone calls related to other staff members or students.

Some the participants believed that control over their physical environment would empower them to be more productive and encourage a feeling of ownership. They commented that an uncontrollable physical environment can affect general health in a bad way. Many of the academic staff stated that their workplace enhanced communication. They found that the common room (tearoom) facilitated interaction and communication regarding their academic work and social life. However, it was hard to communicate from the workstations, as the staff have to be quiet for the consideration of others in the same workplace. Most of the participants thought that their open-plan workplace was suitable for routine business functions and teamwork but not for confidential work.

4.3.4 Conclusion and Discussion for CTL Workplace

The quantitative results were consistent with qualitative results in regard to feelings of satisfaction and perceived productivity. Workplace layout and sound level were identified by the quantitative results as the most influential factors on feelings of satisfaction and perceived productivity. The qualitative results were consistent with the quantitative results regarding the sound level, particularly from colleagues' conversations and movement, and lack of privacy was a major source of distraction, annoyances, and discomfort. This problem is exacerbated by the large number of employees: about 63 staff members and different type of employees classified as academic, general, and administration staff that occupied the same workplace. This finding aligns with previous studies (Kaarlela-Tuomaala et al. 2009; Lamb and Kwok 2016). According to several field studies, colleagues' conversation is the greatest source of annoyance in open-plan offices (Pierrette et al. 2015; Hongisto et al. 2016).

The participants in CTL believed that their workplace does not support the diversity of academic work requirements, such as visual and sound privacy. The majority of participants noted the importance of privacy in enhancing their productivity, as a large part of the job requires the use of computers for general administrative work, collaborative work, meeting attendance, research and reading, confidential phone calls; moreover, some

academics are work-loaded to teach and/or supervise Higher Degree by Research students. This kind of job needs to be secure, private and flexible. Baldry and Barnes (2012) stated that office layouts are constantly being redesigned based on occupants' needs, to improve effectiveness and to support work activities. Moreover, the participants believed that individual offices would be more comfortable and productive than the open-plan workplace, as it is very difficult to concentrate when they need to do writing and solitary work. The lack of control over the environment and lack of privacy in the open-plan office had a major impact on their ability to function cognitively and emotionally. This finding aligns with a previous study by Samani et al. (2015), who concluded that lack of personal control over the work environment that an open-plan office creates can negatively affect employees' satisfaction.

The quantitative results indicated that the majority rated their productivity in the open-plan workplace as a high and extremely high. The qualitative finding attributed that open-plan layout and workstation design (semi-enclosed workstations) support teamwork and facilitate communication. They described that some of their time is spent on communication and working in team groups. This suggests that, while individual offices represented the academic identity for many years, now, it does not suit the new way of working, which calls for more cooperation and teamwork. However, the open-plan workplace has real problems such as lack of privacy and constant noise, especially when the office is large and includes many employees like the CTL workplace. Therefore, the academic office needs to achieve a balance by finding design solutions commensurate with the diverse academic work activities. The correlation coefficients between satisfaction mood and motivation, and productivity show significant relation in terms of IEQ factors, such as sound and layout were common factors between these correlations. Previous studies indicated same relation (Vischer and Wifi 2017; Samani et al. 2018; Küller, Mikellides, and Janssens 2009)

The quantitative results suggest that the six IEQ elements did not show a significant relationship with motivation and mood in CTL. However, the literature review indicated specific IEQs within an open-plan workplace such as colour, light and temperature have significant effects on worker mood (Pejtersen et al. 2006, Cuttle 2013) and motivation (Lan et al. 2010). A possible reason for this conflict with previous literature is that these previous studies were conducted in an experimental (simulated) lab while, in an actual work environment, there are so many contributing factors affecting perceived mood that the

effect of specific IEQs alone is difficult to identify (Bakker et al. 2013). Figure 4-44 shows the main findings for CTL workplace.

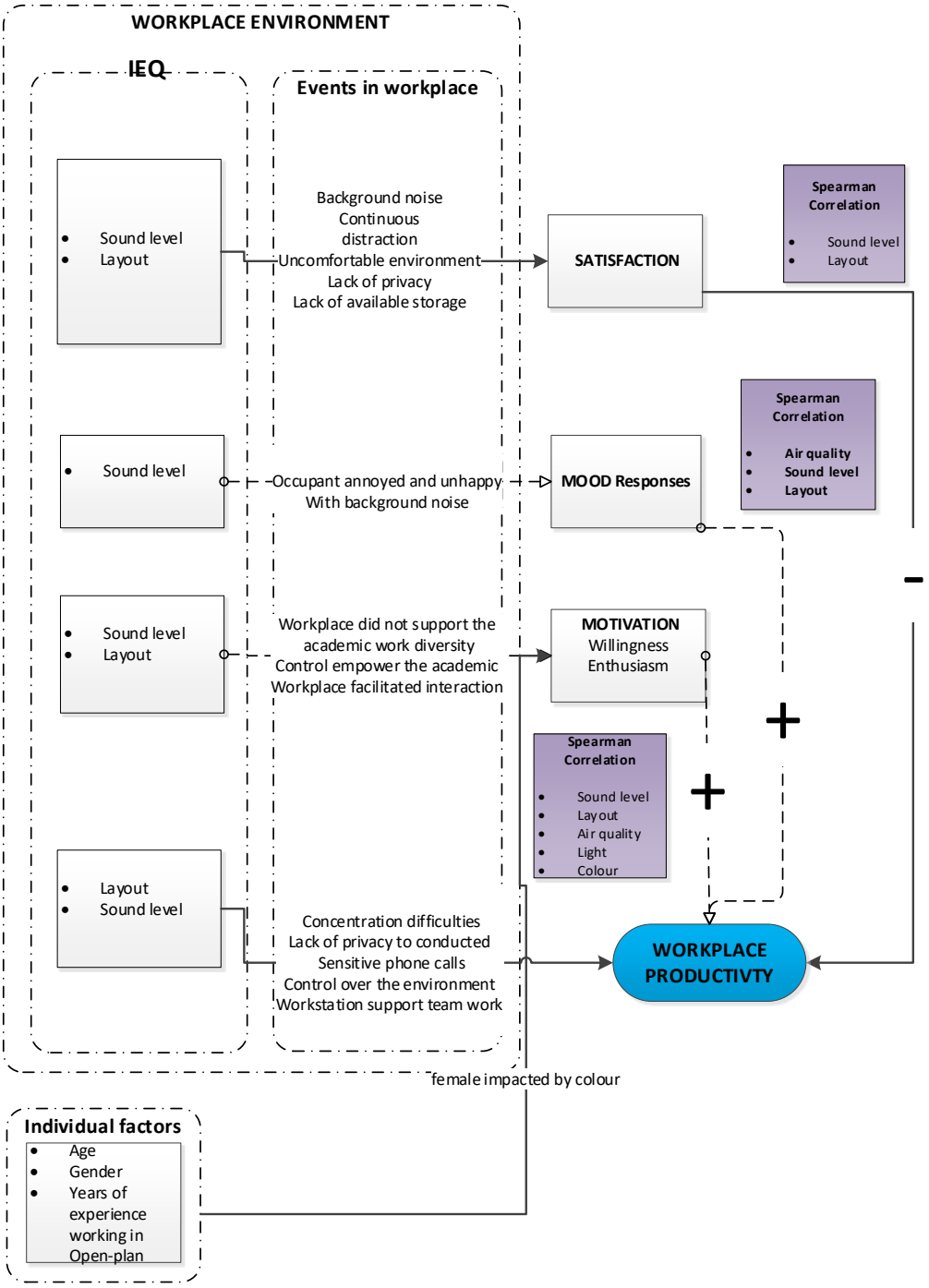

Figure 4-44 Outcomes of CTL workplace (Rashid 2018).

4.4 Case Study Three: Central Institute of Technology (CIT)

4.4.1 Overview

The Central Institute of Technology (CIT) building is part of North Metropolitan TAFE in Perth, Western Australia. The building is the newest building on the Perth campus. Construction of this building began in 2009, with occupancy in early 2011. The open-plan workplace is located on the third floor of the building at 2 Aberdeen Street, Perth, WA. The workplace is occupied by different disciplines: engineering, building and architecture, design, beauty therapy and massage. The open-plan office is occupied by 67 staff, 60 academics, and seven general and reception staff.

4.4.1.1 Participants

The total number of academics in CIT is 60, but only 34 academic staff participated in this study. Table 4-17 provides a summary of the occupants' demographics.

Table 4-17 Demographics of the CIT workplace participants (Rashid 2015).

Age group	Male	Female	Total
>50 years	12	8	20
31-50 years	11	2	13
<30 years	1		1
Total	24	10	34

4.4.1.2 Academic Activities in the Workplace

The CIT employees concentrate on teaching, material preparation, use of computers for e-mail messages, phone conversations, administrative work, and meeting attendance. The academic staff members are often required to leave the office for teaching and meetings. The office is occupied by academic staff and support staff at permanent desks. The academic staff normally are required to attend five days a week for eight working hours each day. The researcher's observations recorded that attendance was approximately 85%. The CIT staff

spent most of their time teaching and working in their open-plan workplace. Figure 4-45, below, illustrates a statistical analysis of the number of academics conducting different types of work.

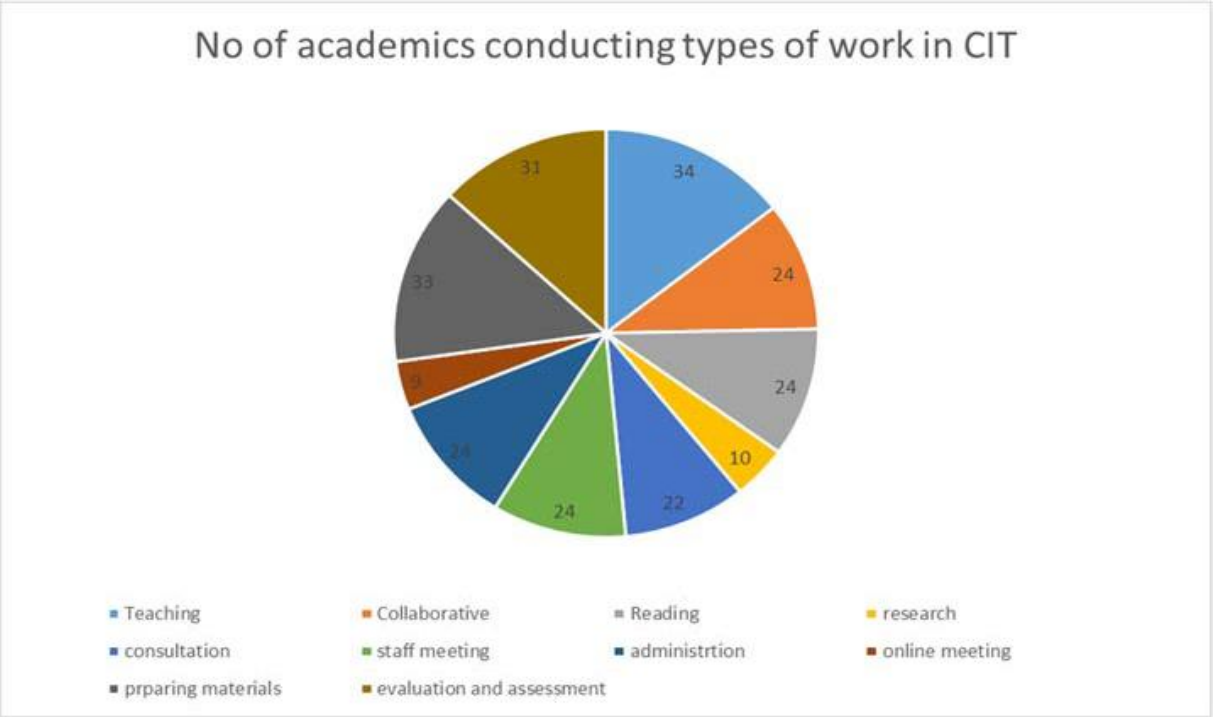

Figure 4-45 Number of academics conducting different types of work (Rashid 2015).

4.4.1.3 Open-plan Workplace Layout

Figure 4-46 shows the floor plan of the workplace layout. The CIT workplace occupies most of the third floor of building 2. The building has one main entrance with a glazed door to reach the workplace through the reception area. The building has an open-plan office layout with two separate meeting rooms, each equipped to accommodate a maximum of eight people, and supplied with a white board (Figure 4-47). These pre-booked rooms are used moderately to hold meetings with colleagues but, in general, the staff prefer to do all their work, even making phone calls, at their own workstations and, as a result, there is a high level of noise in the office. The workplace has one large meetingng room to accommodate at least 16 people and is used occasionally (Figure 4-48).

Figure 4-46 Floor plan for CIT workplace

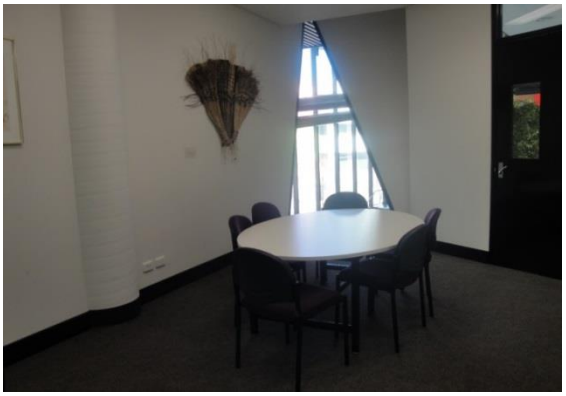

Figure 4-47 Meeting room that accommodates six (Rashid 2015).

Figure 4-48 Large meeting room (Rashid 2015).

The four workplace managers occupy individual offices, each of which overlooks the workplace through a glazed door to enable the managers to watch the workflow (Figure 4-49).

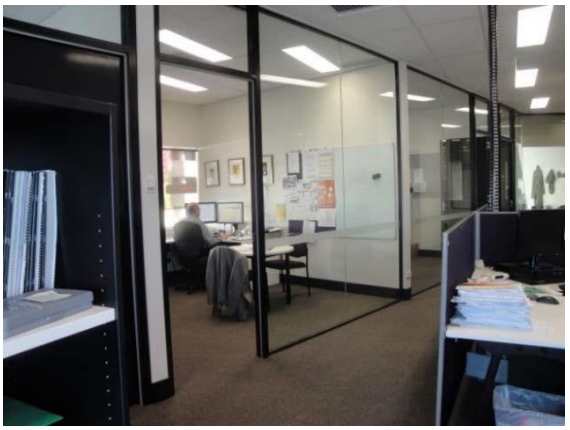

Figure 4-49 Individual offices for managers (Rashid 2015).

The north side of the workplace overlooks a common room, isolated from the place of work by a glass wall. This area includes cabinets, a fridge, a sink and dining tables. The common room is not specifically just for lunch breaks. Some other activities can be undertaken there, such as holding meetings related to work, which is due to overcrowding. (Figure 4-50).

The workplace has five storage rooms. The walls of the workplace are painted white, except for some parts that are painted light orange. Dark grey carpet covers the floor, and the ceiling is formed by white ceiling tiles (Figure 4-51).

Figure 4-50 Common room (Rashid 2015).

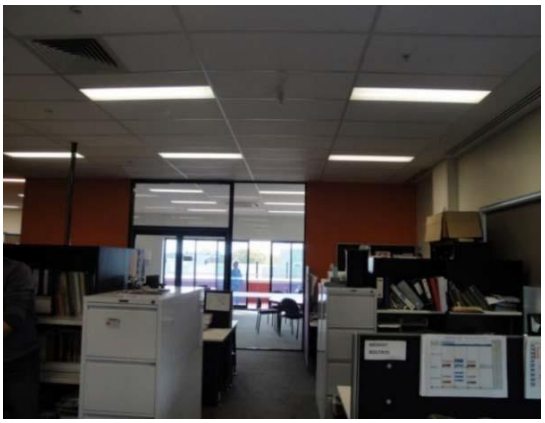

Figure 4-51 Orange wall on the north side of the workplace (Rashid 2015).

4.4.1.4 Workstation layout

The office has a total of 60 sets of workstations and chairs. There are two types of workstations: full-time staff are allocated permanent 'L-shaped' stations (Figure 4-52), while part-time staff share an allocation of approximately eight rectangular 'hot' desks. Each station has a shelf, a drawer, a computer and a phone. It was observed that, even though the area appeared to provide substantial storage space, most of the workstation surfaces were filled with papers and books.

In front of each workstation, 135cm height dark purple partition. This provides little privacy whereas letting daylight through. Behind each workstation are 180 cm high bookshelves and white drawers. The staff are free to personalise their workstations.

Figure 4-52 Workstation designed in an 'L-shape (Rashid 2015).

4.4.1.5 Lighting/windows

The CIT open-plan workplace is illuminated by warm fluorescent tubes, distributed as general lighting in the ceiling. There is no local light in the workstations. The open- plan design includes a wall of windows on the north and east sides. These windows allow plenty of natural lighting into the office space, and window blinds have been installed to block the sun during the day (Figures 4-53).

Figure 4-53 Uniform lighting distribution (Rashid 2015).

4.4.1.6 HVAC system

For its ventilation and air conditioning, the office has a centrally controlled A/C system for the entire workplace. The ventilation diffusers are uniformly distributed in the ceiling. The occupants have no control over the temperature

4.4.1.7 Summary of Case Study Three Overview

Table 4-18 summarises the CIT workplace description including occupancy, type of academic activities and environmental characteristics.

Table 4-18 A summary of the three-academic open-plan workplace characteristics (Rashid 2015).

Case Study	Occupancy	Academics' activities performed by CIT	Environment
Case study 3: Central Institute of Technology (CIT) — open-plan workspace including: Engineering, building and architecture design, beauty therapy and massage departments.	Total number for occupancy is 67 staff: 60 are academic staff and 7 are support staff	-Teaching preparations -Evaluation and assessment	- Thermal comfort AC and automatic ventilation system -Air quality: Limited access to fresh air -Lighting: Uniform light distribution and local light -Plenty of daylight access -Layout: Variety of setting designs -Individual workstations, each one surrounded by three partitions, the front partition height being 120cm -Moderate amount of storage shelves. -Carpet

4.4.2 Quantitative Results for CIT

Physical measurement and questionnaire were used in similar way to the previous case studies to collect the data. The analysed data were presented for the CIT case to explore and understand the impact of IEQ on academics' satisfaction, mood motivation, and productivity in open-plan workplace.

4.4.2.1 Indoor Environment Quality Measurements

The measurements of the physical environment of CIT workplace were taken in four identified areas see (Figure 4-54) and the results were presented in this section.

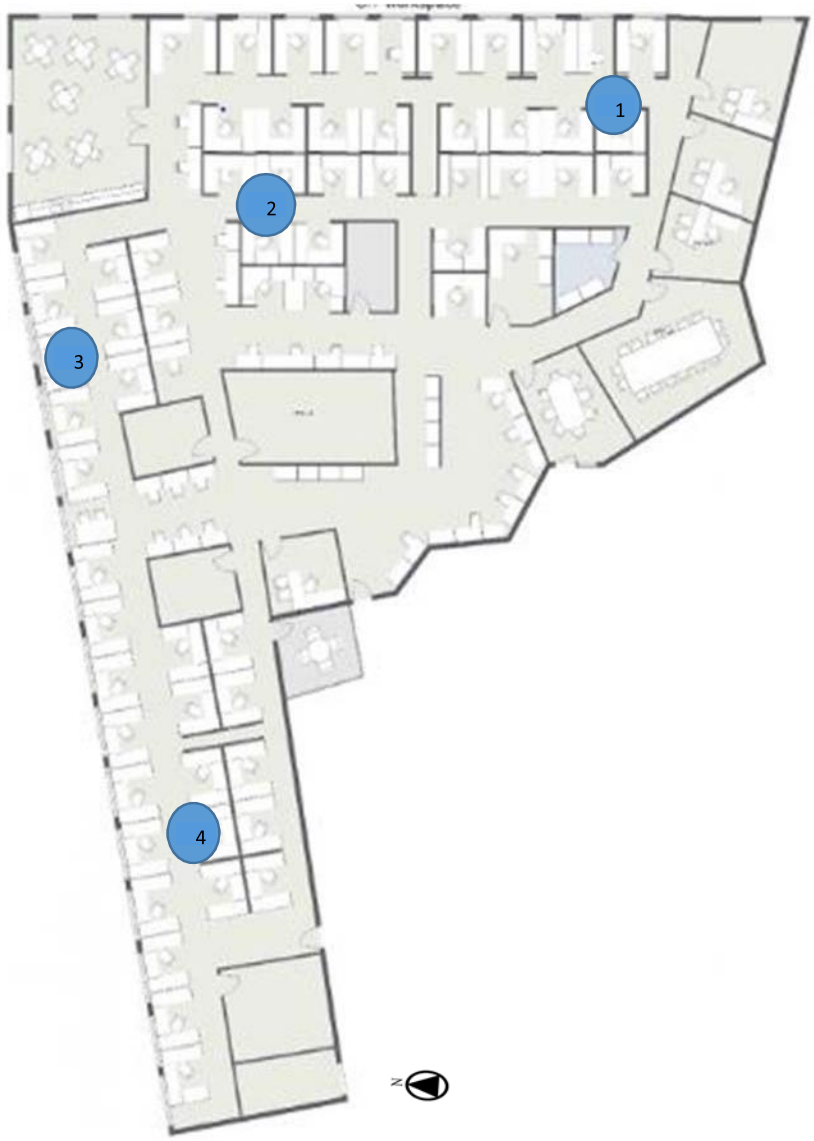

Figure 4-54 Identified spots for physical measurements in CIT (Rashid 2015).

Temperature

The average temperatures in CIT were measured in each of the selected areas. The recommended temperature range for occupant comfort is 20-24ºC (AS/ 1668.2-2012). There were some inconsistencies in temperature across the area except for the afternoon measurements. This fluctuation was just below two degrees. The larger difference in recordings across the CIT workplace was largely due to solar heating, with the late morning sun hitting area 4 resulting in an increased temperature recording. It is worth noting that the

number of occupants was high (67 people) However, in general the temperature readings were compliant with the comfort standards for workplaces. See figure 4-55.

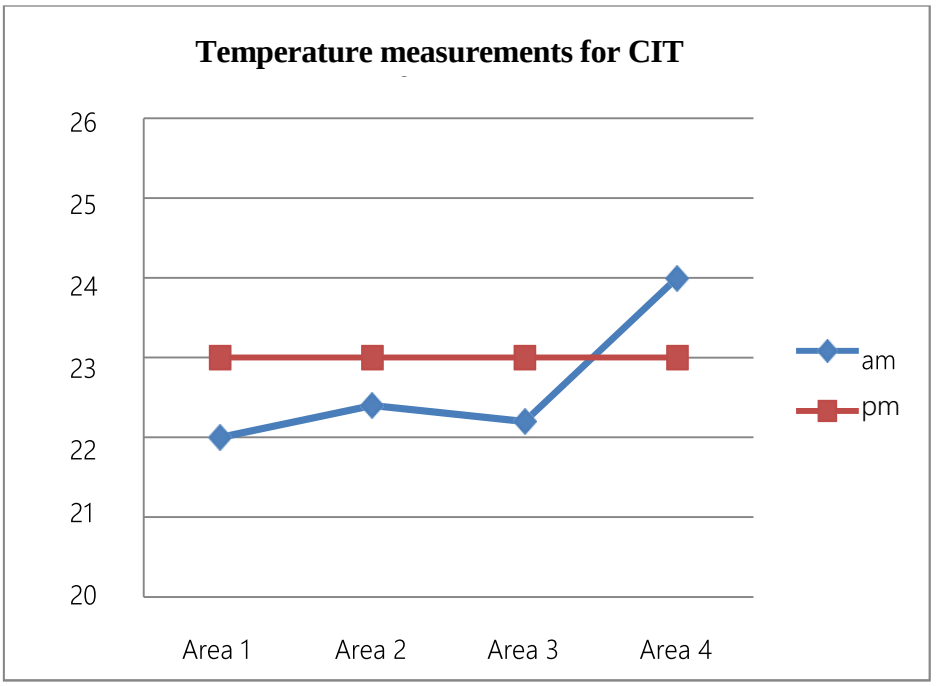

Figure 4-55 Temperature measurements for CIT (Rashid 2015).

Humidity Percentage Fluctuations

The recommended range for relative humidity in the workplace is between 40% and 60% (AS 1668.2-2012 (2016)). The average relative humidity is recorded in Figure 4-56. The readings from the CIT workplace were reasonably consistent across all areas at both a.m. and p.m. readings, except for area 4, which showed a slight drop in both the a.m. and p.m. readings. The relative humidity level in all three workplaces was within the recommended comfort level for workplaces (AS/ 1668.2-2012).

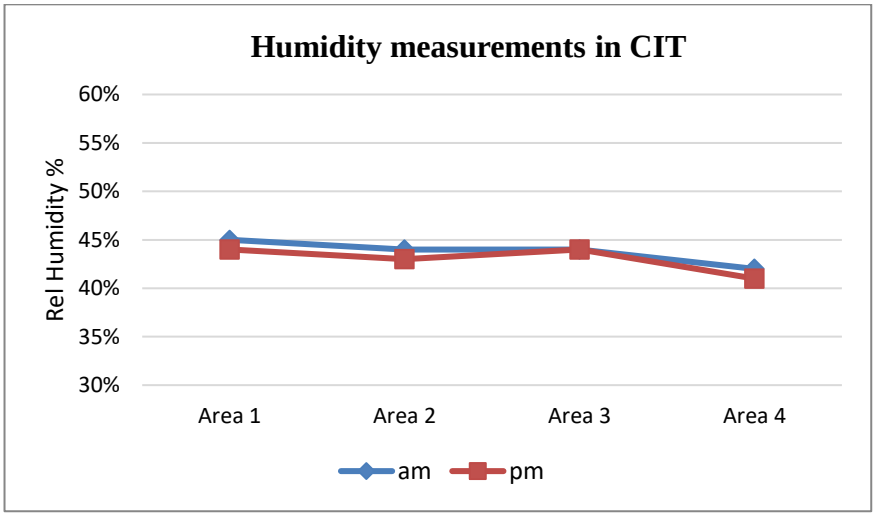

Figure 4-56 Humidity measurements for CIT workplace (Rashid 2015).

CO_2 Concentration

Carbon dioxide (CO_2) concentrations indoors have been associated with perceived air quality and health issues (Seppanen, Fisk and Lei 2005). CO_2 can be affected by many aspects of the indoor environment, including the ventilation rate, indoor pollution from the building, the furniture and equipment, and the number of occupants (Varjo et al. 2015). The CO_2 readings for CIT workplaces showed some inconsistencies between the areas. CIT showed slightly more variance between a.m. and p.m., with the exception of area 3 (Figure 4-57). The measured CO_2 levels were within the acceptable Australian standards for comfort (AS/1668.2 2012).

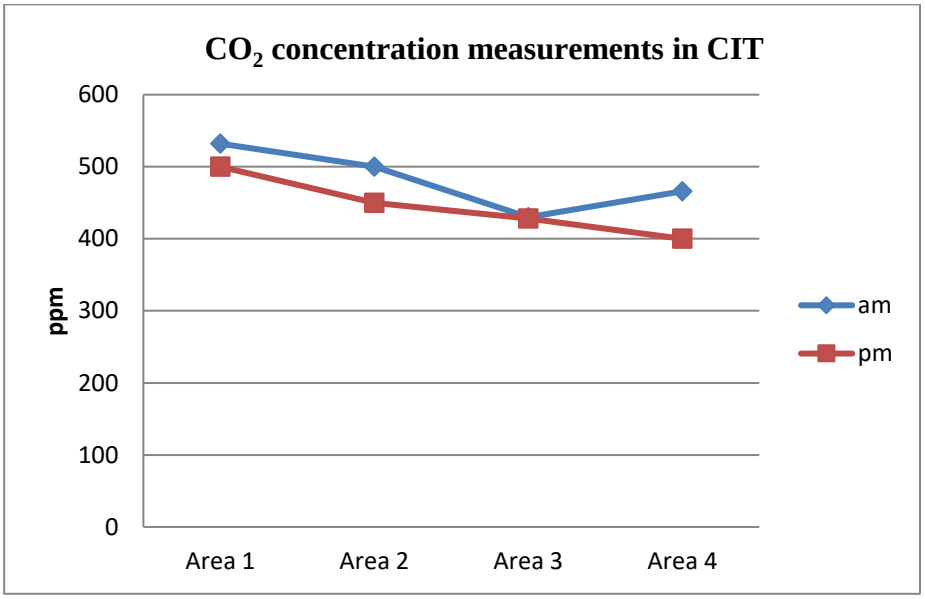

Figure 4-57 CO2 concentration results for CIT workplace (Rashid 2015).

Artificial Light Measurement

Figure 4- 58 showcases the recorded results of measuring lighting illuminance of CIT. The same process that applied in the previous case studies were applied for CIT in terms of lighting measurement. Namely, the horizontal and vertical lighting level for desk-based work was applied in consistence with Australian Standards. In general, the results were relatively high and exceeded the acceptable amount of light illuminance for office work in areas 3 and 4 for both am and pm readings. The reason for this is due to the office have large windows along the north and east side that allow plenty of daylight accesses to the workplace, therefore, the occupants preferred to roll up the blinds during working hours.

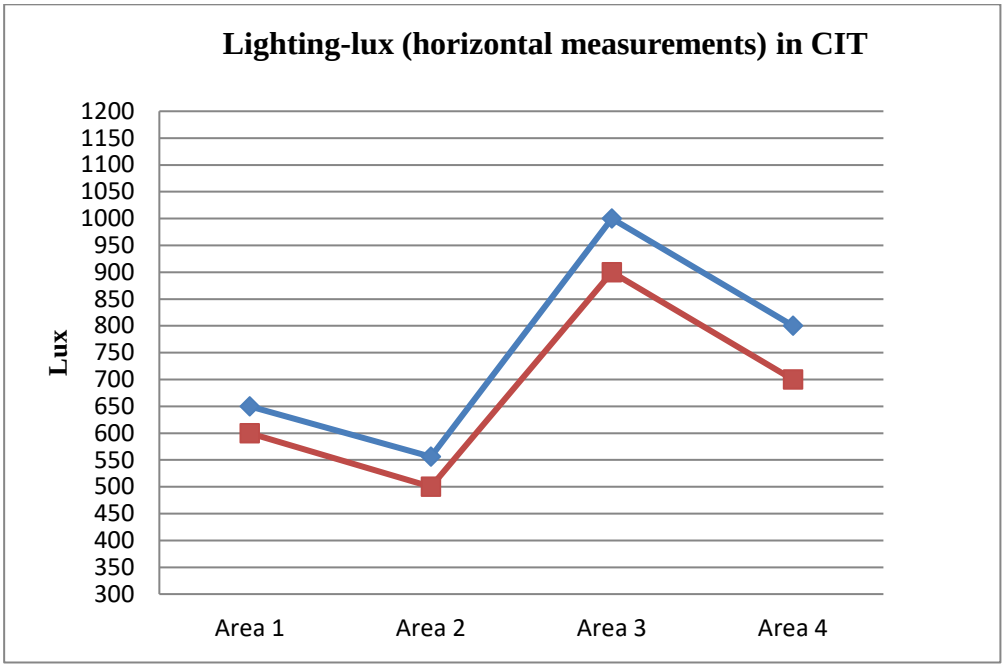

Figure 4-58 Lighting measurements for CIT workplace (Rashid 2015).

Sound Level

The Australian standard for sound level recommends a level in the range of 43-47 Db (AS/NZS 2107:2000). Generally, the measurement of sound level can be difficult to obtain accurately because it is easily altered by somebody speaking or a nearby door closing. The data collection area demonstrated that sound level readings in CIT were not optimal, with sound measurements above the standards for area 1 in both a.m. and p.m. readings. Figure 4-59.

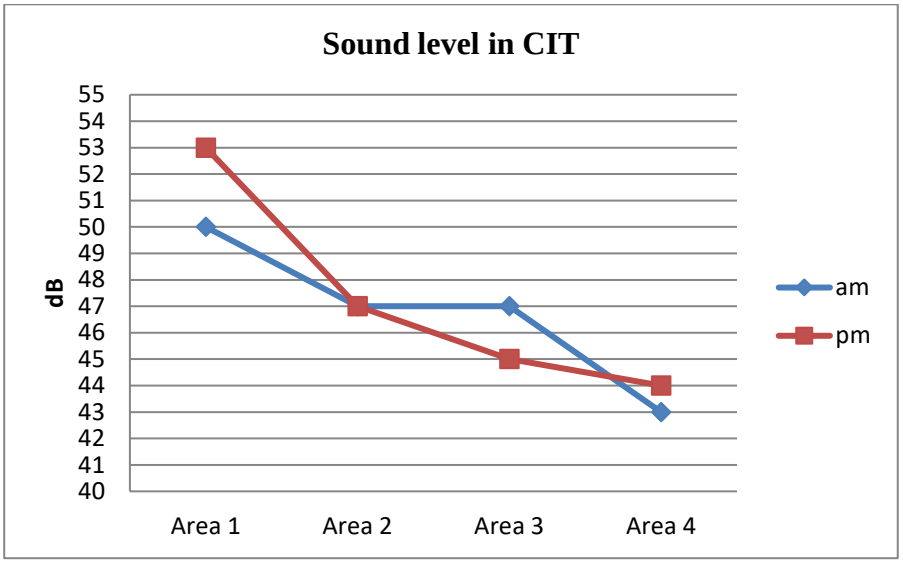

Figure 4-59 Sound level results for CIT workplace (Rashid 2015).

4.4.2.1.1 Summary of Physical Measurements

These readings were taken on a single day in March and July 2015. The timing was selected to align with the teaching semester. The results showed that the indoor environment quality for CIT workplaces was compliant with Australian standards. However, there were exceptions in area 1, which was over the optimum in sound level, and area 3and 4 which were over-lit. The measurement results for the indoor environment showed inconsistencies across the different areas and the different work hours.

4.4.2.2 Statistical Analysis for the Questionnaire

4.4.2.2.1 Indoor Environment Quality and the Impact on Satisfaction

The academic staff in CIT were most satisfied with the lighting of their office spaces, with 64.7% of respondents rating their satisfaction with light as either highly or extremely satisfied, as shows in table 4-19 and figure 4-60. Of note, this workplace has plenty of access to daylight. However, one person (2.9%) was found to be slightly not satisfied with the lighting. When asked to provide comments on what they particularly disliked, light reflection on computer screens was causing discomfort. Staff were also satisfied with the colour in CIT, with a total of 64.7% of the occupants responding as satisfied. Of the 14.7% (5/34) participants who were dissatisfied with the colour, most stated that the colour itself and

colour disharmony in the workplace made them dissatisfied. Sound level and workplace layout were rated as the least satisfactory environmental factors.

The mean score for the sound level was 2.6, with 44% of the respondents rating the sound as not satisfactory. The problems identified included the amount of sound from the other conversations (20/34) and lack of sound privacy (11/34). In addition, three participants found that the presence of different departments in the same workplace created a noisy environment because each department undertook different types of task. This was especially true of the Beauty and Massage departments, who were perceived to have a noisier culture than the engineering, building and architecture, design, and beauty therapy and massage departments that shared the space.

A total of 35.2% rated that they were not at all or slightly satisfied with the layout of the CIT workplace (2.5). Visual privacy (height of partitions), space available for individual work, storage at the workstations (12/34) and noise from interaction with co-workers (9/34) were the main reasons for dissatisfaction with layout. However, 29.3% rated themselves as being highly or extremely satisfied with the layout, and, interestingly, there was no identifiable demographic commonality among these people (i.e., they were from different departments, locations and age groups). However, many other factors (such as personality types) or conditions (such as dyslexia), which could cause people to be unable to concentrate in disruptive environments, were not part of this study (Figure 4-60 and Table 4-19).

Table 4-19 Numbers of respondents and mean score of satisfaction for CIT (Rashid 2015).

IEQ	Not at all	Slightly	Moderately	Highly	Extremely	Mean
Thermal comfort	3 (8.8%)	8 (23.5%)	11 (32.3%)	8 (23.5%)	4 (11.7%)	3.2
Air quality	2 (5.8%)	4 (11.7%)	8 (32.3%)	15 (44.1%)	5 (14.7%)	3.1
Lighting	0	1 (2.9%)	7 (20.5%)	17 (50%)	9 (26.4%)	3.8
Sound level	9 (26.4%)	6 (17.6%)	16 (47.0%)	1 (2.9%)	2 (5.8%)	2.6
Layout	7 (20.5%)	5 (14.7%)	12 (35.2%)	6 (17.6%)	4 (11.7%)	2.5
Colour	2 (5.8%)	3 (8.8%)	7 (20.5%)	17 (50%)	5 (14.7%)	3.8

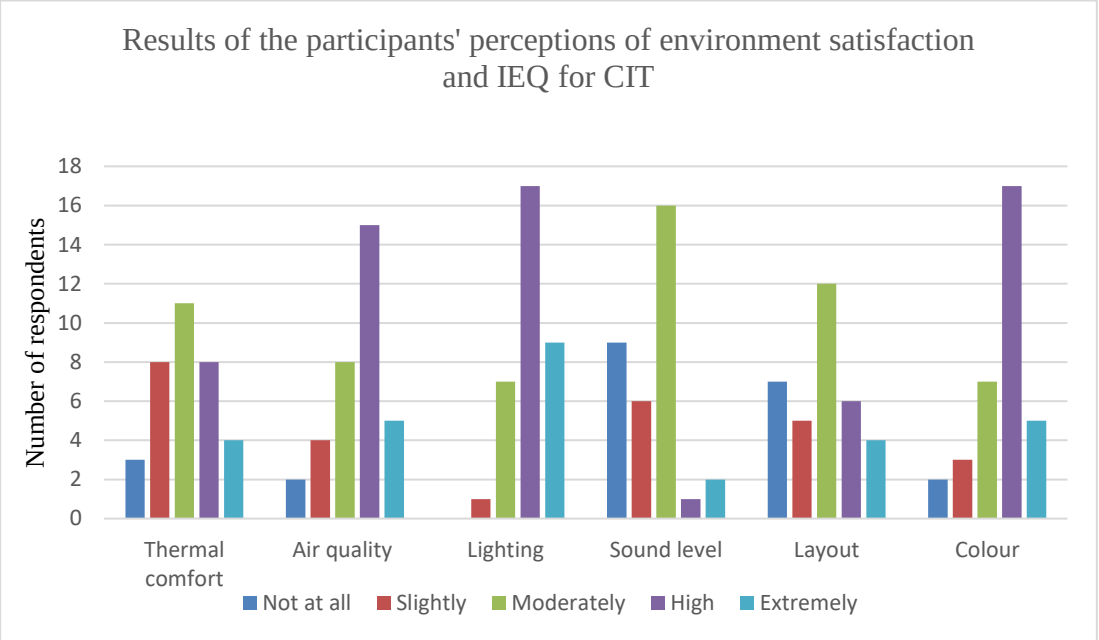

Figure 4-60 Results of the respondents' perceptions of environment satisfaction for CIT (Rashid 2015).

Satisfaction with IEQ results suggest that academics in all three workplaces were significantly dissatisfied with sound level, followed by the layout of the workplace. Academics in all three workplaces agreed on the positive effects of colour and light within their environments.

4.4.2.2.2 Impact of Indoor Environment Quality on Academic Mood

Figure 4-61 displays the results for the mood average ratings in the CIT workplace for each IEQ. The results indicate that the IEQ factors are not strongly associated with the occupant's mood. However, academic staff mood is most associated with the sound level of the workplace, with an average rating of (2.2). Conversely, colour (1.3) followed by lighting (1.4) within the CIT workplace were perceived as being the least associated with mood in the workplace.

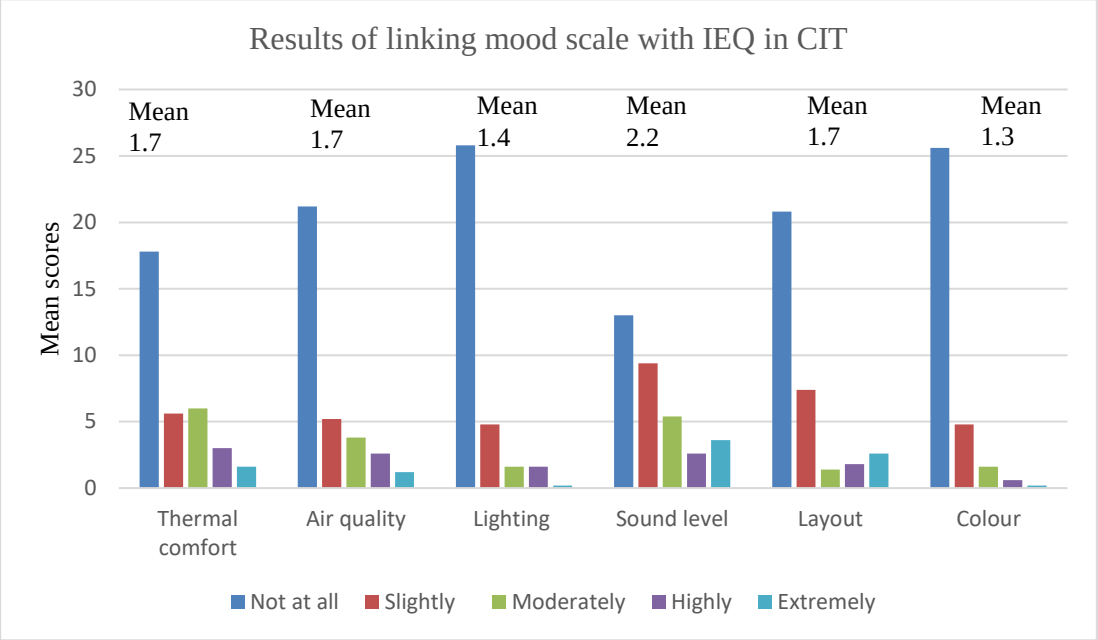

Figure 4-61 Results of the respondents' perception of mood for CIT (Rashid 2015).

4.4.2.2.3 Indoor Environment Quality and the Impact on Staff Motivation

A significant effect of an IEQ on staff motivation was deemed to be for those participants who rated an average of four or above, that is, highly or extremely affected. Conversely, participants whose motivation was not deemed to be affected by an IEQ were those who rated it as two or below, that is, 'not at all' or 'slightly affected'. The results below represent the average of both 'enthusiasm' and 'willingness' for motivation. Figure 4-62 represents the mean ratings for the CIT workplace in terms of each IEQ.

The motivation results showed no significant effect for IEQ on occupants' motivation (willingness and enthusiasm). The motivation of academic staff was most affected by the sound level (2.2) comparing to other IEQ factors. Conversely, colour within the CTL workplace was perceived as being the least influential factor on motivation in the work environment. The mean score for colour was (1.3).

The three workplaces produced different responses for the effect of each IEQ on motivation; however, there was agreement that the colour of the workplace had no negative effect on the academic's motivation to perform tasks.

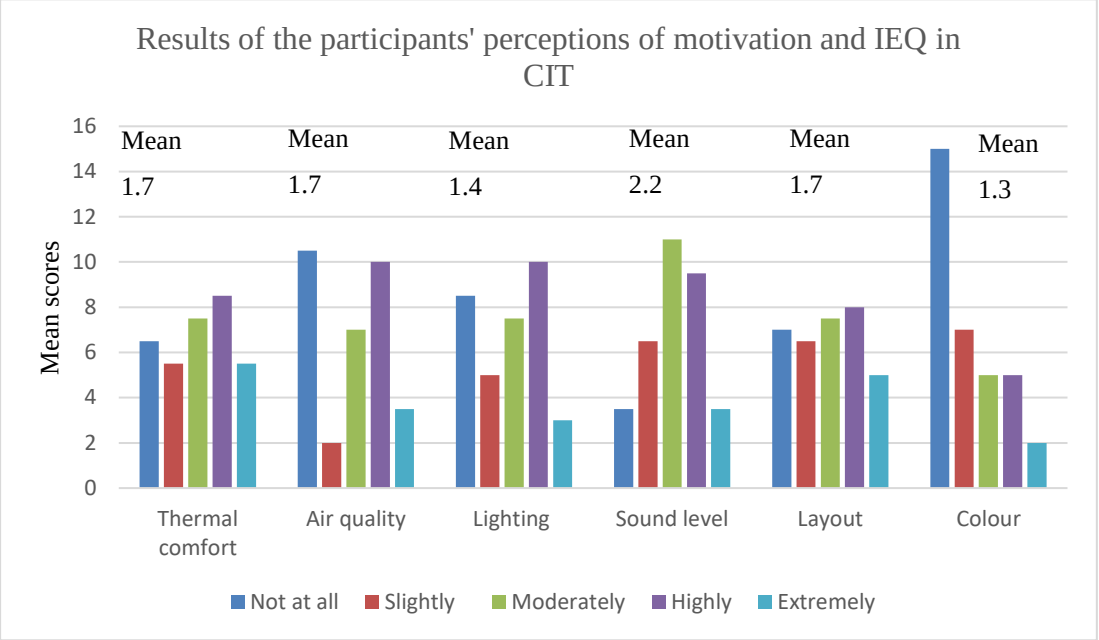

Figure 4-62 Results of the respondents' perceptions of motivation for CIT (Rashid 2015).

4.4.2.2.4 Impact of Indoor Environment Quality on Staff Productivity

The participants were asked to rate their perceptions of their productivity in their open-plan workplaces using a five-point Likert scale, from 'Not at all' (1) through to 'Extremely' (5). A summary of the results is shown in Table 4-20.

Table 4-20 Productivity in CIT open-plan workplace (Rashid 2015).

	Not at all productive	Slightly productive	Moderately productive	Highly productive	Extremely productive
CIT	1 (2.9%)	9 (26.4%)	8 (23.5%)	12 (35.2%)	4 (11%)

Almost half of the respondents in CIT (46.2%) perceived their productivity as highly or extremely productive. Conversely, 29.3% of CIT staff perceived themselves as either not at all or only slightly productive in their open-plan workplace (Figure 4-63).

Productivity in CIT

Figure 4-63 and table 4-21 represent the number of respondent and mean scores for the impact of each IEQ on individual staff productivity in the CIT workplace. The office sound

level was rated by 61.6% of the participants as affecting their productivity, while only 14.6% (five people) rated it as 'not at all or only slightly' affecting their productivity. This result was followed by thermal comfort, layout, air quality and light. On the other hand, more than half of the respondents (58.7%) recorded that colour had no significant effect on their productivity. (Table 4-21).

Table 4-21 Number of respondents and mean score of perceived productivity for CIT (Rashid 2015).

IEQ	Not at all	Slightly	Moderately	Highly	Extremely	Mean
Thermal comfort	5 (14.7%)	5 (14.7%)	8 (23.5%)	7 (20.5%)	9 (26.4%)	3.2
Air quality	8 (23.5%)	3 (8.8%)	7 (20.5%)	13 (38.2%)	3 (8.8%)	3
Lighting	8 (23.5%)	3 (8.8%)	7 (20.5%)	11 (32.3%)	5 (14.7%)	3
Sound level	3 (8.8%)	2 (5.8%)	6 (17.6%)	12 (35.2%)	9 (26.4%)	3.5
Layout	5 (14.7%)	6 (17.6%)	9 (26.4%)	10 (29.4%)	4 (11.7%)	3.2
Colour	14 (41.1%)	6 (17.6%)	7 (20.5%)	7 (20.5%)	0	2.2

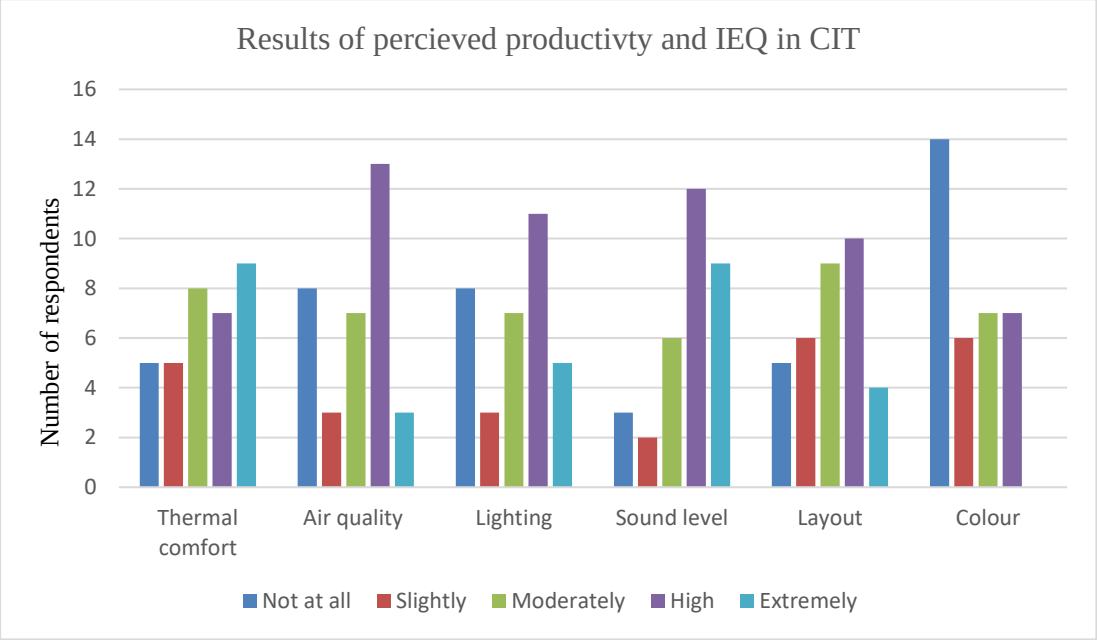

Figure 4-63 Results of the respondents' perceptions of own productivity for CIT (Rashid 2015).

4.4.2.2.5 Relationships of Productivity with Satisfaction, Mood and Motivation

The Spearman correlation coefficient has been used to determine whether an occupant's satisfaction, motivation and mood in regard to each IEQ factor has a relationship with perceived productivity[5] (p-value *< 0.05 and **< 0.01). Table 4.22 shows that there is a significant negative relationship between satisfaction and productivity in relation to lighting, sound, air quality and office layout. In other words, when satisfaction is high or extremely high with a certain IEQ, the effect of that IEQ on productivity is very small (i.e. 'not at all' or 'slightly'). The correlation coefficients result in relation to lighting, sound, air quality and layout were -0.355*, -0.493**, -0.433* and -0.482** respectively.

Table 4-22 The correlation between productivity and satisfaction in CIT workplaces for the current study

Building				How would you rate the impact of the following indoor environment? quality factors on your productivity at work?					
				Lighting	Sound	Air	Thermal	Layout	Colour
CIT	Spearman's rho	Satisfaction - Lighting	Correlation coefficient Sig. (2-tailed)	-0.355* 0.039					
		Satisfaction - Sound level	Correlation coefficient Sig. (2-tailed)		-0.493** 0.003				
		Satisfaction - Air quality	Correlation coefficient Sig. (2-tailed)			-0.433* 0.012			
		Satisfaction - Thermal comfort	Correlation coefficient Sig. (2-tailed)				-0.107 0.545		
		Satisfaction - Office layout	Correlation coefficient Sig. (2-tailed)					-0.482** 0.004	
		Satisfaction - Colour	Correlation coefficient Sig. (2-tailed)						-0.059 0.742

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.05 level (2-tailed).

Table 4-23 shows that there is a significant positive relationship between mood and productivity in relation to sound level, layout, thermal comfort, and air quality. Higher levels of mood associated with sound level, layout, thermal comfort, and air quality are related to higher levels of productivity. The correlation coefficients were, respectively, 0.643, 0.601,

0.492 and 0.469. The results for colour and light showed no significant relationship. Table 4-23.

Table 4-23: The correlation between productivity and mood in CIT workplaces for the current study

Building				How would you rate the impact of the following indoor environment? quality factors on your productivity at work?					
				Lighting	Sound	Air	Thermal	Layout	Colour
CIT	Spearman's rho	Mood - Lighting	Correlation coefficient Sig. (2-tailed) N	0.073 0.682 34					
		Mood - Sound level	Correlation coefficient Sig. (2-tailed)		0.643** 0.000				
		Mood - Air quality	Correlation coefficient Sig. (2-tailed)			0.469** 0.005			
		Mood - Thermal comfort	Correlation coefficient Sig. (2-tailed)				0.492** 0.003		
		Mood - Office layout	Correlation coefficient Sig. (2-tailed)					0.601** 0.000	
		Mood - Colour	Correlation coefficient Sig. (2-tailed)						0.206 0.243

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.05 level (2-tailed).

Table 4.24 shows that there are significant positive relationships between motivation and productivity in relation to colour, air quality, thermal comfort and workplace layout. Higher levels of motivation associated with colour, air quality, thermal comfort and workplace layout are related to higher levels of productivity. The correlation coefficients, respectively, were 0.771, 0.521, 0.517 and 0.409.

Table 4-24 The correlation between productivity and motivation in CIT workplaces for the current study;

Building				How would you rate the impact of the following indoor environment? quality factors on your productivity at work?					
				Lighting	Sound	Air	Thermal	Layout	Colour
CIT		Motivation - Lighting	Correlation coefficient Sig. (2-tailed)	0.235 0.182					

		Motivation - Sound level	Correlation coefficient Sig. (2-tailed)		0.145 0.414				
		Motivation - Air quality	Correlation coefficient Sig. (2-tailed)			0.521** 0.002			
		Motivation - Thermal comfort	Correlation coefficient Sig. (2-tailed)				0.517** 0.002		
		Motivation - Office layout	Correlation coefficient Sig. (2-tailed)					0.409* 0.016	
		Motivation - Colour	Correlation coefficient Sig. (2-tailed)						0.771** 0.000

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.05 level (2-tailed).

4.4.2.3 The Impact of Demographic Variables for cusp workplace

A Pearson chi-squared test χ^2 (Plackett 1983) was adopted to examine the relationships between demographic information (age and gender) and satisfaction, mood and motivation in terms of six IEQs. However, Pearson chi-squared test was unreliable for analysis years of experience working as an academic due to the small cell sizes (cells are less than 5) therefore, Fisher's exact test (Mehta and Patel 1983) was alternatively used to analysis this small cell size.

Age

In this study, age had no significant impact on satisfaction and mood for each of the six IEQ factors (Appendix 6).However, when the tests were run to examine the relationship between age groups (years, 50 years old and over 50 years) and its impact on motivation for each of the six IEQ factors, the results indicated that there was a significant relationship between age and the degree to which the colours of the indoor environment impacted on motivation in the CIT case study. Compared to the under 50s, the over 50s a reported a greater impact of the colours in their environment on their motivation to perform tasks ($\chi^2[4] = 11.96$, $p = 0.018$)

Gender

Gender (male and female) had no significant impact on satisfaction for any of the IEQ factors in the selected workplaces. Similarly, gender and its impact on mood for each of the six IEQ factors returned no significant relationship (Appendix 7). However, females reported a greater impact on their motivation to perform tasks for colour in their environments than males.

Years of Experience Working as an Academic

No significant impact on satisfaction, mood and motivation of any of the IEQ factors in the selected workplace was recorded in relation to years of working as an academic (< 1 year, 1–3 years, > 3 years) (Appendix 8). However, there is just one significant effect (Appendix 8, highlighted in blue). It seems that years of experience working as an academic is associated with the degree to which environmental colours affect motivation to perform tasks. Compared to participants with fewer years of service, participants with more years of service reported a greater impact of environmental colours on their motivation to perform tasks.

4.4.2.4 Summary of Quantitative Results CIT

The results of the questionnaire show that the IEQ in the open-plan workplace has a significant impact on feelings of satisfaction and perceived productivity, and no significant association with mood and motivation. The results indicated that sound was the most common factor that had a negative impact among the six IEQ. The results showed that sound level and layout had a strong negative impact on participants' satisfaction. Additional analyses showed that co-workers conversations and lack of sound privacy were the main source of noise. In addition, the workplace held three different departments in the same workplace, which created a noisy environment because each department undertook different academic scope of work. For layout the participants identified that visual privacy (height of partitions), space available for individual work, and storage at the workstations, were the main reasons for dissatisfaction with layout. The academics were most satisfied with the lighting of their office spaces, despite those physical measurements exceeded the Australian standards limit in some areas; this workplace has plenty of access to daylight. The participants were also satisfied with the colour.

The results also indicated that air quality and lighting equally had a negative impact on productivity. Less than half of the respondents rated their productivity as highly or extremely productive, when asked to rate their perceptions of productivity in their open-plan workplaces. Conversely, colour within the workplace environment was perceived as the factor least affecting perceived productivity. The Spearman's rank correlation coefficient showed a strong relationship between satisfaction, mood and motivation, and perceived productivity. This could indicate that academic focus on teaching and teaching-related work requires a higher level of sound reduction, a supportive layout, and good air quality and light to be satisfied and productive.

4.4.3 Research Results and Analysis — Qualitative Data (Semi-Structured Interviews)

By conducting a semi-structured interview method and by following the same analysis steps that applied in the previous two case studies. Six thematic categories were obtained which are: Distraction, Suitability of the workplace, Control over environment, Feelings, Privacy and Communication.

Distraction in the CIT workplace

For the CIT workplace, 75% (26/34) pointed out that distraction and concentration difficulties were a big disadvantage of the space, constantly impacting upon the academics' performance, particularly when required to do deep thinking and writing papers. The staff indicated that the main reasons for distraction in the open-plan setting were colleagues' conversational noise and movement around the workstations that created an uncomfortable environment, leading eventually to reduced productivity and more delays in their work. Thus, the participants believed that individual offices would be less distracting and more productive. For example:

> *I think the productivity is probably better in a closed office, although sometimes having an open environment it's easier to communicate with other people in an informal basis. But the open office can be distracting if people are talking, depending on what type of work I'm doing. If it's intense work needing a lot of concentration and quiet then it's not so good. (C2)*

Additionally, 15% (4/34) stated that sometimes the temperature of the indoor environment was the factor causing most distraction and negatively influencing their productivity. This finding pointed to the poor location of the workstation, such as being in a main traffic zone (near a door) or near a window, where the sun may cause disturbing; these are important factors in open-plan workplaces that can lead to distraction in workflow. For example:

> *Temperature affects me in a bad way. This building is notorious for being either too hot or too cold and that really stops people from working. (C31).*

> *… it depends where you sit in the open plan. I'm on a corner where there's people coming in both directions, which is not the best place, particularly if you want to work… want to say hello — sometimes — and of course you have to say, I'm sorry, I'm busy, I've just got to do this. But they often walk past and it depends where you sit. It does. I think that's a big factor. (C12).*

However, some academic staff (10%; 3/34) pointed out that the distractions do not affect their productivity level and they are productive anyway. One stated:

> *No, I don't think it makes a difference. It doesn't really affect productivity. Well, it doesn't affect it for me. I don't mind working with noise around, and I don't really easily get distracted. (C30)*

Suitability of the CIT Workplace

Almost half (43%; 15/34) of the CIT participants thought that the open-plan workplace was suitable for academic work. The layout of their workspaces supports collaborative work among the staff, and the presence of the small meeting rooms within the open-plan makes it more convenient for academic work, such as doing deep thinking or meeting students and colleagues. For example:

> *It's good, and you have to collaborate. So, as academic staff, we have to collaborate a lot; so it's easier to either walk over to someone to see if they're there, or just talk across the partitions. So that's quite useful. (C13)*

> *However, 40% (14/34) had a contrary view, that the open-plan layout was not suitable for academic work because it is a distractive, unproductive environment. One participant stated:*

I don't think it's good for academic stuff. I don't mind having a group of people in a room but it's too big a space and it echoes, so you hear all the conversations. I can hear conversations that are sort of down here and I'm the furthest away. (C23)

In addition, some staff (17%; 6/34) stated that open-plan workplace perform well for particular types of work such as administration, and it encourages collaborative work among the staff, but the workplace is not suitable for online teaching and deep- thinking work. For example:

To a certain extent, yeah; it's definitely better than having individual offices because of the collaboration and things involved, but if we are moving towards more online teaching and learning, then you would require [an] individual office because you're going to be talking to the online students. So, typically, if I have to go online… I would have to find a room like this to do my sessions, which sometimes can be not comfortable because I have to carry a lot of things, and I can't find [them]. (C20)

Control in the CIT workplace

Almost a third (30%; 10/34) of the CIT participants stated that control over their physical environment would empower the staff to be more productive and comfortable. They complained about the inability to control the air conditioning system, of feeling too cold in summer and too hot in winter, and not being able to open and close the windows to get fresh air. Those factors made the office uncomfortable and generated a desire among employees to leave their offices as soon as possible. One participant complained:

We've got no control over the air-conditioning. Where I'm situated it seems to be away from air flow so at odd times it gets a little bit stuffy and uncomfortable. (CI21)

However, the rest of the participants did not mention control over the physical environment as a real problem in their workplace

Feelings in the CIT workplace

Half (50%; 17/34) of the CIT participants had negative mood responses because of noise level, interruptions, and lack of privacy that affected their productivity in the open-plan workplace. The participants were annoyed, stressed and unhappy, particularly when they had limited time for their work. Therefore, the academic staff expressed preference for

alternatives to their workstations, such as the library and a laptop computer to do their work. For example:

> *I find it really frustrating and annoying if I need to get work done and I can't concentrate because of noise. (C1)*

> *Well, annoyed, when I have to do lots of stuff like, for example, today we have to prepare all the documentation for next semester and we just cannot actually be absolutely productive. We are making mistakes and we have to go back and fix those mistakes. You cannot focus on the work really. (C33)*

However, about 30% (10/34) of the academic staff responded positively in regard to their mood. They believed that the open-plan layout provides opportunity for better communication with their colleagues and that would encourage them for better performance. For example:

> *The thing is that when [in] an open space we can actually say greetings to each other say good morning … So I think that actually creates [a] friendly environment. It's good. This office is good…. If my mood is not okay to work at that time [it remains with me], but if I can get relief of that — if I find — if I talk to some others around me… (C22)*

Ten percent (3/34) found that there was no relationship between the IEQ of their workplace and their mood/productivity, or they did not know whether it affected them or not. Another 10% of the participants pointed out that mood change can go both ways — positively and negatively — depending on what is going on in the office and what type of work is being done. Both views are expressed here:

> *… to be honest, it's kind of hard to answer that question because I don't really think about how I feel when I'm thinking about work. (C14)*

> *It can go both ways, positively and negatively. I think it depends on your mood — your frame of mind — and what's going on in the office. If there's friction within the office, it can be very negative because you're exposed to that straight away. But if it's positive you're also exposed to those positive experiences as well. So, swings and roundabouts. (C13)*

Privacy in the CIT workplace

The results for CIT demonstrated that about 66% (22/34) did not believe the visual or sound privacy affected their productivity, but it likely reinforced the feeling of discomfort for them. One person explained:

> *… don't think it's important for the work. I just, like — I feel more comfortable when I know I've got a bit of privacy. When you know you can do things and not have to worry about having someone looking over your shoulder you just get things done. (C33).*

However, 31% (11/34) believed that the need of academic staff for privacy is important for their productivity, especially when working on confidential issues. Unlike the individual office, this open-plan workplace arrangement with low dividers between the workstations, cannot achieve a good level of visual and sound privacy to secure the academic work. For example:

> *[An] individual office [is] more efficient and you have your documents, you have your workstation — everything secured. In this case, I don't know whether someone can open my documentation. I didn't have any level of privacy. (C2)*

> *The problem with the layout is the partitions are a bit too low. I would like to have higher partitions or a base activity design, if we have to actually work in this environment of course. (C5)*

Communication in the CIT workplace

Many (61%; 21/34) of the academic agreed that communication in the open-plan CIT workplace is one of the advantages that enables interaction among colleagues, to discuss work-related-issues and create a friendly environment. For example:

> *That's fine. There are up sides to an open-plan office. In fact, I think that the communication is easier and it's good. It's good to be able to talk to your fellow colleagues and discuss things and just chat, whereas in an individual office it's often difficult. I think in an individual office you're often hidden away so you can be left out, isolated. (C31)*

However, 34% (12/34) of the academics stated that communication can produce a negative effect on the staff's productivity. Their open-plan office does enable good communication between workers but also fails to achieve the balance between communication and noise. This duality was described, as:

> *Two things: One is — it's good for interaction. It's good for a kind of teamwork. But sometimes you need some kind of silence,privacy. [Unclear]… some sort of silence or quiet in the environment. I think sometimes we don't get that because when I was working I found twelve of my colleagues were talking to each other, so sometimes my concentration doesn't work that much. That's the only — I think — negative. (C11)*

4.4.3.1 Summary of Qualitative Results for CIT

This section presents a summary of qualitative data from the interviews with the academics in the CIT workplace. The participants believed the open-plan workplace has a significant effect on their work experience as academics. Most of the participants were unhappy with the sound level that comes from other department member's conversations, which are the source of interruption, stress and unhappiness, and eventually reduces academic productivity and causes delays in their work. The participants preferred to find alternatives to their workstations, such as working from library, particularly when they had limited time for their work. In addition, some participants were annoyed that in the open-plan workplace it was difficult to meet students inside the office, they had to reserve the meeting room in advance to ensure that it was not occupied, and this may mean that students do not communicate with their teacher directly.

Interestingly, many of the participants did not believe that privacy affected their productivity, but it could reinforce the feeling of discomfort for them. They complained about their inability to control the air conditioning system, of feeling too cold in summer and too hot in winter, and not being able to open and close the windows to get fresh air. Those factors made the office uncomfortable and generated the desire among employees to leave their offices as soon as possible. The academic participants agreed that communication in the open-plan workplace is one of the advantages that enables interaction among colleagues, to discuss work issues and create a friendly environment. They stated that an open-plan office enables good communication between workers but fails to achieve a balance between communication and noise.

Almost half (43%) of the participants thought that the open-plan workplace was suitable for academic work, and the presence of small meeting rooms within the open- plan makes it more convenient for academic work, such as doing deep thinking or conducting meeting. However, (40%) had a contrary view, that the open-plan layout was not suitable for academic work because it is a distracting and unproductive environment.

4.4.4 Conclusion and Discussion for CIT Workplace

The qualitative results were consistent with the quantitative results in the finding that the colleagues' conversational noise, interruptions, and lack of sound privacy were the main source of dissatisfaction and could cause distraction and concentration difficulties in the open-plan workplace. It is important to note that CIT is a large workplace occupied by four different department staff (engineering, building and architecture, design, beauty therapy and massage); the total number is 67 people. This contributed to noise being one of the most important problems affecting the occupants in CIT. In addition, the qualitative results identified anther issue that made the workplace uncomfortable and generated desire among employees to leave their offices when possible: the inability to control their environment, especially, when they wanted to meet students and have control over the air conditioning system and fresh air. According to Vischer (2008), ownership and control over physical ambient conditions meet the psychological comfort needs for occupants and help them to adapt more quickly to an environment. Inability to control the environment in workplace decision-making has been described as 'demotivating' (McCoy and Evans 2005).

Further anlaysis of the qualitative results identified some issues related to workstation design, such as the height of partitions, which did not provide an adequate level of sound privacy, and the small space available for individual workstations and storage. For teaching-related work, usually academics have a many papers and books around to deal with, such as student reports, exam sheets, and books. This finding aligns with previous studies for example, Lindberg et al. (2018) stated that appropriate workstation design that provides a sense of visual and sound privacy helps to improve workflow and reduce occupant stress levels. Moreover, Kim and de Dear (2013) emphasised that workstation size has a powerful effect and might outweigh the effect of all other physical work environment factors on occupants' overall satisfaction. This suggests that the workstation design for academic work should consider appropriate size and shape to provide sufficient storage capacity according to

the type of work, and provide enclosures for privacy, which is important within the academic office in terms of increasing the workflow and providing functional and physical comfort to the occupants. However, the qualitative data showed that the lack of visual privacy in the CIT workplace did not affect productivity, but it likely reinforced feelings of discomfort. That might be because the type of work is focused on teaching and related work, so privacy is not the priority for completing the work.

The correlation coefficients between satisfaction mood and motivation, and productivity show significant relation in terms of some factors. Layout and air quality were common factors between these correlations. Qualitative results explained that inability to control the air conditioning system, and not being able to open and close the windows to get fresh air, made the staff frustrated and unable to concentrate on their work. In terms of light, the academics who were sitting in workstations near windows tended to rate light as having a negative effect on productivity. The reason behind this result might be attributed to the fact that the physical measurements of light in some areas have exceeded the maximum level established by Australian standards. Also, it was found that the sun's heat and the reflection of the sun on computer screens cause distraction. Hamedani et al. (2020) found that glare and reflection on computer screens can disturb the occupants and cause health issues such as headaches. However, light effects were inconsistent in terms of feelings of satisfaction and productivity. The participants were satisfied with the lighting, but they believed it had a negative effect on their productivity. This suggests that not all elements of IEQ have a negative effect on occupants' satisfaction in the same way that they influence perceived productivity.

The quantitative results suggest that the six IEQ elements did not show a significant relationship with motivation and mood in CIT. Three participants agreed with the quantitative results in the qualitative study; some felt that there was no relationship between the IEQ of their workplace and their mood/productivity; others did not know whether it affected them or not. However, the literature review indicates that specific individual IEQs within an open-plan workplace have significant effects on workers' mood, such as colour and light (Cuttle 2013) and on motivation (Lan et al. 2010). These previous studies were experimental studies where all the variables are controlled; however, in a real space, internal and external factors overlap, making it difficult to determine the extent of the effects on participants' mood and motivation. Figure 4-64 shows the main findings for CIT workplace.

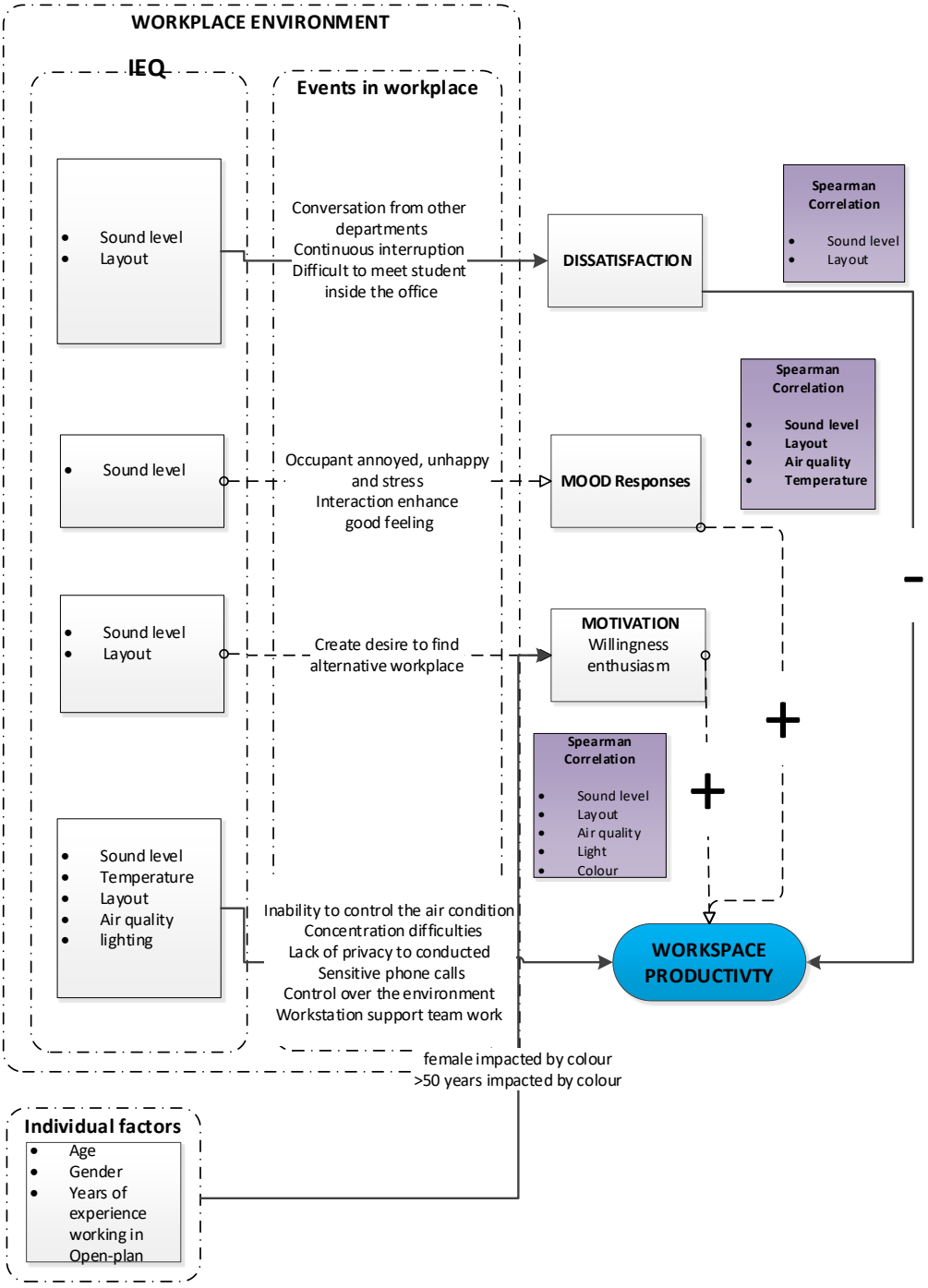

Figure 4-64 Outcomes of CIT workplace (Rashid 2018).

CHAPTER 5: DISCUSSION AND CONCLUSION

5.1 Introduction

There are limited studies that have evaluated open-plan academic workplaces in the higher education sector, and none investigating multiple factors influencing the IEQ. This study aimed to investigate open-plan academic workplaces within higher education institutions for the impact of IEQ on academics' perceptions of their own productivity. Through three carefully selected case studies, the research focused on the effects of six key IEQ factors (thermal comfort, air quality, sound level, lighting, layout and colour) on satisfaction, motivation, mood and productivity. Prior to the case studies, each of the six IEQ factors was first evaluated to understand its effect on satisfaction, motivation and mood. Then, the perceived productivity of the academics was evaluated, taking into account demographic information. Case study methodology was selected to gather data using mixed methods, both qualitative and quantitative, to explore the negative and positive aspects of open-plan workplace environment on academic productivity. This study employed convergent technique for designing mixed methods, when both qualitative and quantitative data collected and analysed separately (Creswell et al. 2007). The two sets of results then emerged together to interpret with giving the quantitative data the priority to explain and investigate measurable data in an unbiased and objective manner (Todd et al. 2004). Drawing on both qualitative and quantitative methods for the methodology proved to be an appropriate choice for this study, because it enabled the researcher to evaluate and explore the effects of the six IEQ factors on the academics' perceived productivity, satisfaction, motivation, and mood.

As universities across the globe are adjusting to changing work practices, due to the development of technologies and collaborative work demands, they are facing increasing pressures to create space efficacies and to restructure themselves through organisational change mechanisms. It is within this context that this research tackled the important issues in regard to the impact of open-plan workplace on academics and their productivity — a topic that has not yet received adequate attention. The main question is: how does indoor environment quality impact upon academic productivity in open-plan workplaces? In order to assess the suitability of open-plan workplaces for academic work, each of the three case studies selected for this research represented at least one of the main academic activities; that

is, research, teaching and administration. Through evaluation of the three different academic open-plan case studies, the current study offers new and constructive knowledge for academic property managers who manage academic workplace as well as designers, by providing a richer understanding of the impact of open-plan workplace on academic work tasks and productivity. This chapter provides a discussion of key findings in relation to the impact of the six IEQ elements on the academics' satisfaction, motivation, mood and perceived productivity. Finally, the results will be examined to understand the relationship between satisfactions, mood, and/or motivation with academic productivity.

In the first section of the chapter, the results will be discussed in relation to each of the research objectives (see Chapter 1, section 1.2). The second and third sections present the conclusions and contributions of this study to the field of academic workplace design. The final two sections will discuss limitations of the research, suggesting the direction of future research.

5.1.1 Evaluation of the Direct Impact of IEQ Factors on the Degree of Satisfaction

The literature review found studies indicating that IEQ has a significant impact on worker satisfaction in an open-plan workplace (Vischer and Wifi 2017; Kang, Ou and Mak 2017). The results from the questionnaire survey showed that the academic staff in all three workplaces were satisfied with the colour scheme and lighting. Some participants attributed their satisfaction with lighting to windows that provide daylight, and sustain the occupant's connection with outside environment, which in turn reduces the feeling of isolation. According to Bluyssen et al. (2003), occupants feel satisfied with the environment when they have no complaints, and the risk of illness or injury is low. The latter is especially of interest, given that the location of the case study two, CTL, was in a basement with minimum natural daylight, but overall, participants were satisfied with the lighting. That is not in alignment with the results from the literature review, which indicated that lighting levels are a common cause of dissatisfaction in open-plan workplaces (Cuttle 2013). The possible explanation for this may be that the Australian Standard provides a guidance for lighting design that ensure satisfactory environment with lighting for administrative academic workers in CTL who spend a lot of time working on computers.

Both quantitative and qualitative results identified that in terms of IEQ factors, the most negative impacts on satisfaction were associated with noise levels, office layout, air quality, and thermal comfort in the workspace. Other research agreed with the findings of this study, that these factors are the main cause of dissatisfaction among occupants (Kim and de Dear 2019; Kim and de Dear 2013). In relation to sound level, the questionnaire results were very much in alignment with the extant literature, since sound levels were found to be a cause for dissatisfaction in all three case studies. Further qualitative analysis through the interview indicated that the most common sources of noise in the open-plan workplace included colleagues' conversations and sound from ventilation systems. In addition, participants recorded dissatisfaction with the lack of acoustic privacy, noting that their environment made it uncomfortable to talk to others for fear of disturbing those around them. The inability to control the noise level is a problem in open-plan workplaces, leading to reduce their ability to concentrate on deep thinking work, which leads to less productive work environment. Radun el al. (2021) findings were in agreement with this study, they found that working during other people conversation was annoying and raising level of stress therefore, they emphasised that special care should be paid to control the level of noise in workplace environment with activities that require high level of concentration.

Staff located in areas, such as around meeting rooms or the main entrance, reported experiencing higher levels of discomfort. Pejtersen et al.'s (2011) study stated that the distance from the noise source determines amount of noise impact on people comfort. Academics engaging in administrative work (CTL) were most disturbed by sound levels, particularly due to other colleagues' conversations. They were also negatively affected by the lack of acoustic privacy, especially when they needed to make confidential phone calls. This suggests that academic administrative work might require a higher standard of sound control than that required for either research or teaching-related activities. However, it is also important to note that, due to the nature of their work, staff in CUSP and CIT had more flexibility to work from home when required to do deep-thinking tasks.

Despite differences across a range of academic work activities, sound was consistently reported as the most significant contributor to dissatisfaction in all three case studies. This indicates that, regardless of academic activity, sound levels in an academic environment can have a significant impact on worker satisfaction. This problem was identified as requiring appropriate consideration during the design processes of academic workplace. Sound

problems can be further exacerbated when different departments, or different academic scope of work, are co-located in the same workplace for example, in CIT the Beauty and Massage department was sharing the open-plan workplace with Engineering and Design department. Here, the differing needs of these departments resulted in conflicts around noise levels in their shared space. The questionnaire results were very much in alignment with the existing literature in relation to workplace space-planning and layout (Kang, Ou, and Mak 2017; Kim and de Dear 2013), which was found to be the second highest ranking factor causing dissatisfaction in the three case studies. Further quantitative analysis identified dissatisfaction with visual privacy (for example, the height of partitions), individual academic's access to available storage space, and difficulties with work interactions between co-workers. The qualitative analysis of interview responses indicated that the most common causes of dissatisfaction with the open-plan layouts included distraction and lack of concentration due to noise and movement around the workstations. This finding is consistent with a previous study conducted by Park et al. (2020) who identified that a large population in an open-plan workplace increased audio distractions, which impact negatively on participants' privacy and job characteristics such as skills task significant and task identity.

The lack of privacy created an insecure environment, as illustrated in this study, with participants stating that they had difficulties undertaking confidential work and finding private places for holding confidential conversations. Moreover, increasing requirements to engage with online teaching and the associated video-conferencing essential to be carried out by the academics on their computers posed problems in an open-plan workplace. Similarly, other researchers have found that open- plan offices have a negative impact on the ability of staff to focus or implement confidential tasks (Bluyssen et al. 2011; Lee 2010; Veitch et al. 2007). In conclusion, the lack of privacy causes higher levels of discomfort during the workday, especially for staff located in areas around meeting rooms and along passageways, for example.

Another impact of the layout on occupants' satisfaction is evident in participants' perceptions of their control over the physical environment, and their ability to accommodate the differences in individual needs. The results of Borgeson et al. (2008) went to the same conclusion, as their study stated that employees' ability to control the opening and closing of windows was an important factor which determined their satisfaction. Their qualitative results indicated that the lack of individual control over fresh air, temperature, and sound levels due

to the open-plan layout has a negative effect on occupants' comfort and happiness. Other studies (Shahzad et al. 2016; Xue, Mak, and Ai 2016) support that control over fresh air and room temperature is a major quality which determines employees' comfort.

While there was no evidence that the workplace air quality was causing any dissatisfaction in CIT or CTL, there were some issues noted in the CUSP case study. This is despite the recorded air quality measurements in all three workplaces being well within the Australian Standards guidelines. Further quantitative analysis showed that the lack of fresh air and the lack of air movement in this open-plan workplace were the most common reasons for dissatisfaction. This outcome might be attributed that staff in CUSP specialised and have more awareness regarding sustainability policy. The interview results indicated that increased control over the air conditioning system and the ability to open and close the windows would help to resolve the issues. Respondents noted that the CUSP environment was uncomfortable to stay in for a long time and affected their ability to concentrate. Academics focusing on research and work requiring higher levels of concentration were more dissatisfied with air quality, particularly their inability to open windows. This could indicate that academic research work requires higher levels of fresh air to stimulate concentration, thinking and creativity than that required by either administrative or teaching-related activities. This study came to conclusion that each type of works requires particular type of design setting.

5.1.2 Evaluation of the Direct Impact of IEQ Factors on Mood

The literature review found studies that indicated physical environment has a significant relationship with emotion in workplace (Ashkanasy et al. 2014; Ashkanasy, Hartel and Daus 2002). Most of the previous research investigating the relationship between the IEQ factors and mood of workers focused on a specific single factor within the IEQ; for example, the workplace temperature (Pejtersen et al. 2006). Some other studies focused on two elements; for example, colour and light (Küller et al. 2006; Hoffmann et al. 2008; Cuttle 2013). However, the quantitative data of this study indicated that the six IEQ factors are not strongly associated with occupants' mood, although responses to the study's questionnaire showed that the academics' mood is most affected by the element of sound levels in the open-plan work environment. The possible explanation for this result may be that mood is difficult to evaluate in the academic workplace because it covers a wide spectrum of academic activities

such as research, teaching, and administration, as illustrated by Leathwood and Hey (2009). In addition, according to Stets (2010), and Wegge et al. (2006), characteristics of the academic identity which are competitive and collaborative produce a mix of positive and negative responses, which in turn cause more difficulties in evaluating the mood. Therefore, more investigation is needed to understand the role of mood in the academic work environment. The quantitative results indicated that about half of the participants in CTL and CIT workplaces and 40% of the participants in CUSP determined that sound levels had the highest negative impact on their mood and can determine levels of annoyance or unhappiness in the work environment. The most common source of noise is colleagues' conversations; participants reported that uncontrollable sound levels can shift their mood towards annoyance and stress. A study by Haapakangas et al. (2017) stated that the negative impact of sound levels stem from the nature of the open-plan layout itself, which amplifies sounds because sound waves are not absorbed within the space. Also, the findings of this study were consistent with a previous study conducted by Jahncke et al. (2011); they investigated the effect of two different noise levels (high noise: 51 LAeq, and low noise: 39 LAeq) on mood, stress and cognition in an open plan office. They found that in the noisy, open-plan workplace environment, the participants were tired, and they were in a negative mood. When work demands high levels of concentration, an open-plan office becomes very annoying because of constant distraction. In conclusion, the empirical outcomes are in agreement with Ashkanasy et al. (2014) theoretical framework which explained how the IEQ factors in open-plan workplaces reshapes occupants' attitude and behaviour through effecting their emotion, to result in influencing on both behaviour and productivity.

Despite the differences across the diversity of academic activities, sound consistently appeared to have an impact on mood, as demonstrated across all three case studies. The literature review revealed that the effect of sound on mood in workplace has been neglected in comparison with the studies that investigated the impact of sound on occupants' satisfaction in the workplace. This suggests that there is an urgent need for more investigations in relation to the impact of workplace sound on occupants' mood in open-plan workplaces.

The interviews showed that some of the participants in the three cases reported that open-plan offices could not support their work needs. They emphasised the impact the lack of privacy can have on their mood, raising the feelings of annoyance and unhappiness within the workplace environment. In addition, one of the participants stated that having to relocate to a

quiet, private workplace with their laptops and books was a source of annoyance and frustration.

In terms of temperature, the literature review supports that workplace temperature has a negative impact on worker's mood in the open plan, causing discomfort and leading to physiological consequences. For example, Lan, Lian, and Pan (2010) found a significant correlation between temperature and mood, in that the study's participants experienced a more negative mood in the warmer environment of 28°C and a less negative mood in the cooler environment of 21°C. However, the findings of the current study do not support the previous research. The collected data of this study suggests that thermal comfort did not have significant effect on mood possibly due to the temperature being within the recommended range.

On the other hand, analysis of the qualitative data indicated that the academics agreed that the open-plan workplace has its advantages in enabling and sustain social interaction among colleagues, which affected their mood positively. The results of this study align with previous research by Dimotakis, Scott, and Koopman (2011) the study conducted an experimental study, which found a relationship between mood and interaction in the workplace, confirming that positive social interaction correlated positively with mood and that a negative mood resulted from negative interactions.

The interviews showed that 25% of the academics in CTL were happy and comfortable with their work environment, and they reported that the open plan workplace sustained their work activities. This 25% percent of respondents were working within team groups; they stated that the open- plan office facilitated their teamwork by increasing the rate of interaction between the groups, and bringing them closer to each other and eventually enhancing their positive mood. It can be concluded from this outcome that an open-plan layout may be more suitable for academic teamwork activities.

5.1.3 Evaluation of the Direct Impact of IEQ Factors on Motivation

Wibowo (2016) consider motivation to be a process that stimulates continuous efforts and directs a person's behavior towards the achievement of aims. The literature review confirms that workplace environments have a significant impact on worker motivation and productivity (Rozman, Treven and Cancer 2017; Veitch et al. 2013; Lan et al. 2010), mostly focusing on a single IEQ element; for example, light. However, there is limited studies

evaluating multiple IEQ elements and their effects on motivation. Motivation feeling in workplace is essential to increase occupant performance. Self-determination Theory (SDT) provides a framework to investigate how the surrounding environment facilitates an individual's sense of motivation and productivity. In addition, SDT theory suggests that if any of these psychological needs are obstructed, there will be a negative impact on performance and wellness (Ryan and Deci 2017). In line with this theory the results from the questionnaire survey of this study demonstrated that the motivation of the academics was affected by their environment particularly layout, sound level, lighting and air quality in CUSP. Kim and de Dear (2013) highlighted how the occupants who experiencing uncontrollable noise work environment in open-plan can impact negatively on their motivation. Similarly, this study revealed that high sound levels and the layout (space-planning) of CUSP's open-plan workplace negatively affected the academics' motivation (willingness and enthusiasm) to work. Participants noted that the high levels of concentration required to work effectively necessitated a work environment isolated from distraction and noise. They added that the open-plan layout did not support the diversity of academic work. Consequently, academics reported leaving their workstations early to find somewhere else to complete their day's work. Some participants in CUSP believed that all the IEQs had a role in impacting their motivation in their workplace and it was hard to identify specific factors. However, 30% of the participants noted that the value of informal interactions was facilitated by the layout of the open-plan workplace and that the absence of barriers between workstations positively affected their motivation and made them stay and work late with their colleagues to complete tasks. In line with this, Hughes and Kinder (2007) highlighted that an optimum workplace quality would encourage workers to work an extra hour in their workday to the researcher's knowledge.

The CUSP building has general lighting distribution (LED white/warm light, suspended on the ceiling above the workstations) and each workstation has local light. In addition to artificial lighting, the office has a set of windows along both north and south sides of the building and glazing in the middle of the west wall, allowing the daylight to penetrate inside. Despite that, the participants reported that the lighting impacted negatively on their motivation. The glare caused by morning sun which reflected on computer screens in CUSP was found to give rise to both discomfort and frustration to the academics, and eventually impacted negatively on their motivation. The finding reached here is consistent with the literature, which indicated that lighting (including illuminance and glare) in the workplace

was a common factor affecting workers' motivation to undertake required tasks (Flynn 1973; Küller et al. 2006). In addition, some participants who sit on the south side of the building mentioned that looking at concrete wall from their window was frustrating and uninspiring. This situation created a desire to leave the workstation and go outside and make a connection with the nature for a while, and come back later, which negatively affects the consistency of the work. Several studies support this finding, reporting that occupants of an open-plan office situated next to an outside view reacted positively, because the outdoor space provided the occupants with a feeling of satisfaction and calmness (Kim et al. 2018; Ko et al. 2020)

In terms of air quality, Cui et al. (2013), found that fresh air and room temperature changes in open-plan workplaces was a common factor affecting workers' motivation to undertake tasks, and their motivation improved when they were more comfortable with their indoor environment's temperature which was in consistencies with the findings of this study. Some participants in the interviews of this study indicated that the lack of control over the air conditioning, sound and light can negatively affect academic motivation, which effecting their behaviour and productivity. This result agrees with the outcome of McCoy and Evans (2005) who found that uncontrollable workplace created demotivating work environment.

In CTL and CIT workplaces, the correlation between the IEQ and motivation was found to be weak. The reason behinds this may be attributed to academic staff are usually motivated by the job itself (Zhang 2014). They are influenced by desire for achievement, a sense of responsibility, performance recognition, job significance and personal growth. Gagne and Deci (2005) also came to the same conclusion that internal motivating comes from worker's personal engagement found in undertaking a certain task. Another explanation for these differences between CTL, CIT, and CUSP cases may be attributed to the differences in the main academic activity. Namely, motivation for academic activities focused on administration and teaching are less impacted by IEQ. In contrast, the mental and creative academic works showed more sensitivity towards some IEQs that have a significant impact on their motivation. The statistical analysis conducted to find the relationship between demographic information and motivation showed that females reported a greater impact of colour on their motivation to perform tasks in their environments than males in the three case studies. The outcome of many studies supports this finding and confirmed that colour preference and effect are not universal and influenced by the differences in gender, age and culture (Sorokowski et al. 2014; Baniani and Yamamoto 2015).

5.1.4 Evaluation of the Direct Impact of IEQ on Perceived Productivity

While there is some controversy surrounding the relationship between IEQ and worker productivity, the majority of the results from the in-depth literature review indicated that IEQ factors have a significant impact on worker productivity in an open-plan workplace. Kim (2014) in his model to understand the impact of physical work environment on occupants' outcomes, showed that the IEQ factors had a significant effect on behavioral responses, ultimately creating better work performance. The study results of CUSP, CIT, and CTL workplaces are generally in agreement with the extant literature. However, the quantitative results from the questionnaire survey showed some variance across the three case studies. For example, most of the six IEQ factors have an impact on perceived productivity in both CUSP and CIT workplace, whereas only three factors — sound level, layout, and thermal comfort were perceived as the factors influencing productivity in CTL. The results from the three case studies emphasised that sound levels had the highest perceived negative impact among other factors upon academic productivity.

Further qualitative analysis of the interviews indicated that the open-plan layout failed to block the noises from co-workers nearby, which in turn impacted on their concentration level. These results reinforce the significance of high noise levels in reducing worker productivity in open-plan workplaces, as found in the literature review. However, in previous studies, sound levels were not the highest-ranking factor among the IEQ elements (Mak and Lui 2012; Frontczak et al. 2012). A possible explanation for this could be that the nature of activities in which the academics within the three case studies of CUSP, CIT and CTL were engaged were, for the most part, complex mental activities requiring a high level of concentration, and that those activities are different to those conducted in general office work. This suggests that an academic environment has a higher requirement for acoustic control to improve productivity. Further analysis of the qualitative data supports this proposition, with lack of sound privacy being noted as particularly detrimental to those academics engaging in online teaching while at their workstations. This kind of work needs a workplace that provides a secure and private place. Participants in all three case studies believed that individual offices would be less distracting and would allow them to be more productive. This was not surprising, as Wilhoit et al. (2016) study stated that academic tend to be workplace change resistance to keep their identity.

The questionnaire results indicated that there was a significant relationship between the open-plan layout and academic productivity. The qualitative analysis of the data collected through the interviews revealed that, within the open-plan workplace layout, it was the lack of visual privacy, difficulties in concentrating, and increased interruptions that were the root causes of the poor acoustic environment that negatively affected academic productivity. This result supports the significant impact of workplace layout on workers' productivity in open-plan work environments (Al Horr et al. 2016; Vischer and Wifi 2017).

The possible explanation for the differences in the results between CUSP, CIT, and CTL, might attribute to the differences in the scope of works between these three cases. These case studies indicated that an open-plan layout has a negative impact on the high level of concentration required and the intellectual demands of research activities, while it has a lower negative impact on teaching-related activities.

Results from previous studies investigating the open-plan workplaces indicated that lack of thermal comfort has a negative impact on productivity (Hellwig 2015; Shahzad et al 2016). In agreement with that, the results of this study confirmed this relationship between thermal comfort and perceived productivity of the academic work which characterised as complex and creative. The literature has found that the optimal thermal temperature for creative or complex activities is higher than any other type of intellectual work, and that creative work is positively affected by the moderate rise in temperature (Wyon and Wargocki 2006). This can be attributed to those moderate temperatures that do not cause sweating and reduce arousal among workers lead to an enhancement of productivity, considering the inverse relationship between arousal and productivity (Wyon 1996). The case studies also revealed that the academics felt frustrated, tended to take breaks, and leave the workplace frequently to seek out fresh air. They believed that not having control over the ventilation system and not being able to open and close windows contributed to changing workplace temperatures.

In terms of lighting, in both CUSP and CIT was found to have a significant impact on productivity. And this result is consistent with the physical measurements in both workplaces which confirmed that the occupants were exposed to high light intensity. Some participants in both places raised the issue of glare reflection from computer which affected on their eyes. The literature supported this result, and some studies found the same reaction from the

participants when they were unable to control artificial or natural lighting (Al Zaabi, Nassif and Mushtaha 2017). This result suggests that providing the required standard levels of indoor environment quality such as lighting important to guarantee obtaining the optimal level of productivity. On the other hand, CTL results did not show any significant impact on productivity in terms of lighting. But a small ratio of CTL participants who were in a slightly lit area compared with Australian Standards indicated that artificial light had a negative impact on their productivity. When examining why the results were different across the three case studies, it was found that the various factors, including sun's heat, natural light, number of academics in the workplace, and inability to control windows for fresh air, all led to distraction, affecting workers' productivity. In some instances, technology was seen to be impeding individual's control, for example with security measures ('beeping') relating to doors and windows.

The questionnaire results also revealed that less than half of the academics in the open-plan workplaces of CUSP (47.3%), CTL (45%) and CIT (46.2%) perceived their productivity as being high or extremely high when they asked to rate their perceptions of productivity in their open-plan workplaces. Further, some academics in CUSP (36.8%), CTL (15%) and CIT (29.3%) perceived themselves as being less productive in the open-plan workplace. The reason behind the low rate of productivity for those academic participants might be attributed to the significant amount of energy exerted to cope with the workplace environment due to the high level of distraction. According to Vischer (2008), the difference between a work environment with functional comfort and work environment without functional comfort is based on the amount of energy maintained and exerted on their tasks, with part of their energy spent in coping with different work environment conditions. Therefore, when the occupants were influenced negatively, as indicated in this study, when the environment did not support their work, this eventually impacted upon their productivity. Qualitative analysis found that most academics noted that open-plan workplaces might suit some types of work, such as routine administration, but did not suit all academic activities, and that academic work needs a private, quiet and secure environment in order to be completed effectively. This finding aligns with the literature review, where several studies found that workers in open-plan workplaces were less productive, even though the open-plan environment was conducive to more successful teamwork because it stimulated interaction and facilitated collaboration (O'Neill 2008; Kim and de Dear 2013). The result for CTL as an example of an academic

teamwork workplace, presenting the lowest rate of occupants' unproductivity among the three case studies. This was inconsistent with the literature, supporting the position that the main incentive to create an open-plan office is to sustain the interactions among occupants.

5.1.5 Does the Impact of IEQ on Satisfaction, Mood and Motivation Influence on Productivity?

The relationship between IEQ and productivity has received much attention and still remains controversial. More attention has turned to the psychological impacts of the indoor environment of general open-plan workplaces, particularly in relation to workers' satisfaction, motivation, and mood and the associated impact on their productivity (Zibarras and Lewis 2013; Veitch et al. 2008). To date, most of these research have focused on the relationship with satisfaction, due to the concept of workplace environment satisfaction goes beyond what occupants like or dislike, to be a way of assessing building performance itself by evaluating building performance to support different activities accomplished by employees (Samani et al. 2018). Affective events theory has proven the relationship between the worker's emotion and reaction to their work environment, which affects productivity and wellbeing (Ashkanasy et al. 2014). However, less attention has been paid to investigating the relation between mood and motivation with productivity in workplaces.

In Chapter 4, The Spearman correlation coefficient was used to determine whether occupants' satisfaction, motivation and mood in regard to each IEQ factor has a relationship with perceived productivity. In terms of satisfaction with each of the six IEQ factors and perceived academic productivity, the level of dissatisfaction with the sound level and layout had a significant correlation with perceived low productivity in the three academic workplaces (CUSP, CTL and CIT). The dissatisfaction with the air quality and light in CIT also had a significant correlation with perceived productivity. Thus, when academics are satisfied with the IEQ factors in their workplace, there is no perceived effect on their productivity. For example, in CUSP, whilst the academics were on average dissatisfied with the air quality of their workplace, they did not feel that the air quality was influencing their productivity. Conversely, in CIT, where the academics were on average satisfied with the air quality, they did feel that the air quality had an impact on their productivity. A similar contradiction was reported by van Voordt (2004), who conducted a POE in a new open-plan workplace, activity-based work. The results showed that, while the participants were satisfied with the

new workplace IEQ, such as the design layout which, from their point of view, positively fostered interaction and communication, 40% of the respondents indicated that the new workplace had a negative impact on their own perceived productivity; another 40% had a neutral opinion; only 20% were positive. However, it is worth noting that in the current study, the correlation coefficients between satisfaction and productivity related to sound level and workplace layout are consistently strong, and are common across all three workplaces, reinforcing the notion that noise and workplace layout type in an academic setting have very significant effects on the occupants' productivity. According to Vischer and Wifi (2017) and Samani et al. (2018) satisfaction with the physical workplace environment evaluates environment ability to support different activities performed by employees. This suggests that when users feel satisfied with the physical workplace, the environment will be considered as a productive one.

The Spearman's rank correlation coefficient between the effect of IEQ factors on mood and perceived academic productivity showed a positive correlation ($p\text{-value} < 0.05$). This means that the participants' perceived productivity increased when they are in good mood and vice versa. The strongest relationship was demonstrated between the impact of workplace layout on mood and productivity, seen in all three case studies. Sound level and air quality also had a significant positive correlation with perceived productivity in both CTL and CIT, and thermal comfort in CIT. However, in all three of these workplaces, the results did not indicate that no significant relationship between the IEQ factors and academic's mood. These results are in direct contradiction to previous studies, which demonstrated that workers' mood response is affected by the quality of their surrounding workplace environment, which in turn influences their productivity. In particular, Küller, Mikellides, and Janssens (2009) demonstrated that both mood and performance of workers were enhanced in a multi-coloured environment when compared to a monotone grey room. Jahncke et al. (2011) showed that as noise levels increased, participants' performance and motivation decreased, and mood was negatively impacted. However, these previous studies were all conducted in a simulated workplace where all other variables were under control. In this study, there was no such control, and it is possible that in this authentic setting, with so many other factors impacting on mood, the impact of IEQ was lost.

The results also showed that the IEQ factors that affect motivation and have a significantly positive correlation between impact on motivation and perceived productivity in

the three academic workplaces (see Chapter 4, Table 5-16) are sound level and layout (CUSP) and thermal comfort (CIT). While the Spearman's rank correlation coefficient result showed that thermal comfort, air quality, colour, layout and sound level in CUSP, colour, air quality, light and sound in CTL, and colour, air quality, thermal comfort and layout in CIT, all showed a significant relationship between motivation and productivity. It should be noted that, for example, if thermal comfort is not considered to have an impact on motivation, it will not have any impact on productivity. Thus, only those results which have a corresponding impact on motivation can be considered as relevant. These results reinforce the findings of Lan et al. (2010) and Hellwig (2015) which demonstrated that productivity in the workplace can be affected by IEQ and worker motivation.

While the data purposefully collected for this study is not suited for an analysis of the mediating effect of satisfaction, mood and motivation on productivity, the results suggest the need to pay more attention for better understanding of the effect of sound level and open-plan layout in the academic workplace. In addition, thorough investigation is required to comprehend the significance of the IEQ factors on occupants' satisfaction, mood, and motivation, which in turn impacted on their productivity.

5.2 Conclusion

The intention of this study was to evaluate the suitability of open-plan layout for academic purposes and establish a knowledge base for optimum workplace design that supports academic work needs. The research objectives arose from the research question: "How does the indoor environment quality impact upon academic productivity in open-plan workplaces?"

The significance of this study is derived from its general but inclusive focus on the impact of the six IEQ factors while investigating the academic open-plan workplace. While utilization of the open-plan workplace design has been well documented, only a limited number of studies have investigated academic open-plan workplace (Sadick, Kpamma and Agyefi-Mensah 2020; Wilhoit et al. 2016). The review of literature revealed a gap in knowledge specifically in relation to a holistic approach placing emphasis on evaluating all six IEQs in open-plan academic workplaces, and their relation with the satisfaction, mood, motivation and perceived productivity. This study therefore addressed the limitations of

research regarding academic open-plan workplaces adding useful knowledge for professionals and designers to better understand needs of academic open-plan offices.

This study found that most modern workplace buildings in universities meet basic physical standards by addressing health and safety concerns of the occupants. However, they don't ensure functional comfort of the workplace that supports academic performance. As a result, uncomfortable workplace may cause energy drain due to academics need to exert their energy to tackle the environmental barriers instead of focusing on performing their tasks.

The analysis of the qualitative and quantitative data suggests that there is a direct correlation between the IEQ factors in open-plan workplaces and levels of academic staff's satisfaction, motivation, mood and perceived productivity. The academic staff in all three workplaces were satisfied with the colour scheme and lighting, though varying degrees of sensitivity and motivation were recorded in relation to colour between males and females, with females showing greater sensitivity towards colour than males in terms of its impact on motivation. In addition, data indicates that high sound levels are consistently ranked as having the biggest negative impact on satisfaction, motivation, mood and productivity. For example, the participants emphasised that noise generated by colleagues' conversations and movements, impeded their ability to concentrate on tasks. This study also found that the location of workstations, particularly in relation to work activities, can result in different sensitivities to sound level and distraction, principally due to the needs for quiet and privacy. For example, the workstations located adjacent to main traffic zones, such as near an entrance increase the distraction which leads to dissatisfaction with the sound levels and layout. On the contrary, similar studies in other sectors show that temperature, light levels and lack of natural lighting in the workplace were found to be the most significant in causing dissatisfaction and stress among employees (Bluyssen et al., 2011; Cuttle 2013). Accordingly, this study confirmed that sound level control is particularly important in an academic context because academic work requires high levels of concentration. However, analysis of the quantitative data showed that the correlation between IEQ factors and mood was not strongly associated in all three workplaces. This may be attributed to mood being difficult to evaluate in real academic workplace because the academic work covers a wide spectrum of activities which aligns with the finding of Leathwood and Hey's (2009) study.

Qualitative data analysis indicates that because open-plan design is limited in its ability to provide an individual level of control, it fails to cater to the often-conflicting needs of occupants. Lack of control over fresh air was the most common factor to negatively influence academics' mood and motivation. The study found that occupants with greater control over their workplace environment tend to report increase in their motivation levels due to the feeling of empowerment which subsequently increases their productivity. Control over air-conditioning systems to adjust temperature, movable blinds on windows, and ability to control the noise level around workstations were therefore shown to be important.

This study identified that deep thinking, collaboration and interaction are three main work requirements for any academic activities and any failure to meet these requirements might negatively affect academic staff's productivity. In order to fulfil these requirements, the optimal academic workplace design should be secure, private, quiet and a flexible. Conversely, this study also showed that open-plan workplaces within an academic context appear to promote teamwork, collaboration, and communication with colleagues which in turn enhances academic productivity. This result is consistent with outcomes of previous studies which showed that the nature of open-plan layout sustains both collaboration and interaction among occupants (O'Neill 2008; Kim and de Dear 2013). This research emphasises that the degree of diversity in design setting plays an important role in impeding or facilitating the academic work activities.

Regarding the relationship between perceived productivity and satisfaction, mood and motivation, this study found that degree of perceived productivity depends on the participants satisfaction, mood or motivation status, with staff having better productivity perception when they are experience positive satisfaction, mood and motivation.

5.2.2 Recommendations from this Study

This research has important implications for evaluation of the effects of IEQ factors on satisfaction, motivation, mood and productivity, particularly in the context of an academic open-plan workplace in the Tertiary Education sector. This study enhances the theoretical ideas about how IEQ factors affect productivity for academic types of work, and it provides a comprehensive model for evaluating perceived productivity in the workplace. In addition, several valuable recommendations resulting from the research findings are presented, which

higher education organisations could address when aiming to deliver academic open-plan workplaces:

Use of more effective and advanced insulation techniques to reduce the noise levels in the open-plan workplaces.

Given the occupants a greater control over work environment which in turn strengthen the sense of satisfaction and motivation and subsequently the perceived of productivity among occupants, such as control over fresh air and provide occupants with adjustable light.

Presentation areas or meeting rooms should be acoustically and visually separated from open-plan workplaces to reduce distraction and minimize noise level for those who are not participating in these activities.

Academic open-plan workplaces should be designed with consideration given to the different types of academic work to be undertaken and their specific requirements. Such as, small meeting room to maintain privacy and reduce noise level.

While academic roles are rapidly adapting to a new digital age, there is still a need to provide adequate storage options for staff to keep their files, books, papers and archived materials. Even though these information and documents will not be used frequently but, still useful to have them on hand instead of shelving them in storage rooms.

This research recommended that workplace design requires integration of multiple disciplinary to obtain optimal productive workplace. Such as interdisciplinary investigation process would provide better comprehension of how academic satisfaction and wellbeing could improve performance and productivity.

This study highlighted that the impact of IEQ factors on mood and motivation within the complexities of the tertiary education workplace is an important consideration in workplace design and, so for, remains an under-explored area of research.

5.2.3 Limitations of this Study

This research has limitations in terms of sample size, IEQs studied and productivity measurement.

The first limitation in the current study is the sample size. The study used a case study sample of three higher education institutes in the state of Western Australia. Therefore, the

results of the current study may not represent a wide range of open-plan workplaces internationally or nationally. However, the three workplaces were selected to represent the three main academic work activities of research, administration and teaching and, hence, could be viewed as a representative sample.

This study addressed the effects of a broad range of IEQ elements (thermal comfort, air quality, sound level, light, layout and colour) on academic productivity. Consequently, the results provide a breadth of knowledge across all six IEQ elements rather than an in-depth study of an individual IEQ element. This was considered appropriate, because the aim of this study is to present a comprehensive understanding of the influence of the indoor environment quality on academics' satisfaction, motivation, mood and productivity.

The quantitative data collected and analysed for each of the case studies used a self-reported measurement to evaluate productivity. This was considered to be appropriate, because no agreed measurement exists for productivity within an academic workplace. However, the nature of self-reporting means that the results are subjective, and interpretations of scales may differ across institutes and regions.

Physical measurements (sound level, light illuminance, CO_2 concentration, and humidity) were taken to check for compliance with Australian Standards. The instrument was not the most dependable but does give indications of the legitimacy of environment conditions across the cases.

The physical measurements for the three academic workplaces were taken in autumn/winter, therefore, these measurements and related data collection may not be generalized for all seasons of the year.

While a rigorous pilot testing of the data collection instrument was conducted, some language issues became apparent during the analysis of the case study data. While it is acknowledged that the instrument would be revised for any future studies, the data collected is still considered to be valid. The author understands the nuances of the language used and has interpreted the results accordingly.

5.2.4 Future Studies

The results of this study contribute to the current understanding of the impact of IEQ factors upon academic productivity in open-plan workplaces. The study shows that IEQ

factors have a significant effect on academics' degree of satisfaction, motivation, mood and perceived productivity. Based on the result of this study, five key areas for future research have emerged and are recommended:

- This study focused on the measurement of psychological and psychosocial aspects to understand the effects of IEQ on productivity. In future studies, it is recommended that these measurements should be coupled with less subjective, physical measurements, such as heart rate, skin moisture levels, etc., to better understand the relationships with productivity.
- This study relied on self-reported measurement of productivity. While studies have already been conducted using objective productivity measurements, such as speed and accuracy of completing tasks, there is a need for further research in this area, particularly relating to academic productivity.
- Investigation of the psychological factors that have a mediating effect on productivity in open-plan workplaces is required, particularly with larger samples.
- The results from this study indicate that noise levels in academic environments plays a very significant role in affecting productivity. It is recommended that future studies of the effectiveness of noise treatments in open-plan offices should be conducted, including consideration of the impact of transient noise sources, such as colleagues' conversations, as well as sounds from systems such as the ventilation. While this study covered a breadth of IEQ factors, further studies would benefit from exploration of other indoor workplace environmental factors, such as daylight, views to the outside, and external noise.

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APPENDIX 1

Permission Letter

Dear Sir/Madam

It is my understanding that you/your organisation are the copyright holder for the following material:xxxxxx. I would like to reproduce an extract of this work in a doctor's thesis which I am currently undertaking at Curtin University in Perth, Western Australia. The subject of my research is Academic workplace. I am carrying out this research in my own right and have no association with any commercial organisation or sponsor.

Once completed, the thesis will be made available in online form via Curtin University's Institutional Repository espace (http://espace.curtin.edu.au). The material will be provided strictly for educational purposes and on a non-commercial basis.

I would be most grateful for your consent to the copying and communication of the work as proposed. If you are willing to grant this consent, please complete and sign the attached approval slip and return it to me at the address shown. Full acknowledgement of the ownership of the copyright and the source of the material will be provided with the material.

If you are not the copyright owner of the material in question, I would be grateful for any information you can provide as to who is likely to hold the copyright.

I look forward to hearing from you and thank you in advance for your consideration of my request.

Kind regards

Samhar Rashid
PhD Candidate, Architecture and Interior Architecture
Curtin University, Design and built environment
Faculty of Humanities
Email: s.rashid3@student.curtin.edu.au

APPENDIX 2

Invitation, Information Sheet and Consent Sheet

Dear academic staff

I am Samhar Rashid a PhD student / Interior Architecture Department. My thesis tittle is: "**The Influence of Indoor Environment Quality on Academic Productivity in the Open-plan Workplace**". I need volunteers who could give me their opinion about the influence of indoor environment quality (thermal, air quality, acoustic, lighting, layout and colour) in an open-plan workplace, on their productivity .The questionnaire and the interview will take about 30-45 minutes and include judging the influence of the variety of indoor environment qualities on the productivity.

Please let me know if you are willing to donate 30-45 minutes from your time and I will be extremely grateful.

Please contact me using the details below

Kind regards

Samhar Rashid
PhD Candidate / Department of Architecture Interior Architecture
School of Built Environment
Curtin University Mobile:
Email | s.rashid3@student.curtin.edu.au Web | http://curtin.

Information Sheet

Dear Participant,

1. This PhD student research project aims to explore the main research objective:
   - Evaluate the impact of IEQ on satisfaction
   - Evaluate the impact of IEQ on mood
   - Evaluate the impact of IEQ on motivation
   - Evaluate the impact of IEQ on productivity, and
   - Explore whether the impact of IEQ upon satisfaction, motivation or mood affects academic staff perceptions of productivity.

2. You will be required to answer a questionnaire and do an interview.

3. The total expected time for your responses is 30-45 minutes

4. Your participation is completely voluntary; you will be at liberty to withdraw at any time without giving a reason for withdrawal.

5. The proposed research will not involve potential physical or psychological harms. The researcher will take every possible precaution to minimise the participants' discomfort and inconvenience.

The contact details of the principal supervisor should readers require further information:

- Dr. Lynn Churchilll, Senior Lecturer, School of Built Environment, Architecture and Interior Architecture.
- E-mail: s.rasid3@student.curtin.edu.au

The contact details of the researcher should readers require further information:

- Samhar Hikmat Rashid, PhD candidate
- School of Built Environment, Architecture and Interior Architecture.

Curtin University Human Research Ethics Committee (HREC) has approved this study (HREC number 5276). Should you wish to discuss the study with someone not directly involved, in particular, any matters concerning the conduct of the study or your rights as a participant, or you wish to make a confidential

complaint, you may contact the Ethics Officer on (08) 9266 9223 or the Manager, Research Integrity on (08) 9266 7093 or email hrec@curtin.edu.au.

Curtin University

Letter of Consent

Dear Participant,

Thank you for your cooperation in this study. Your signature will certify that you

-Have been informed of and understand the purposes of the study.

-Have been given an opportunity to ask questions.

-Have received enough information about this study.

-Understand that you are free to withdraw from this study at any time without giving a reason for your withdrawal.

-Are aware that any information, which might potentially identify you, will not be used in published material.

Do you agree to take part in this study? YES NO

Signature of participant: Date:

Name (BLOCK LETTER):

Signature of investigator: Date:

APPENDIX 3

Questionnaire – Quantitative Data

Code of participant:

University Site:

The Influence of Indoor Environment Quality on Academic Productivity in the Open-plan Workplace

I would like to thank you for your cooperation in assisting with the proposed research. The following questions ask about your experience in a workplace environment.

The questionnaire is divided into seven sections:

- Section One: Artificial Lighting Quality
- Section Two: Sound
- Section Three: Air Quality
- Section Four: Thermal Conditions
- Section Five: Layout
- Section Six: Colour
- Section Seven: Overall

In each Section you will be asked to consider:

- A: degree of satisfaction;
- B: mood evaluation
- C: motivation scale.

All responses will be kept strictly confidential.

Section one: Artificial Lighting quality

A-Degree of satisfaction

How satisfied you are with the quality of **artificial lighting** in your workstation?

Not at all	Slightly	Moderately	Quite	Extremely

State what you dislike or what is uncomfortable in relation to the **artificial lighting** in your workstation:

☐ Quantity of light in your workstation surface

☐ Glare

☐ Colour of light (e.g. bluish, reddish)

☐ I am happy with artificial lighting

☐ Others, please explain _____

_____

Do you have access to natural **daylight** in your workplace?

None	Not enough	Reasonable	Plenty	Too much

Do you have control over the **daylight** in your workplace?

☐ Yes ☐ Sometimes ☐ No

B: Mood evaluation

Please answer the question: "**What mood response do you associate with the overall lighting level in your work area during the last week ?"**

Mood response	Not at all	Slightly	Moderately	Quite	Extremely
Annoyed					
Confusion					
Unhappy					
Fatigued					
Energetic					
Nervous					

C: Motivation scale

Rate the effect of the following factors in your workplace on your **willingness** to perform tasks.

-Artificial Lighting quality of your workstation

Not at all	Slightly	Moderately	Quite	Extremely

Rate the effect of the following factors on your **enthusiasm** to perform tasks.

-Lighting quality

Not at all	Slightly	Moderately	Quite	Extremely

Section two: Sound

A-Degree of satisfaction

How satisfied you are with the **sound level** in your workstation?

Not at all	Slightly	Moderately	Quite	Extremely

State what you dislike or what is uncomfortable in relation to the **sound level** of your workstation:

- ☐ Amount of sound from other people's conversations
- ☐ Amount of sound from ventilation
- ☐ Acoustic privacy
- ☐ I am happy with the sound level
- ☐ Others, please explain _____

_____

B: Mood evaluation

Please answer the question: "**What mood response do you associate with the sound level in your work area during the last week?"**

Mood response	Not at all	Slightly	Moderately	Quite	Extremely
Annoyed					
Confusion					
Unhappy					
Fatigued					
Energetic					
Nervous					

C- Motivation scale

Rate the effect of the **sound level** on your **willingness** to perform tasks:

Not at all	Slightly	Moderately	Quite	Extremely

Rate the effect of the **sound level** on your **enthusiasm** to perform tasks:

Not at all	Slightly	Moderately	Quite	Extremely

Section three: Air quality

A- Degree of Satisfaction

How satisfied are you with the overall **air quality** in your workplace?

Not at all	Slightly	Moderately	Quite	Extremely

State what you dislike or what is uncomfortable in relation to the **air quality** in your workplace:

☐ Air movement

☐ Fresh air

☐ I am happy with the air quality

☐ Others

Please, explain _____

_____

B: Mood evaluation

Please answer the question: "**What mood response do you associate with the air quality in your work area during the last week?"**

Mood response	Not at all	Slightly	Moderately	Quite	Extremely
Annoyed					
Confusion					
Unhappy					
Fatigued					
Energetic					
Nervous					

C-Motivation scale

Rate the effect of the **air quality** on your **willingness** to perform tasks:

Not at all	Slightly	Moderately	Quite	Extremely

Rate the effect of the **air quality** on your **enthusiasm** to perform tasks:

Not at all	Slightly	Moderately	Quite	Extremely

Section four: Thermal conditions

Do you have **air conditioning** in your workplace?

☐ Yes ☐ No

Do you have control over **thermal conditions** in your workplace?

☐ Yes ☐ Sometime ☐ No

A- Degree of satisfaction

How satisfied you are with the **thermal conditions** in your workplace?

Not at all	Slightly	Moderately	Quite	Extremely

State what you dislike or what is uncomfortable in relation to the **thermal conditions** in your workplace.

☐ The temperature (e.g. cold, hot)

☐ Humidity

☐ I am happy with the thermal condition

☐ Others

Please, explain _____

_____

B: Mood evaluation

Please answer the question: "**What mood response do you associate with the thermal conditions in your work area during the last week?"**

Mood response	Not at all	Slightly	Moderately	Quite	Extremely
Annoyed					
Confusion					
Unhappy					
Fatigued					
Energetic					
Nervous					

C-Motivation scale

Rate the effect of the **thermal conditions** on your **willingness** to perform tasks:

Not at all	Slightly	Moderately	Quite	Extremely

Rate the effect of the **thermal conditions** on your **enthusiasm** to perform tasks:

Not at all	Slightly	Moderately	Quite	Extremely

Section five: Layout

A- Degree of satisfaction

How satisfied you are with the **open –plan office** as a workplace

Not at all	Slightly	Moderately	Quite	Extremely

State what you dislike or uncomfortable in relation to the **layout of open plan office** of your workstation:

☐ Space available for individual work and storage in your office.

☐ Visual privacy (height of partitions).

☐ Interaction with co-workers in your office.

☐ I am happy with the layout of open plan office

☐ Others, please explain _____

_____

B: Mood evaluation

Please answer the question: "**What mood response do you associate with the Layout in your work area during the last week?"**

Mood response	Not at all	Slightly	Moderately	Quite	Extremely
Annoyed					
Confusion					
Unhappy					
Fatigued					
Energetic					
Nervous					

C- Motivation scale

Rate the effect of the office **layout o**n your **willingness** to perform tasks:

Not at all	Slightly	Moderately	Quite	Extremely

Rate the effect of the office **layout** on your **enthusiasm** to perform tasks.

Not at all	Slightly	Moderately	Quite	Extremely

Section six: Colour

A-Degree of satisfaction

How satisfied you are with the **colours** in your workplace

Not at all	Slightly	Moderately	Quite	Extremely

State what you dislike or what is uncomfortable in relation to the **colour conditions i**n your workplace

☐ Colour itself

☐ Depth of colour

☐ Too much colour

☐ Colour Disharmony

☐ I am happy with the colours

☐ Others

Please, explain _____

_____

B: Mood evaluation

Please answer the question: "**What mood response do you associate with the colour in your work area during the last week?"**

Mood response	Not at all	Slightly	Moderately	Quite		Extremely
Annoyed						
Confusion						
Unhappy						
Fatigued						
Energetic						
Nervous						

C -Motivation scale

Rate the effect of the **colours** on your **willingness** to perform tasks:

Not at all	Slightly	Moderately	Quite	Extremely

Rate the effect of the **colours** on your **enthusiasm** to perform tasks:

Not at all	Slightly	Moderately	Quite	Extremely

Section seven: Overall

How would you weight the impact of the following indoor environment quality factors on your productivity at work?

1-**Lighting system**

Not at all	Slightly	Moderately	Quite	Extremely

2-**Sound level**

Not at all	Slightly	Moderately	Quite	Extremely

3-**Air quality**

Not at all	Slightly	Moderately	Quite	Extremely

4-**Thermal conditions**

Not at all	Slightly	Moderately	Quite	Extremely

5-**Layout**

Not at all	Slightly	Moderately	Quite	Extremely

6-**Colour**

Not at all	Slightly	Moderately	Quite	Extremely

Background information

How long have you been working as an academic in an open-plan office?

☐ Less than one year.

☐ From 1 year to 3 years.

☐ More than 3 years.

Has your academic workplace ever been an individual office?

☐ Yes ☐ No

If yes, how do you rate your productivity in an individual office?

Very substandard	Substandard	Moderately	Good	Extremely good

How do you rate your productivity in open-plan office?

Very substandard	Substandard	Moderately	Good	Extremely good

What are the types of work you are involved in?

☐ Teaching (undergraduate or postgraduate)

☐ Collaboration work

☐ Reading

☐ Undertaking research

☐ Consultation with students

☐ Staff meeting

☐ Administrative work,

☐ Online meeting

☐ Preparing for study materials

☐ Evaluation and assessment

☐ Others, please clarify _____

_____

Name: _____

Date: _____

Age:

Under 50 years 50 years old over 50 years

Gender:

Male - Female

Academic Field: _____

Academic qualification: _____

APPENDIX 4

Semi-Structured Interview — Quantitative Data

1- Describe your open-plan office.

2- Have you worked in a private office? If yes, compare your productivity between private and open-plan office.

3- What aspect of indoor environment quality affects your work in the office? …. Why do IEQ factors influence your work?

4- Do you think IEQ affects your mood/ motivation? Which one the most and why?

5- Do you think this kind of office is suitable for your work activates as academic?

6- How many hours do you spend in your office?

7- Do you want to add something?

8- Do you think this study has covered all aspects of working in open-plan office?

APPENDIX 5

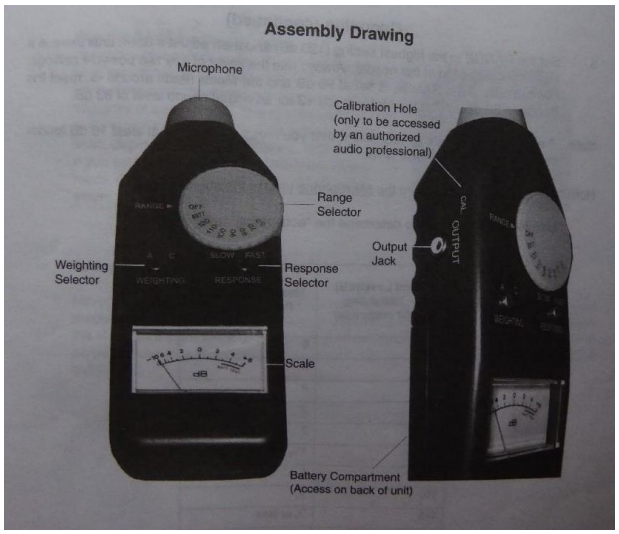
Handhold Devices Details

Lux Meters to measure light intensity light

Measuring Range (Lux)	0 - 20000 Lux, 0 - 40000 Lux, 0 - 100000 Lux, 0- 200000 Lux, 0 - 50000 Lux
Accuracy (%)	3 %, 10 %, 5 %
Resolution (Lux)	100 Lux, 0.1 Lux, 10 Lux, 1 Lux
Model	LX-10
Power	Electric

Digital Carbon Dioxide Temperature Humidity

Measurements:	CO2 level, temperature & Humidity Meter
CO2 Range:	0~9999ppm
Temperature Range:	-10~60°C (14~140°F)
Humidity Range:	0.1% ~ 99.9%RH
Dew Point Range:	-20.0~59.9°C



Sound Level meter

APPENDIX 6

Relationship Between age (< 50, >=50) and Satisfaction, Mood and Motivation with six IEQ Factors

- Satisfaction

Relationship between age (< 50, >=50) and satisfaction with sound level

Chi-Square Tests

Building		Value	df	Asymp. Sig. (2-sided)
T & L	Pearson Chi-Square	7.259	4	.123
	Likelihood Ratio	7.897	4	.095
	Linear-by-Linear Association	1.443	1	.230
	N of Valid Cases	20		
CUSP	Pearson Chi-Square	5.155	3	.161
	Likelihood Ratio	5.606	3	.132
	Linear-by-Linear Association	2.401	1	.121
	N of Valid Cases	19		
CIT	Pearson Chi-Square	4.283	4	.369
	Likelihood Ratio	4.787	4	.310
	Linear-by-Linear Association	2.824	1	.093
	N of Valid Cases	34		

Relationship between age (< 50, >=50) and satisfaction with air quality

Chi-Square Tests

Building		Value	df	Asymp. Sig. (2-sided)
T & L	Pearson Chi-Square	5.778	5	.328
	Likelihood Ratio	7.217	5	.205
	Linear-by-Linear Association	.032	1	.858
	N of Valid Cases	20		
CUSP	Pearson Chi-Square	2.249	4	.690
	Likelihood Ratio	2.637	4	.620
	Linear-by-Linear Association	.273	1	.601
	N of Valid Cases	19		

CIT	Pearson Chi-Square	1.033	4	.905
	Likelihood Ratio	1.399	4	.844
	Linear-by-Linear Association	.109	1	.741
	N of Valid Cases	33		

Relationship between age (< 50, >=50) and satisfaction with thermal conditions

Chi-Square Tests

Building		Value	df	Asymp. Sig. (2-sided)
T & L	Pearson Chi-Square	.533	3	.912
	Likelihood Ratio	.773	3	.856
	Linear-by-Linear Association	.295	1	.587
	N of Valid Cases	20		
CUSP	Pearson Chi-Square	4.505	3	.212
	Likelihood Ratio	5.409	3	.144
	Linear-by-Linear Association	2.929	1	.087
	N of Valid Cases	19		
CIT	Pearson Chi-Square	11.276	5	.056
	Likelihood Ratio	13.706	5	.018
	Linear-by-Linear Association	.526	1	.468
	N of Valid Cases	34		

Relationship between age (< 50, >=50) and satisfaction with colours

Chi-Square Tests

Building		Value	df	Asymp. Sig. (2-sided)
T & L	Pearson Chi-Square	5.067	4	.281
	Likelihood Ratio	6.032	4	.197
	Linear-by-Linear Association	.000	1	1.000
	N of Valid Cases	20		
CUSP	Pearson Chi-Square	4.950	5	.422
	Likelihood Ratio	6.820	5	.234
	Linear-by-Linear Association	.538	1	.463
	N of Valid Cases	18		
CIT	Pearson Chi-Square	.745	4	.946
	Likelihood Ratio	.745	4	.946

	Linear-by-Linear Association	.074	1	.786
	N of Valid Cases	34		

Relationship between age (< 50, >=50) and satisfaction with office layout

Chi-Square Tests

Building		Value	df	Asymp. Sig. (2-sided)
T & L	Pearson Chi-Square	5.067	4	.281
	Likelihood Ratio	6.032	4	.197
	Linear-by-Linear Association	.000	1	1.000
	N of Valid Cases	20		
CUSP	Pearson Chi-Square	4.950	5	.422
	Likelihood Ratio	6.820	5	.234
	Linear-by-Linear Association	.538	1	.463
	N of Valid Cases	18		
CIT	Pearson Chi-Square	.745	4	.946
	Likelihood Ratio	.745	4	.946
	Linear-by-Linear Association	.074	1	.786
	N of Valid Cases	34		

-Mood

Relationship between age (< 50, >=50) and mood evoked by overall lighting level

Chi-Square Tests

Building		Value	df	Asymp. Sig. (2-sided)
T & L	Pearson Chi-Square	5.600	8	.692
	Likelihood Ratio	6.766	8	.562
	Linear-by-Linear Association	.004	1	.947
	N of Valid Cases	20		
CUSP	Pearson Chi-Square	5.130	6	.527
	Likelihood Ratio	6.939	6	.327

	Linear-by-Linear Association	2.876	1	.090
	N of Valid Cases	19		
CIT	Pearson Chi-Square	9.129	8	.331
	Likelihood Ratio	11.801	8	.160
	Linear-by-Linear Association	1.185	1	.276
	N of Valid Cases	34		

Relationship between age (< 50, >=50) and mood evoked by sound level

Chi-Square Tests

Building		Value	df	Asymp. Sig. (2-sided)
T & L	Pearson Chi-Square	4.711	11	.944
	Likelihood Ratio	6.399	11	.845
	Linear-by-Linear Association	.360	1	.548
	N of Valid Cases	20		
CUSP	Pearson Chi-Square	14.214	12	.287
	Likelihood Ratio	19.272	12	.082
	Linear-by-Linear Association	.447	1	.504
	N of Valid Cases	19		
CIT	Pearson Chi-Square	14.395	14	.421
	Likelihood Ratio	18.972	14	.166
	Linear-by-Linear Association	1.920	1	.166
	N of Valid Cases	34		

Relationship between age (< 50, >=50) and mood evoked by air quality

Chi-Square Tests

Building		Value	df	Asymp. Sig. (2-sided)
T & L	Pearson Chi-Square	8.000	6	.238
	Likelihood Ratio	8.997	6	.174
	Linear-by-Linear Association	.763	1	.383
	N of Valid Cases	20		
CUSP	Pearson Chi-Square	4.505	6	.609
	Likelihood Ratio	5.950	6	.429

	Linear-by-Linear Association	2.154	1	.142
	N of Valid Cases	19		
CIT	Pearson Chi-Square	9.241	12	.682
	Likelihood Ratio	12.595	12	.399
	Linear-by-Linear Association	3.801	1	.051
	N of Valid Cases	34		

Relationship between age (< 50, >=50) and mood evoked by thermal conditions

Chi-Square Tests

Building		Value	df	Asymp. Sig. (2-sided)
T & L	Pearson Chi-Square	8.000	6	.238
	Likelihood Ratio	8.997	6	.174
	Linear-by-Linear Association	.763	1	.383
	N of Valid Cases	20		
CUSP	Pearson Chi-Square	4.505	6	.609
	Likelihood Ratio	5.950	6	.429
	Linear-by-Linear Association	2.154	1	.142
	N of Valid Cases	19		
CIT	Pearson Chi-Square	9.241	12	.682
	Likelihood Ratio	12.595	12	.399
	Linear-by-Linear Association	3.801	1	.051
	N of Valid Cases	34		

Relationship between age (< 50, >=50) and mood evoked by colours

Chi-Square Tests

Building		Value	df	Asymp. Sig. (2-sided)
T & L	Pearson Chi-Square	3.407	2	.182
	Likelihood Ratio	3.424	2	.181
	Linear-by-Linear Association	2.433	1	.119
	N of Valid Cases	20		

CUSP	Pearson Chi-Square	1.907	4	.753
	Likelihood Ratio	2.637	4	.620
	Linear-by-Linear Association	.778	1	.378
	N of Valid Cases	19		
CIT	Pearson Chi-Square	9.075	6	.169
	Likelihood Ratio	12.054	6	.061
	Linear-by-Linear Association	1.254	1	.263
	N of Valid Cases	34		

Relationship between age (< 50, >=50) and mood evoked by office layout

Chi-Square Tests

Building		Value	df	Asymp. Sig. (2-sided)
T & L	Pearson Chi-Square	3.378	9	.947
	Likelihood Ratio	4.673	9	.862
	Linear-by-Linear Association	1.229	1	.268
	N of Valid Cases	20		
CUSP	Pearson Chi-Square	12.847	10	.232
	Likelihood Ratio	17.546	10	.063
	Linear-by-Linear Association	2.116	1	.146
	N of Valid Cases	19		
CIT	Pearson Chi-Square	14.685	12	.259
	Likelihood Ratio	19.903	12	.069
	Linear-by-Linear Association	1.039	1	.308
	N of Valid Cases	34		

-Motivation

Relationship between age (< 50, >=50) and the degree to which lighting level impacts motivation to perform tasks

Chi-Square Tests

Building		Value	df	Asymp. Sig. (2-sided)
T & L	Pearson Chi-Square	6.489	6	.371
	Likelihood Ratio	8.125	6	.229
	Linear-by-Linear Association	.413	1	.520
	N of Valid Cases	20		

A

CUSP	Pearson Chi-Square	7.200	7	.408
	Likelihood Ratio	9.821	7	.199
	Linear-by-Linear Association	.651	1	.420
	N of Valid Cases	18		
CIT	Pearson Chi-Square	14.115	7	.059
	Likelihood Ratio	17.497	7	.014
	Linear-by-Linear Association	1.458	1	.227
	N of Valid Cases	34		

Relationship between age (< 50, >=50) and the degree to which sound level impacts motivation to perform tasks

Chi-Square Tests

Building		Value	df	Asymp. Sig. (2-sided)
T & L	Pearson Chi-Square	9.333	7	.230
	Likelihood Ratio	11.036	7	.137
	Linear-by-Linear Association	.011	1	.918
	N of Valid Cases	20		
CUSP	Pearson Chi-Square	2.454	6	.874
	Likelihood Ratio	3.178	6	.786
	Linear-by-Linear Association	.124	1	.725
	N of Valid Cases	19		
CIT	Pearson Chi-Square	5.945	8	.653
	Likelihood Ratio	7.846	8	.449
	Linear-by-Linear Association	.165	1	.684
	N of Valid Cases	34		

Relationship between age (< 50, >=50) the degree to which air quality impacts motivation to perform tasks

Chi-Square Tests

Building		Value	df	Asymp. Sig. (2-sided)
T & L	Pearson Chi-Square	4.000	7	.780
	Likelihood Ratio	5.491	7	.600
	Linear-by-Linear Association	.305	1	.581
	N of Valid Cases	20		

A

CUSP	Pearson Chi-Square	3.958	7	.785
	Likelihood Ratio	5.042	7	.655
	Linear-by-Linear Association	.198	1	.656
	N of Valid Cases	19		
CIT	Pearson Chi-Square	12.219	8	.142
	Likelihood Ratio	15.350	8	.053
	Linear-by-Linear Association	.794	1	.373
	N of Valid Cases	34		

Relationship between age (< 50, >=50) and the degree to which thermal conditions impact motivation to perform tasks

Chi-Square Tests

Building		Value	df	Asymp. Sig. (2-sided)
T & L	Pearson Chi-Square	9.206	6	.162
	Likelihood Ratio	10.160	6	.118
	Linear-by-Linear Association	.029	1	.864
	N of Valid Cases	20		
CUSP	Pearson Chi-Square	9.086	4	.059
	Likelihood Ratio	10.552	4	.032
	Linear-by-Linear Association	3.985	1	.046
	N of Valid Cases	19		
CIT	Pearson Chi-Square	10.301	7	.172
	Likelihood Ratio	13.678	7	.057
	Linear-by-Linear Association	1.640	1	.200
	N of Valid Cases	34		

Relationship between age (< 50, >=50) and the degree to which environmental colours impact motivation to perform tasks

Chi-Square Tests

Building		Value	df	Asymp. Sig. (2-sided)
T & L	Pearson Chi-Square	4.667[a]	6	.587
	Likelihood Ratio	6.363	6	.384
	Linear-by-Linear Association	.002	1	.960
	N of Valid Cases	20		

A

CUSP	Pearson Chi-Square	5.140[b]	4	.273
	Likelihood Ratio	6.259	4	.181
	Linear-by-Linear Association	.777	1	.378
	N of Valid Cases	19		
CIT	Pearson Chi-Square	**11.962[c]**	**4**	**.018**
	Likelihood Ratio	14.758	4	.005
	Linear-by-Linear Association	.009	1	.926
	N of Valid Cases	34		

Relationship between age (< 50, >=50) and the degree to which the office layout impacts motivation to perform tasks

Chi-Square Tests

Building		Value	df	Asymp. Sig. (2-sided)
T & L	Pearson Chi-Square	9.511	8	.301
	Likelihood Ratio	10.898	8	.208
	Linear-by-Linear Association	.450	1	.502
	N of Valid Cases	20		
CUSP	Pearson Chi-Square	4.105	5	.534
	Likelihood Ratio	5.213	5	.390
	Linear-by-Linear Association	.039	1	.844
	N of Valid Cases	19		
CIT	Pearson Chi-Square	3.057	6	.802
	Likelihood Ratio	3.808	6	.703
	Linear-by-Linear Association	.168	1	.682
	N of Valid Cases	34		

A

APPENDIX 7

Relationship Between Gender and Satisfaction, Mood and Motivation with six IEQ Factors

-Satisfaction

Relationship between gender and satisfaction with sound level

Chi-Square Tests

Building		Value	df	Asymp. Sig. (2-sided)
T & L	Pearson Chi-Square	2.667	4	.615
	Likelihood Ratio	3.765	4	.439
	Linear-by-Linear Association	1.443	1	.230
	N of Valid Cases	20		
CUSP	Pearson Chi-Square	2.801	3	.423
	Likelihood Ratio	2.703	3	.440
	Linear-by-Linear Association	1.241	1	.265
	N of Valid Cases	19		
CIT	Pearson Chi-Square	4.172	4	.383
	Likelihood Ratio	4.466	4	.347
	Linear-by-Linear Association	1.090	1	.297
	N of Valid Cases	34		

Relationship between gender and satisfaction with air quality

Chi-Square Tests

Building		Value	df	Asymp. Sig. (2-sided)
T & L	Pearson Chi-Square	4.593	5	.468
	Likelihood Ratio	6.309	5	.277
	Linear-by-Linear Association	2.578	1	.108
	N of Valid Cases	20		
CUSP	Pearson Chi-Square	3.958	4	.412
	Likelihood Ratio	5.337	4	.254
	Linear-by-Linear Association	3.295	1	.069

A

	N of Valid Cases	19		
CIT	Pearson Chi-Square	5.607	4	.230
	Likelihood Ratio	5.620	4	.229
	Linear-by-Linear Association	1.544	1	.214
	N of Valid Cases	33		

Relationship between gender and satisfaction with thermal conditions

Chi-Square Tests

Building		Value	df	Asymp. Sig. (2-sided)
T & L	Pearson Chi-Square	.533	3	.912
	Likelihood Ratio	.773	3	.856
	Linear-by-Linear Association	.295	1	.587
	N of Valid Cases	20		
CUSP	Pearson Chi-Square	6.658	3	.084
	Likelihood Ratio	8.423	3	.038
	Linear-by-Linear Association	2.056	1	.152
	N of Valid Cases	19		
CIT	Pearson Chi-Square	4.399	5	.493
	Likelihood Ratio	4.478	5	.483
	Linear-by-Linear Association	1.085	1	.298
	N of Valid Cases	34		

Relationship between gender and satisfaction with colours

Chi-Square Tests

Building		Value	df	Asymp. Sig. (2-sided)
T & L	Pearson Chi-Square	8.148	4	.086
	Likelihood Ratio	10.128	4	.038
	Linear-by-Linear Association	.239	1	.625
	N of Valid Cases	20		
CUSP	Pearson Chi-Square	3.500	5	.623
	Likelihood Ratio	5.004	5	.415
	Linear-by-Linear Association	.054	1	.817

A

	N of Valid Cases	18		
CIT	Pearson Chi-Square	5.434	4	.246
	Likelihood Ratio	5.286	4	.259
	Linear-by-Linear Association	.012	1	.913
	N of Valid Cases	34		

Relationship between gender and satisfaction with office layout

Chi-Square Tests

Building		Value	df	Asymp. Sig. (2-sided)
T & L	Pearson Chi-Square	5.600	5	.347
	Likelihood Ratio	6.766	5	.239
	Linear-by-Linear Association	1.173	1	.279
	N of Valid Cases	20		
CUSP	Pearson Chi-Square	5.501	3	.139
	Likelihood Ratio	7.063	3	.070
	Linear-by-Linear Association	2.252	1	.133
	N of Valid Cases	19		
CIT	Pearson Chi-Square	4.384	4	.356
	Likelihood Ratio	5.693	4	.223
	Linear-by-Linear Association	.258	1	.611
	N of Valid Cases	34		

- Mood

Relationship between gender and mood evoked by overall lighting level

Chi-Square Tests

Building		Value	df	Asymp. Sig. (2-sided)
T & L	Pearson Chi-Square	8.000	8	.433
	Likelihood Ratio	9.677	8	.288
	Linear-by-Linear Association	.358	1	.549
	N of Valid Cases	20		
CUSP	Pearson Chi-Square	3.352	6	.764
	Likelihood Ratio	4.774	6	.573

	Linear-by-Linear Association	1.825	1	.177
	N of Valid Cases	19		
CIT	Pearson Chi-Square	6.215	8	.623
	Likelihood Ratio	6.925	8	.545
	Linear-by-Linear Association	.012	1	.911
	N of Valid Cases	34		

Relationship between gender and mood evoked by sound level

Chi-Square Tests

Building		Value	df	Asymp. Sig. (2-sided)
T & L	Pearson Chi-Square	6.844	11	.812
	Likelihood Ratio	8.125	11	.702
	Linear-by-Linear Association	.069	1	.792
	N of Valid Cases	20		
CUSP	Pearson Chi-Square	13.600	12	.327
	Likelihood Ratio	17.107	12	.146
	Linear-by-Linear Association	1.294	1	.255
	N of Valid Cases	19		
CIT	Pearson Chi-Square	16.874	14	.263
	Likelihood Ratio	19.926	14	.132
	Linear-by-Linear Association	.048	1	.827
	N of Valid Cases	34		

Relationship between gender and mood evoked by air quality

Chi-Square Tests

Building		Value	df	Asymp. Sig. (2-sided)
T & L	Pearson Chi-Square	6.667	6	.353
	Likelihood Ratio	8.630	6	.195
	Linear-by-Linear Association	2.014	1	.156
	N of Valid Cases	20		
CUSP	Pearson Chi-Square	8.047	6	.235
	Likelihood Ratio	10.377	6	.110
	Linear-by-Linear Association	.933	1	.334

A

	N of Valid Cases	19		
CIT	Pearson Chi-Square	10.024	12	.614
	Likelihood Ratio	11.940	12	.451
	Linear-by-Linear Association	.075	1	.784
	N of Valid Cases	34		

Relationship between gender and mood evoked by thermal conditions

Chi-Square Tests

Building		Value	df	Asymp. Sig. (2-sided)
T & L	Pearson Chi-Square	6.667	6	.353
	Likelihood Ratio	8.630	6	.195
	Linear-by-Linear Association	2.014	1	.156
	N of Valid Cases	20		
CUSP	Pearson Chi-Square	8.047	6	.235
	Likelihood Ratio	10.377	6	.110
	Linear-by-Linear Association	.933	1	.334
	N of Valid Cases	19		
CIT	Pearson Chi-Square	10.024	12	.614
	Likelihood Ratio	11.940	12	.451
	Linear-by-Linear Association	.075	1	.784
	N of Valid Cases	34		

Relationship between gender and mood evoked by colours

Chi-Square Tests

Building		Value	df	Asymp. Sig. (2-sided)
T & L	Pearson Chi-Square	3.407	2	.182
	Likelihood Ratio	3.424	2	.181
	Linear-by-Linear Association	2.433	1	.119
	N of Valid Cases	20		
CUSP	Pearson Chi-Square	4.344	4	.361
	Likelihood Ratio	5.650	4	.227

A

	Linear-by-Linear Association	.592	1	.442
	N of Valid Cases	19		
CIT	Pearson Chi-Square	7.194	6	.303
	Likelihood Ratio	9.579	6	.144
	Linear-by-Linear Association	.950	1	.330
	N of Valid Cases	34		

Relationship between gender and mood evoked by office layout

Chi-Square Tests

Building		Value	df	Asymp. Sig. (2-sided)
T & L	Pearson Chi-Square	11.733	9	.229
	Likelihood Ratio	12.991	9	.163
	Linear-by-Linear Association	.031	1	.861
	N of Valid Cases	20		
CUSP	Pearson Chi-Square	10.129	10	.429
	Likelihood Ratio	12.609	10	.246
	Linear-by-Linear Association	2.556	1	.110
	N of Valid Cases	19		
CIT	Pearson Chi-Square	12.348	12	.418
	Likelihood Ratio	13.586	12	.328
	Linear-by-Linear Association	.693	1	.405
	N of Valid Cases	34		

- Motivation

Relationship between gender and the degree to which lighting level impacts motivation to perform tasks

Chi-Square Tests

Building		Value	df	Asymp. Sig. (2-sided)
T & L	Pearson Chi-Square	2.933	6	.817
	Likelihood Ratio	3.765	6	.708
	Linear-by-Linear Association	1.020	1	.312
	N of Valid Cases	20		

A

CUSP	Pearson Chi-Square	6.750	7	.455
	Likelihood Ratio	9.052	7	.249
	Linear-by-Linear Association	.045	1	.832
	N of Valid Cases	18		
CIT	Pearson Chi-Square	7.259	7	.402
	Likelihood Ratio	8.040	7	.329
	Linear-by-Linear Association	.910	1	.340
	N of Valid Cases	34		

Relationship between gender and the degree to which sound level impacts motivation to perform tasks

Chi-Square Tests

Building		Value	df	Asymp. Sig. (2-sided)
T & L	Pearson Chi-Square	6.667	7	.464
	Likelihood Ratio	8.264	7	.310
	Linear-by-Linear Association	.011	1	.918
	N of Valid Cases	20		
CUSP	Pearson Chi-Square	3.804	6	.703
	Likelihood Ratio	4.832	6	.566
	Linear-by-Linear Association	.058	1	.809
	N of Valid Cases	19		
CIT	Pearson Chi-Square	5.956	8	.652
	Likelihood Ratio	7.579	8	.476
	Linear-by-Linear Association	1.641	1	.200
	N of Valid Cases	34		

Relationship between gender and the degree to which air quality impacts motivation to perform tasks

Chi-Square Tests

Building		Value	df	Asymp. Sig. (2-sided)
T & L	Pearson Chi-Square	5.778	7	.566
	Likelihood Ratio	7.584	7	.371

	Linear-by-Linear Association	1.836	1	.175
	N of Valid Cases	20		
CUSP	Pearson Chi-Square	5.115	7	.646
	Likelihood Ratio	6.696	7	.461
	Linear-by-Linear Association	1.843	1	.175
	N of Valid Cases	19		
CIT	Pearson Chi-Square	9.273	8	.320
	Likelihood Ratio	9.999	8	.265
	Linear-by-Linear Association	.880	1	.348
	N of Valid Cases	34		

Relationship between gender and the degree to which thermal conditions impact motivation to perform tasks

Chi-Square Tests

Building		Value	df	Asymp. Sig. (2-sided)
T & L	Pearson Chi-Square	4.762	6	.575
	Likelihood Ratio	5.661	6	.462
	Linear-by-Linear Association	.735	1	.391
	N of Valid Cases	20		
CUSP	Pearson Chi-Square	4.344	4	.361
	Likelihood Ratio	4.568	4	.335
	Linear-by-Linear Association	.037	1	.847
	N of Valid Cases	19		
CIT	Pearson Chi-Square	3.394	7	.846
	Likelihood Ratio	4.221	7	.754
	Linear-by-Linear Association	.988	1	.320
	N of Valid Cases	34		

Relationship between gender and the degree to which environmental colours impact motivation to perform tasks

Chi-Square Tests

Building		Value	df	Asymp. Sig. (2-sided)
T & L	Pearson Chi-Square	2.444	6	.875

	Likelihood Ratio	3.591	6	.732
	Linear-by-Linear Association	.721	1	.396
	N of Valid Cases	20		
CUSP	Pearson Chi-Square	4.851	4	.303
	Likelihood Ratio	5.682	4	.224
	Linear-by-Linear Association	.775	1	.379
	N of Valid Cases	19		
CIT	Pearson Chi-Square	**10.709**	**4**	**.030**
	Likelihood Ratio	13.473	4	.009
	Linear-by-Linear Association	.175	1	.676
	N of Valid Cases	34		

Relationship between gender and the degree to which the office layout impacts motivation to perform tasks

Chi-Square Tests

Building		Value	df	Asymp. Sig. (2-sided)
T & L	Pearson Chi-Square	7.733	8	.460
	Likelihood Ratio	9.172	8	.328
	Linear-by-Linear Association	.216	1	.642
	N of Valid Cases	20		
CUSP	Pearson Chi-Square	4.509	5	.479
	Likelihood Ratio	5.820	5	.324
	Linear-by-Linear Association	1.578	1	.209
	N of Valid Cases	19		
CIT	Pearson Chi-Square	3.063	6	.801
	Likelihood Ratio	3.542	6	.738
	Linear-by-Linear Association	.058	1	.809
	N of Valid Cases	34		

APPENDIX 8

Relationship between Years Working as an Academic' (< 1 year, 1 – 3 years, > 3 years) and Satisfaction, Mood and Motivation with six IEQ Factors

-Satiation

Relationship between 'years working as an academic' (< 1 year, 1 – 3 years, > 3 years) and satisfaction with sound level

Chi-Square Tests

Building		Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)	Point Probability
T & L	Pearson Chi-Square	22.231	8	.005	.039		
	Likelihood Ratio	10.691	8	.220	.177		
	Fisher's Exact Test	10.725			.193		
	Linear-by-Linear Association	1.940	1	.164	.183	.118	.054
	N of Valid Cases	20					
CUSP	Pearson Chi-Square	6.821	6	.338	.393		
	Likelihood Ratio	5.878	6	.437	.587		
	Fisher's Exact Test	5.849			.545		
	Linear-by-Linear Association	.830	1	.362	.457	.238	.093
	N of Valid Cases	19					
CIT	Pearson Chi-Square	4.610	8	.798	.738		
	Likelihood Ratio	4.111	8	.847	.860		
	Fisher's Exact Test	8.708			.576		
	Linear-by-Linear Association	.652	1	.419	.497	.255	.087
	N of Valid Cases	34					

Relationship between 'years working as an academic' (< 1 year, 1 – 3 years, > 3 years) and satisfaction with air quality

Chi-Square Tests

Building		Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)	Point Probability
T & L	Pearson Chi-Square	4.389	10	.928	.913		
	Likelihood Ratio	5.629	10	.845	.913		
	Fisher's Exact Test	9.201			.887		
	Linear-by-Linear Association	.998	1	.318	.362	.210	.081
	N of Valid Cases	20					
CUSP	Pearson Chi-Square	5.846	8	.664	.805		
	Likelihood Ratio	5.337	8	.721	.858		
	Fisher's Exact Test	7.011			.858		
	Linear-by-Linear Association	.981	1	.322	.354	.214	.086
	N of Valid Cases	19					
CIT	Pearson Chi-Square	4.724	8	.787	.704		
	Likelihood Ratio	5.027	8	.755	.802		
	Fisher's Exact Test	7.650			.703		
	Linear-by-Linear Association	.870	1	.351	.454	.226	.089
	N of Valid Cases	33					

Relationship between 'years working as an academic' (< 1 year, 1 – 3 years, > 3 years) and satisfaction with thermal conditions

Chi-Square Tests

Building		Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)	Point Probability
T & L	Pearson Chi-Square	3.517	6	.742	.807		
	Likelihood Ratio	3.488	6	.746	.907		
	Fisher's Exact Test	5.185			.853		
	Linear-by-Linear Association	.007	1	.933	1.000	.523	.158
	N of Valid Cases	20					
CUSP	Pearson Chi-Square	4.209	6	.648	.674		
	Likelihood Ratio	4.832	6	.566	.674		
	Fisher's Exact Test	4.689			.807		
	Linear-by-Linear Association	1.459	1	.227	.262	.162	.083
	N of Valid Cases	19					
CIT	Pearson Chi-Square	13.053	10	.221	.206		

	Likelihood Ratio	13.339	10	.205	.081		
	Fisher's Exact Test	14.588			.096		
	Linear-by-Linear Association	.066	1	.797	.878	.468	.119
	N of Valid Cases	34					

Relationship between 'years working as an academic' (< 1 year, 1 – 3 years, > 3 years) and satisfaction with colours

Chi-Square Tests

Building		Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)	Point Probability
T & L	Pearson Chi-Square	12.770	8	.120	.128		
	Likelihood Ratio	11.716	8	.164	.093		
	Fisher's Exact Test	12.605			.086		
	Linear-by-Linear Association	.093	1	.761	.850	.422	.131
	N of Valid Cases	20					
CUSP	Pearson Chi-Square	4.367	10	.929	.917		
	Likelihood Ratio	5.912	10	.823	.917		
	Fisher's Exact Test	8.370			1.000		
	Linear-by-Linear Association	.161	1	.688	.795	.425	.106
	N of Valid Cases	18					
CIT	Pearson Chi-Square	3.454	8	.903	.870		
	Likelihood Ratio	3.747	8	.879	.949		
	Fisher's Exact Test	7.063			.761		
	Linear-by-Linear Association	.029	1	.865	1.000	.539	.144
	N of Valid Cases	34					

Relationship between 'years working as an academic' (< 1 year, 1 – 3 years, > 3 years) and satisfaction with office layout

Chi-Square Tests

Building		Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)	Point Probability
T & L	Pearson Chi-Square	10.544	10	.394	.382		

	Likelihood Ratio	6.904	10	.734	.805		
	Fisher's Exact Test	10.165			.772		
	Linear-by-Linear Association	.454	1	.500	.621	.313	.109
	N of Valid Cases	20					
CUSP	Pearson Chi-Square	2.582	6	.859	1.000		
	Likelihood Ratio	2.739	6	.841	1.000		
	Fisher's Exact Test	3.514			1.000		
	Linear-by-Linear Association	.169	1	.681	.770	.408	.110
	N of Valid Cases	19					
CIT	Pearson Chi-Square	5.900	8	.658	.794		
	Likelihood Ratio	6.433	8	.599	.754		
	Fisher's Exact Test	6.433			.829		
	Linear-by-Linear Association	.068	1	.794	.888	.457	.109
	N of Valid Cases	34					

-Mood

Relationship between 'years working as an academic' (< 1 year, 1 – 3 years, > 3 years) and mood evoked by overall lighting level

Chi-Square Tests

Building		Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)	Point Probability
T & L	Pearson Chi-Square	8.900	16	.917	.918		
	Likelihood Ratio	8.997	16	.914	.939		
	Fisher's Exact Test	16.558			.939		
	Linear-by-Linear Association	.000	1	.983	.964	.508	.004
	N of Valid Cases	20					

CUSP	Pearson Chi-Square	5.011	12	.958	.975		
	Likelihood Ratio	6.362	12	.897	.975		
	Fisher's Exact Test	9.876			1.000		
	Linear-by-Linear Association	1.924	1	.165	.181	.075	.018
	N of Valid Cases	19					
CIT	Pearson Chi-Square	10.363	16	.847	.713		
	Likelihood Ratio	8.507	16	.932	.701		
	Fisher's Exact Test	20.999			.655		
	Linear-by-Linear Association	.296	1	.587	.604	.355	.008
	N of Valid Cases	34					

Relationship between 'years working as an academic' (< 1 year, 1 – 3 years, > 3 years) and mood evoked by sound level

Chi-Square Tests

Building		Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)	Point Probability
T & L	Pearson Chi-Square	14.211	22	.894	.887		
	Likelihood Ratio	13.129	22	.929	.945		
	Fisher's Exact Test	25.519			.935		
	Linear-by-Linear Association	.506	1	.477	.523	.272	.008
	N of Valid Cases	20					
CUSP	Pearson Chi-Square	23.092	24	.514	.562		
	Likelihood Ratio	22.514	24	.549	.411		
	Fisher's Exact Test	30.362			.411		
	Linear-by-Linear Association	.769	1	.381	.405	.209	.009
	N of Valid Cases	19					
CIT	Pearson Chi-Square	27.601	28	.486	.458		
	Likelihood Ratio	20.216	28	.856	.292		
	Fisher's Exact Test	38.313			.243		
	Linear-by-Linear Association	.064	1	.800	.830	.457	.030
	N of Valid Cases	34					

Relationship between 'years working as an academic' (< 1 year, 1 – 3 years, > 3 years) and mood evoked by air quality

Chi-Square Tests

Building		Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)	Point Probability
T & L	Pearson Chi-Square	6.625	12	.881	.860		
	Likelihood Ratio	7.410	12	.829	.913		
	Fisher's Exact Test	11.700			.886		
	Linear-by-Linear Association	1.073	1	.300	.360	.199	.036
	N of Valid Cases	20					
CUSP	Pearson Chi-Square	10.348	12	.585	.714		
	Likelihood Ratio	11.965	12	.449	.535		
	Fisher's Exact Test	12.819			.615		
	Linear-by-Linear Association	.927	1	.336	.358	.176	.009
	N of Valid Cases	19					
CIT	Pearson Chi-Square	23.815	24	.472	.444		
	Likelihood Ratio	13.025	24	.966	.606		
	Fisher's Exact Test	34.120			.502		
	Linear-by-Linear Association	.345	1	.557	.596	.321	.029
	N of Valid Cases	34					

Relationship between 'years working as an academic' (< 1 year, 1 – 3 years, > 3 years) and mood evoked by thermal conditions

Chi-Square Tests

Building		Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)	Point Probability
T & L	Pearson Chi-Square	6.625	12	.881	.860		
	Likelihood Ratio	7.410	12	.829	.913		
	Fisher's Exact Test	11.700			.886		
	Linear-by-Linear Association	1.073	1	.300	.360	.199	.036
	N of Valid Cases	20					

CUSP	Pearson Chi-Square	10.348	12	.585	.714		
	Likelihood Ratio	11.965	12	.449	.535		
	Fisher's Exact Test	12.819			.615		
	Linear-by-Linear Association	.927	1	.336	.358	.176	.009
	N of Valid Cases	19					
CIT	Pearson Chi-Square	23.815	24	.472	.444		
	Likelihood Ratio	13.025	24	.966	.606		
	Fisher's Exact Test	34.120			.502		
	Linear-by-Linear Association	.345	1	.557	.596	.321	.029
	N of Valid Cases	34					

Relationship between 'years working as an academic' (< 1 year, 1 – 3 years, > 3 years) and mood evoked by colours

Chi-Square Tests

Building		Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)	Point Probability
T & L	Pearson Chi-Square	4.463	4	.347	.447		
	Likelihood Ratio	3.929	4	.416	.447		
	Fisher's Exact Test	6.337			.447		
	Linear-by-Linear Association	1.216	1	.270	.250	.250	.158
	N of Valid Cases	20					
CUSP	Pearson Chi-Square	1.997	8	.981	1.000		
	Likelihood Ratio	2.739	8	.950	1.000		
	Fisher's Exact Test	6.503			1.000		
	Linear-by-Linear Association	.221	1	.639	.694	.383	.073
	N of Valid Cases	19					
CIT	Pearson Chi-Square	4.001	12	.983	.726		
	Likelihood Ratio	4.130	12	.981	.847		
	Fisher's Exact Test	14.641			.675		
	Linear-by-Linear Association	.078	1	.780	.838	.509	.034
	N of Valid Cases	34					

Relationship between 'years working as an academic' (< 1 year, 1 – 3 years, > 3 years) and mood evoked by office layout

Appendices

Chi-Square Tests

Building		Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)	Point Probability
T & L	Pearson Chi-Square	8.900	18	.962	.972		
	Likelihood Ratio	9.677	18	.942	.972		
	Fisher's Exact Test	18.926			.975		
	Linear-by-Linear Association	1.660	1	.198	.215	.100	.003
	N of Valid Cases	20					
CUSP	Pearson Chi-Square	16.515	20	.684	.737		
	Likelihood Ratio	18.015	20	.586	.553		
	Fisher's Exact Test	24.236			.580		
	Linear-by-Linear Association	1.488	1	.222	.246	.117	.014
	N of Valid Cases	19					
CIT	Pearson Chi-Square	12.645	24	.972	.879		
	Likelihood Ratio	11.213	24	.987	.875		
	Fisher's Exact Test	30.310			.879		
	Linear-by-Linear Association	.059	1	.809	.832	.472	.022
	N of Valid Cases	34					

-Motivation

Relationship between years working as an academic' (< 1 year, 1 – 3 years, > 3 years) and the degree to which lighting level impacts motivation to perform tasks

Chi-Square Tests

Building		Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)	Point Probability
T & L	Pearson Chi-Square	14.178	12	.290	.311		
	Likelihood Ratio	14.176	12	.290	.186		
	Fisher's Exact Test	15.850			.189		
	Linear-by-Linear Association	1.727	1	.189	.211	.113	.028
	N of Valid Cases	20					

CUSP	Pearson Chi-Square	14.150	14	.439	.455		
	Likelihood Ratio	15.505	14	.345	.310		
	Fisher's Exact Test	17.072			.360		
	Linear-by-Linear Association	1.037	1	.308	.370	.185	.041
	N of Valid Cases	18					
CIT	Pearson Chi-Square	18.790	14	.173	.154		
	Likelihood Ratio	15.521	14	.344	.115		
	Fisher's Exact Test	18.756			.135		
	Linear-by-Linear Association	1.297	1	.255	.280	.151	.038
	N of Valid Cases	34					

Relationship between 'years working as an academic' (< 1 year, 1 – 3 years, > 3 years) and the degree to which sound level impacts motivation to perform tasks

Chi-Square Tests

Building		Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)	Point Probability
T & L	Pearson Chi-Square	13.111	14	.518	.604		
	Likelihood Ratio	12.221	14	.589	.539		
	Fisher's Exact Test	15.080			.643		
	Linear-by-Linear Association	.368	1	.544	.598	.319	.056
	N of Valid Cases	20					
CUSP	Pearson Chi-Square	9.354	12	.672	.726		
	Likelihood Ratio	10.918	12	.536	.601		
	Fisher's Exact Test	12.819			.616		
	Linear-by-Linear Association	.149	1	.699	.752	.386	.057
	N of Valid Cases	19					
CIT	Pearson Chi-Square	19.858	16	.227	.247		
	Likelihood Ratio	14.071	16	.593	.288		
	Fisher's Exact Test	20.422			.267		

	Linear-by-Linear Association	.025	1	.874	.938	.479	.067
	N of Valid Cases	34					

Relationship between 'years working as an academic' (< 1 year, 1 – 3 years, > 3 years) and the degree to which air quality impacts motivation to perform tasks

Chi-Square Tests

Building		Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)	Point Probability
T & L	Pearson Chi-Square	10.611	14	.716	.756		
	Likelihood Ratio	11.680	14	.632	.619		
	Fisher's Exact Test	15.527			.579		
	Linear-by-Linear Association	.737	1	.391	.461	.234	.048
	N of Valid Cases	20					
CUSP	Pearson Chi-Square	12.131	14	.596	.634		
	Likelihood Ratio	13.150	14	.515	.644		
	Fisher's Exact Test	15.846			.644		
	Linear-by-Linear Association	1.076	1	.300	.338	.178	.035
	N of Valid Cases	19					
CIT	Pearson Chi-Square	13.920	16	.605	.436		
	Likelihood Ratio	12.381	16	.717	.328		
	Fisher's Exact Test	22.503			.346		
	Linear-by-Linear Association	3.102	1	.078	.077	.039	.009
	N of Valid Cases	34					

Relationship between 'years working as an academic' (< 1 year, 1 – 3 years, > 3 years) and the degree to which thermal conditions impact motivation to perform tasks

Chi-Square Tests

Building		Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)	Point Probability
T & L	Pearson Chi-Square	15.361	12	.222	.248		
	Likelihood Ratio	13.634	12	.325	.176		
	Fisher's Exact Test	16.434			.124		

	Linear-by-Linear Association	1.419	1	.234	.256	.138	.036
	N of Valid Cases	20					
CUSP	Pearson Chi-Square	3.459	8	.902	1.000		
	Likelihood Ratio	3.785	8	.876	1.000		
	Fisher's Exact Test	6.119			1.000		
	Linear-by-Linear Association	.214	1	.644	.745	.374	.081
	N of Valid Cases	19					
CIT	Pearson Chi-Square	22.159	14	.075	.112		
	Likelihood Ratio	17.247	14	.243	.055		
	Fisher's Exact Test	20.507			.055		
	Linear-by-Linear Association	4.421	1	.035	.031	.015	.007
	N of Valid Cases	34					

Relationship between 'years working as an academic' (< 1 year, 1 – 3 years, > 3 years) and the degree to which environmental colours impact motivation to perform tasks

Chi-Square Tests

Building		Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)	Point Probability
T & L	Pearson Chi-Square	7.750	12	.804	.783		
	Likelihood Ratio	8.595	12	.737	.746		
	Fisher's Exact Test	12.275			.862		
	Linear-by-Linear Association	.784	1	.376	.418	.224	.039
	N of Valid Cases	20					
CUSP	Pearson Chi-Square	6.222	8	.622	.618		
	Likelihood Ratio	7.408	8	.493	.561		
	Fisher's Exact Test	8.275			.569		
	Linear-by-Linear Association	.000	1	.988	1.000	.538	.106
	N of Valid Cases	19					
CIT	Pearson Chi-Square	14.538	8	.069	.092		
	Likelihood Ratio	14.336	8	.073	.023		
	Fisher's Exact Test	**13.709**			**.024**		

	Linear-by-Linear Association	.000	1	.986	1.000	.574	.108
	N of Valid Cases	34					

Relationship between 'years working as an academic' (< 1 year, 1 – 3 years, > 3 years) and the degree to which the office layout impacts motivation to perform tasks

Chi-Square Tests

Building		Value	df	Asymp. Sig. (2-sided)	Exact Sig. (2-sided)	Exact Sig. (1-sided)	Point Probability
CT L	Pearson Chi-Square	28.600	16	.027	.074		
	Likelihood Ratio	16.948	16	.389	.181		
	Fisher's Exact Test	21.292			.158		
	Linear-by-Linear Association	.002	1	.962	1.000	.497	.059
	N of Valid Cases	20					
CUSP	Pearson Chi-Square	10.231	10	.420	.450		
	Likelihood Ratio	11.366	10	.330	.304		
	Fisher's Exact Test	12.112			.300		
	Linear-by-Linear Association	1.794	1	.180	.217	.115	.032
	N of Valid Cases	19					
CIT	Pearson Chi-Square	6.291	12	.901	.987		
	Likelihood Ratio	6.604	12	.883	.982		
	Fisher's Exact Test	9.577			.982		
	Linear-by-Linear Association	.472	1	.492	.561	.285	.053
	N of Valid Cases	34					