Université de Montréal

OCCUPANTS' QUALITY OF LIFE EXPERIENCE WITH SUSTAINABLE WORK ENVIRONMENTS:

Using a Mixed-Methods Approach to Develop a Humane and Sustainable Framework for Assessing the Indoor Environmental Quality in Office Buildings

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RESUME

Cette recherche étudie la perception de la qualité de vie (QV) et de la qualité de l'environnement intérieur (QEI) du point de vue des occupants d'espaces de travail certifiés « durables » selon le système d'énergie et de conception environnementale (LEED) et des occupants des immeubles de bureaux conventionnels. Dans cette étude, la QV est définie en termes de santé perçue, confort, et productivité.

La qualité des environnements intérieurs est importante, car les gens passent la majorité de leur vie à l'intérieur des immeubles et, dans notre société contemporaine, plus de ce temps est passé dans des espaces de travail, tels que les espaces de bureaux. Les préoccupations grandissantes pour la durabilité des espaces de vie et la prise de conscience des effets négatifs que des bâtiments peuvent avoir sur les occupants font émerger les constructions dites 'vertes' comme étant des alternatives plus durables.

LEED est le système d'accréditation le plus populaire de nos jours en Amérique du Nord qui évalue les bâtiments verts en terme de leur performance environnementale. Toutefois, la revue de littérature indique que des occupants des édifices de bureaux certifiés LEED ne sont pas toujours satisfaits avec la QEI. Les bâtiments certifiés LEED sont en effet uniquement évalués selon des critères techniques de performance. Pourtant, il y peut avoir des écarts entre les performances mesurées et celles perçues par les occupants. Cela soulève la question suivante: à quel point les bâtiments construits selon les critères LEED prennent-ils en compte la qualité de vie (QoL) et les facteurs humains dans l'évaluation des espaces de travail ? Cette recherche a donc pour but de proposer un nouveau cadre qui prend en considération non seulement des facteurs durables, mais aussi humains pour évaluer les environnements de travail.

Cette recherche utilise une approche mixte – quantitative et qualitative – en trois phases afin d'étudier de manière approfondie la perception de la qualité de vie des occupants de deux bâtiments certifiés LEED et d'un immeuble de bureaux conventionnel. La phase I est dédiée à l'observation des environnements de travail et la documentation des traces d'interaction entre l'utilisateur et l'espace. La phase II est dédiée aux entrevues permettant aux participants de décrire leur expérience de la QV et les facteurs de la QEI qui façonnent leur expérience. Ils

nous aident aussi à identifier les éléments constitutifs d'un environnement humain de travail. Parallèlement, des questionnaires aident à comprendre la relation entre la qualité de vie perçue par les occupants et les facteurs de QEI dérivés de la littérature. À l'aide de groupes de discussion, menés lors de la phase III, nous cherchons à valider les résultats préliminaires. Les données sont ensuite analysées séparément en utilisant la 'triangulation' afin d'interpréter et corroborer les résultats.

Cette étude compare les expériences des espaces de travail « verts » et « conventionnels » et révèle 32 facteurs (30 facteurs QEI et deux autres) qui peuvent affecter de manière significative l'expérience des édifices de bureaux. De plus, des éléments constitutifs d'un environnement de travail humain du point de vue des occupants ont été identifiés. Ceux-ci nous permettent donc de mettre au point un nouveau cadre global, intégrant des critères humains pour évaluer la QEI dans des environnements de travail durables. Ce cadre met en relation la QEI des environnements de travail et la QV des occupants en tant que système environnement-comportement.

Mots-clés: *développement durable, bâtiments verts, LEED, environnements de travail, humain, Qualité des Environnements Intérieurs (QEI), Qualité de Vie (QV*), *occupants de bâtiment.*

ABSTRACT

This research studies perceived Quality of Life (QoL) and Indoor Environmental Quality (IEQ) of occupants' in the work environments of sustainable office buildings certified under the Leadership in Energy and Environmental Design (LEED) system (green buildings) and in conventional office buildings. QoL is defined in this research in terms of perceived health, comfort, and productivity.

The quality of indoor environments is important because people spend most of their time inside buildings, and in contemporary society, much of the time spent in work environments is in office buildings. In this era of growing concerns about sustainability and the increased awareness of buildings' negative impacts on occupants, green buildings have been promoted as sustainable solutions to these issues. LEED is the most popular rating system for measuring the performance of green buildings in North America. However, the literature review indicates that there are user complaints about the IEQ of LEED-certified office buildings. LEED-certified buildings are assessed based on technical measures of building performance. This assessment way may create a gap between measured and perceived performance from the user perspective. This raises the question of whether buildings certified with the LEED criteria are humane from the QoL experience of occupants in office buildings. Hence, this research is therefore to propose a new framework that takes into account not only sustainable but also humane factors for evaluating work environments.

The study uses a mixed-methods approach – using both quantitative and qualitative methods and proceeds in three phases to comprehensively study occupants' perceived QoL experience in two LEED and one conventional office building. Phase I uses observations to document the physical work environment and users' behavioral interactions with the environment. Phase II uses interviews to describe the occupants' QoL experience, explore the possible IEQ factors shaping their QoL, and to define the constructs of a humane work environment. Questionnaires were distributed concurrently to measure the relationship between occupants' perceived QoL and IEQ factors that are derived from the literature. Phase III uses focus groups to converge and focus the results of the study. The results are analyzed separately and triangulated using an integrative mixed-methods analysis to interpret, corroborate, conclude, and increase the validation of the findings.

The study compared occupants' perceived QoL in «green» and «conventional» office buildings and revealed 32 quality factors (30 IEQ factors and two others) that influence the QoL experience in office work environments. Also the constructs of what composes a humane work environment based on occupants' viewpoints have been identified. A new comprehensive, sustainable, and humane framework for assessing IEQ in work environments is developed. This framework guides the relationship between IEQ in work environments and occupants' QoL as an environment-behavior system.

Keywords: *Sustainable development, Green buildings, LEED, work environments, humane, Indoor Environmental Quality (IEQ), Quality of Life (QoL), building occupants.*

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

"The time has come. This is a great moment in which to be an architect or designer. We live in an era in which we have the opportunity to make the strongest contribution in the history of our profession to the health and success of humanity. We are the ushers of sustainability, masters of digital visualization in the service of society, and harbingers of a social perspective that acknowledges the role of the physical environment in our interactions, education, and healing. We are becoming more brilliant in our aspirations, more caring in our endeavors, and more integral to social progress on daily basis."

Mardelle McCuskey Sheply, 2011

OPERATIONAL DEFINITIONS

Quality of Life (QoL): It is defined as "*the degree to which the experience of an individual's life satisfies that individual's wants and needs (both physical and psychological)*" (Rice, 1984). It has subjective and objective measures (Kerce, 1992).

- **Objective measures:** Those are the measures that include physical conditions, and these depend on standards set by experts believing that these standards will satisfy human needs and wants (Kerce, 1992).
- **Subjective measures:** Those are a set of *affective beliefs* perceived by people and depend on individuals themselves in defining their own qualities of life, wants, and needs (Blishen & Atkinson, 1980).

QoL descriptors/Indicators: Perceived health, comfort, and productivity.

- **Health:** "*Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity*" (WHO, 1948)[1].
- **Comfort:** There are different types of environmental comfort perceived by occupants, such as:
  - **Psychological Comfort:** Territoriality, privacy; satisfaction, environmental empowerment (Vischer, 2003).
  - **Functional Comfort:** Workspace designed with environmental elements that support, or fail to support, work (Vischer, 2007).
  - **Physical Comfort:** Health and safety; responsible design decisions; respecting construction standards, comfort standards (Vischer, 2003).
- **Productivity:** Perceived performance and ability to get the work done.

[1] WHO. Preamble to the constitution of the World Health Organization as adopted by the International Health Conference. New York: 19e22 June, 1946; 1948; signed on 22 July 1946 by the representatives of 61 states (Official Records of the World Health Organization, no. 2, p. 100) and entered into force on 7 April 1948.

Satisfaction: According to the definition in the *Oxford English Dictionary*, it is the "*fulfillment of one's wishes, expectations, or needs, or the pleasure derived from this*." (Oxford University Press, 2016). However, in the literature on the assessment of the quality of indoor environments, other definitions are found, such as the desirability or feeling of liking (of an indoor quality) as judged by subjects (occupants) (Lee, 2007).

Sustainable: "*Meets the needs of the present without compromising the ability of future generations to meet their own needs*" (Brundtland, 1987, p.43). Seeks to improve human quality of life while living within the carrying capacity of supporting ecosystems, without depleting the planet's resources so it can be sustained for future generations (IUCN, 1991).

Green Buildings/Sustainable Buildings: Buildings following sustainable design principles in all phases (construction, operations, etc.) to provide "*environmentally responsible, profitable and healthy places to live and work*" (USGBC, 2004).

Green Buildings' Rating Systems: Systems of assessment used to evaluate the environmental performance of green buildings.

LEED-certified buildings: Buildings that achieved the accreditation of LEED® (Leadership in Energy & Environmental Design). LEED is the national benchmark used in USA, as well as widely used in Canada, and **LEED Canada** is the rating system used by Canada Green Building Council (CaGBC).

Workspaces/Office Environment/Work Environment: "*Settings where the primary activities comprise the handling of information and the making of plans and decisions*" (Sundstrom, 1987:733).

Conventional Office Buildings: Typical modern office facilities that are non-green, in the sense that they are designed without sustainable building design intentions.

Indoor Environmental Quality (IEQ)/Environmental Quality (EQ): "*The combination of environmental elements that interact with users of the environment to enable that environment to be the best possible one for the activities that go on in it*" (Vischer, 1989). According to Rapoport (1977), environmental quality is classified into physical and perceived qualities of built environments.

Levels of Meaning in Environmental Quality: Instrumental, latent, and symbolic qualities.

- **Instrumental Qualities:** Represent the physical properties and functional qualities of the environment, enabling the occupants to perform their tasks. Examples include the ambient comfort conditions and ergonomics (Brill, 1984; Davis, 1984; Donald, 1994; Utzinger & Wasely, 1997).
- **Latent Qualities:** Represent the psychological, socio-cultural, and socio-psychological qualities, such as privacy, safety, territoriality, wayfinding, personalization, etc. (Becker, 1990; Ornstein, 1992; Fischer, 1997).
- **Symbolic Qualities:** Qualities that compose the meanings and values related to traditions, beliefs, historical values, pride, culture, etc. (Rapoport, 1983; Turner 1990; Doxtater, 1994).

Humane IEQ/Humane Work Environment: Considers human experience, supporting and fulfilling all different types of human needs by providing the physical material aspects such as: air quality, lighting, and temperature, that are measurable and impacts occupants' physical health, safety, and task performance. Also, supporting the perceived material and immaterial subjective qualities that are perceived by occupants as impacting their psychological, social, and cultural structures (i.e., supporting and respecting occupants' needs in the best way for them to live and work).

Framework: A relationship among different concepts or existing theories.

LIST OF ABBREVIATIONS

QoL: Quality of Life.

QV: Qualité de Vie

QWL: Quality of Work Life

SQoL: Subjective Quality of Life

OQoL: Objective Quality of Life

PQoL: Perceived Quality of Life

IEQ: Indoor Environmental Quality

QEI: Qualité de l'Environment Intérieur

IAQ: Indoor Air Quality

GB: Green Building

GBs: Green Buildings

CaGBC: Canada Green Building Council

USGBC: United States Green Building Council

GBRS: Green Building Rating System

LEED®: Leadership in Energy and Environmental Design

POE: Post Occupancy Evaluation

BPE: Building Performance Evaluation

BIU: Building-In-Use

BEE: Building Environmental Efficiency

BREEAM: Building Research Establishment Environmental Assessment Method

HQE: High Quality Environmental Standard

HK BEAM: Hong Kong Building Environmental Assessment

CASBEE: Comprehensive Assessment System for Building Environmental Efficiency

CBE: Centre of Built Environment

BUS: Building Use Studies

CDC: Child Development Centre.

GLW: The Glenmore Workplace of Tetranex Solutions Inc.

WCB: The Water Centre Building.

CDC-IP1: Child Development Centre - Interview Participant # 1

CDC-IP2: Child Development Centre - Interview Participant # 2

CDC-IP3: Child Development Centre - Interview Participant # 3

GLW-IP1: Glenmore Workplace - Interview Participant # 1

GLW-IP2: Glenmore Workplace - Interview Participant # 2

GLW-IP3: Glenmore Workplace - Interview Participant # 3

GLW-IP4: Glenmore Workplace - Interview Participant # 4

WCB-IP1: Water Centre Building- Interview Participant # 1

WCB-IP2: Water Centre Building- Interview Participant # 2

WCB-IP3: Water Centre Building- Interview Participant # 3

DEDICATION

It is a humble action to serve humanity with the intention of pleasing Allah (GOD) the creator of humanity.

It is personally dedicated with love to my smaller family, my husband Ahmed Eweda, my three girls Kenzy, Saja, and Ruqayyah; and my bigger family, my parents Abdalla Wifi and Samia Naguib, my brother, father and mother in law Mohamed Eweda and Laila Moharram, and sisters in law.

It is also a sincere message to designers, policy makers, business managers, and all who share the same love to design and care to the people.

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"I have studied architecture because I have always loved helping people, and helping them build their dreams was a dream to me. I chose indoor environmental quality specifically to design for peoples' comfort and help in improving their quality of life through humane spaces. This is because we spend more time indoors than anywhere else."

Mariam Wifi

PROLOGUE

> *"I believe that the major justification for the profession of architecture is that it should contribute to the quality of life for people by improving the quality of their physical environment. Without understanding the meaning people give to environments, it is very difficult to know what constitutes 'improvement' or 'quality'"* (Honikman, 1976).

I have always believed that buildings and their spaces are not just the bricks, cement, wood, or concrete that compose them. Habitable buildings are meant for human use. Occupants are the reason for buildings; without people, they would be dead structures of no use. When people are the main focus of designs for habitable buildings, the architect is concerned with the needs of the occupants. The meanings and needs of indoor environments have changed through the ages, from a cave or hut providing shelter and protection from the environment and enemies, to a place for activity fulfillment and even a place for cultural and emotional expressions. Even in ancient times, expressions included examples such as the use of walls to document life scenes and habits in buildings. Architectural history is a witness to human physical and non-physical needs in indoor environments.

I have always been concerned with humans' relation to buildings and how this relationship is shaped, what causes it, and what the consequences of their interactions are. Winston Churchill (1960), has stated that "*we shape our buildings; thereafter they shape us.*" This is also my own belief, and is especially true because people spend most of their lives indoors, whether eating, sleeping, playing, working, studying, or doing any other type of activity. Interaction between humans and the built environment is a well-known fact; places affect us: "*Beyond their biological effects, they make us feel uncomfortable and ill-at-ease, energetic and stimulated or relaxed and at peace…They can work so deeply into our being that they affect our state of health"* (Day, 2002). The quality of buildings' indoor environments is my personal concern. I am passionate about helping to create the qualities that contribute to better human QoL.

1 CHAPTER I: INTRODUCTION

1.1 Problem Statement

The quality of indoor environments is of great importance in the everyday lives of people. According to the U.S. Environmental Protection Agency (EPA) and the U. S. Consumer Product Safety Commission (1995), people spend about 90% of their time indoors. Thus, the Indoor Environmental Quality (IEQ) of buildings may affect occupants' Quality of Life (QoL), since the QoL is impacted by where a person's life is spent, indoor places can affect our QoL physically, psychologically, and functionally. As stated by Day (2002), "*Beyond their biological effects, they make us feel uncomfortable and ill-at-ease, energetic and stimulated or relaxed and at peace . . . They can work so deeply into our being that they affect our state of health.*"

In developed countries, workplaces constitute a major role in the country's economy, and by investing in employees' health, comfort, and satisfaction, companies can improve their productivity. Brown (2008) states that "*the potential cost of lost productivity from poor IEQ has been estimated to exceed building operation costs."* In the literature, the main focus for understanding the workplace is the office, and it is suggested that in the information age,[2] 50% of people working in North American countries such as the USA work in offices (McCoy, 2002). Hence, research on the quality of office work environments is of interest to many research disciplines, including architecture, interior design, environmental design, environment-behavior, environmental psychology fields, and for sustainable development approaches. Sustainable development seeks to improve human QoL while living within the carrying capacity of supporting ecosystems, without depleting the planet's resources so that they will remain for future generations (IUCN, 1991). As human QoL is fundamental within a sustainable development perspective, improving occupants' QoL in sustainable office buildings is a pertinent reflection of such a perspective.

[2] Information age is a term used to describe the post-industrial era as information and information technology became the primary focus of work

Adams (2006) has stated that the *"twenty-first century is widely heralded as the era of sustainability."* This growing interest is compounded by an increasing awareness of the negative environmental impacts that buildings can have on occupants, alongside increased energy consumption, resource depletion, and waste production, all factors related to building construction, operation, and demolition. This increased awareness has resulted in the sustainable building design movement, with its goal to produce *green buildings* that are "*environmentally responsible, profitable and healthy places to live and work*" (USGBC, 2004). In 2010, McGraw-Hill Construction in the United States reported that green construction grew 50% during the last two years, and calculated that LEED specifications are mentioned in 71% of all development that is valued more than $50 million (Illia, T., 2010). They also added that "*we don't have any clients that don't want a sustainable building. It has now become a common practice.*" JMA President Thomas Schoeman said, "*The city wants to be a sustainable-oriented public agency. I think it's important to them because public buildings make a statement about where you live*" (Illia, T., 2010). Russ Golightly (personal communication, October 28, 2015), a former project manager in the city of Calgary (with close to 20 years' experience in the planning, design, and construction management of sustainable buildings), states that "s*ustainability isn't an add-on anymore . . . It's part of how we deliver buildings*." It can be inferred that green buildings' popularity has increased to such an extent that sustainable development is now perceived as being a major asset to the marketing of architectural practice, and an essential quality that makes other options ordinary when constructing new buildings.

Green Building Rating Systems (GBRSs) were created to ensure the quality of green buildings and to rate their performance. In March of 2000, the U.S leadership developed the Leadership in Energy and Environmental Design (LEED) system as the first rating system in North America and the national benchmark in the USA for green buildings. LEED has become known as the most popular internationally-recognized green building certification system (USGBC, 2010). It is also the rating system used by the Canada Green Building Council (CaGBC).

Environmental Quality (EQ) is a concept is defined as *"the combination of environmental elements that interact with users of the environment to enable that environment to be the best*

possible one for the activities that go on in it" (Vischer, 1989). Vischer (2005) developed a model for environmental quality in offices that hierarchs EQ according to three occupants' comfort levels: physical, functional, and psychological.

Rapoport (1988) has also suggested that EQ has three levels of meaning: the instrumental, latent, and symbolic. The instrumental level represents the physical properties and functional qualities of the environment enabling the occupants to perform their tasks. Examples include the ambient comfort conditions and ergonomics (Brill, 1984; Davis, 1984; Donald, 1994; Utzinger & Wasely, 1997). Latent qualities represent the psychological, socio-cultural, and socio-psychological aspects, such as privacy, safety, territoriality, way-finding, personalization, etc. (Becker, 1990; Ornstein, 1992; Fischer, 1997). The third level constitutes the symbolic qualities that compose the meanings and values related to traditions, beliefs, historical values, pride, culture, etc. (Rapoport, 1983; Turner 1990; Doxtater, 1994).

The importance of a GBRS in general is undeniable (see **Section 2.2.1.1**). However, the literature review on IEQ assessment, occupants' perceived QoL, green buildings, LEED, and office work environments uncovers several problems. These problems are identified out of: (1) gaps, limitations, and issues raised from previous studies in the literature, and (2) problems that arise in the GBRSs and LEED assessment criteria themselves.

Findings and limitations in previous literature:

Issues derived from the literature include the following:

First, previous post-occupancy evaluation (POE) studies reveal occupant complaints. The literature review indicates that despite the popularity of green buildings, there have been several occupants' complaints associated with the IEQ in LEED certified buildings (Lee, 2007, Abbaszadeh, Zagreus, Lehrer & Huizenga, 2006; Turner, 2006; Leaman & Bordass, 2007). These complaints include issues with Lighting Quality, Acoustical Quality, Noise Control, Controllability of Systems, Thermal Comfort, Visual and Sound Privacy factors.

Second, the LEED system (the most popular GBRS) is found to lack adequate knowledge about occupants' experience. According to a report by members of the United States Green Building Council,

> *"Today, the majority of empirical data collection in built environments focuses on physical attributes and environmental performance, such as energy or water consumption…While information about the* ***experience*** *of people in and around built environments lags far behind."* (Pyke C., McMahon S., & Dietsche T., 2010).

This viewpoint is in line with the criticism of current building professionals' tendency to place a high reliance on technology while not necessarily considering how occupants actually live and work inside buildings (Leaman & Bordass, 2005).

Furthermore, one of the suggestions for the lack of adequate knowledge is that only a few studies have evaluated the IEQ effect in relation to the occupants' viewpoint in LEED certified buildings (Abbaszadeh et al. 2006), Turner, 2006, Lee, 2007). The study of IEQ in sustainable office buildings is relatively new. The first institutional effort to measure occupants' perceptions of IEQ and the influence of IEQ on issues like perceived productivity, satisfaction, comfort, and health was done by the Center of Built Environment (CBE). Although it is an ongoing effort, as of 2003, it was noted that only three LEED-certified buildings were surveyed in the CBE occupant IEQ survey (Huizenga, Zagreus, Arens, & Lehrer, 2003). The survey is also limited in the number of IEQ factors evaluated.

Third, the methodological approaches used in previous studies. Most of the literature studied the phenomena use a cause-effect deterministic approach to test the significance of specific IEQ factors on occupants' QoL aspects such as satisfaction, comfort, productivity, and health (Lee, 2007, Prakash, 2005). Very few studies compare the objective and subjective measures of specific IEQ factors and test them in both conventional and sustainable office buildings (Woo, 2010). It is difficult to find studies that explore all the possible IEQ factors shaping occupants' QoL experience, excepting the study by Elzeyadi (2001). Elzeyadi used an explorative qualitative approach to study occupants' experience; however, sustainable office buildings were not studied. Most of the studies on IEQ from the occupants' viewpoint use Post-occupancy Evaluation (POE) or case study approaches (Lee, 2007), and most of the studies in this area use quantitative approaches. Furthermore, during the course of this research, studies of occupants' experience with IEQ in LEED office buildings that used a mixed-method approach were not found.

Fourth, there are shortcomings in previous models and theoretical frameworks. A review of environmental quality or occupants' experience with previous models and frameworks (Canter, 1991, Guerin, 1992, Vischer, 2005) and studies in IEQ in work environments, both sustainable and conventional (Woo, 2010; Brown, 2009; Prakash, 2005; Elzeyadi, 2001; Lee, 2007), revealed the lack of a comprehensive occupant-oriented framework that assesses workspaces' IEQ in green buildings. Missing issues in previous frameworks would account for possible IEQ factors, IEQ levels of meaning, and their influences on occupants' QoL in sustainable office buildings.

Limitations in the Green Building Rating Systems (GBRSs) and LEED criteria:

There are limitations within the GBRSs and the LEED criteria themselves. These include the following:

First, their measurement of building performance uses quantified, prescriptive approaches and ignores occupants' subjective reality. GBRSs and LEED assessment tools have undeniable numerous benefits. They provide a means of performance measurement and form a standard or common language among different stakeholders in terms of how sustainable their buildings are, as well as being a means to recognize and encourage best practices and stimulate the construction market for sustainable properties. One of the explanations for the rapid spread of LEED assessment in North America and abroad is the transparency and ease of using it without the need for an added expertise (although having an expert in a project adds to the credits). Another important feature in LEED is that it promotes public interaction in decision-making through web-based comments during a 45-day public comment period through an online form displayed on the USGBC website. Simpler methods are more likely to be accepted by the construction industry and to spread widely in the market, but if they are too simple, they could lose some of their credibility as a robust, verifiable rating system (Yu & Kim, 2011). However, systems that rely on achieving a required number of credits from a larger set of credits in a prescriptive manner can mask other values. This situation gives rise to a focus on the scores that can be achieved from the predetermined checklist and does not actually indicate how "green" a building is; for example, identical LEED certification levels on different buildings would not likely be indicative of identical

"green" building characteristics (Lucuik, Trusty, Larsson, & Charette, 2005), and cannot be compared to the greenness of another building under a different GBRS such as Green Globes, BREEM, or CASBEE.

To illustrate this aspect further, Schendler and Udall (2005) state, "*What works in theory should work in practice, but in practice it sometimes doesn't*," so if a point credited to ensure sustainable practice compromised occupants' QoL, then it also compromises the targets of a sustainable development (that intends to improve human QoL). For example, the Aspen Skiing Company (ASC) built one of the first LEED-certified buildings in the United States, with Auden Schendler, a LEED accredited professional, the environmental affairs director of the Aspen Skiing Company. Schendler observed that owners are more driven by scoring points and not by actually designing sustainable buildings for a particular site and use. He called this phenomenon a *LEED brain*. Schendler described this as '' . . . *overblown claims for green buildings*'' and was concerned, when he stated: "*Was it possible that buildings having high LEED ratings were not actually that sustainable?"* (Reed, Bilos, Wilkinson, & Schulte, 2009). Andrew Scott (2006) suggests that the emergence of the accreditation process and its associated points and checklist format for buildings, such as in the LEED system, can mask the need for architectural projects to focus on effective design strategies integrating sustainability with the design process. He also says that "*green accountability does not always go hand in hand with architectural quality: a good building is certainly not necessarily a green building, while a green building is not always a good work of architecture"* (Scott, 2006). In addition, when assessment is purely based on prescriptive features, it could prevent buildings with different design features other than those listed in the checklist from obtaining a good assessment result, regardless of the actual performance (BEAM Plus NB Version 1.1, 2010). This actually is coherent with the interesting question addressed by Malmqvist (2008), who asks whether GBRSs are assessing the most significant environmental aspects or are there other considerations that lie behind the choices of such systems.

Second, the lack of comprehensive assessment within the LEED criteria. Although the sustainable building design movement has been greatly impacted by LEED, there are emerging criticisms questioning whether or not the LEED standards are addressing the right issues of sustainability (Lee & Kim, 2008). Others have argued that LEED lacks a scientific

approach in the development of its criteria (Schendler & Udall, 2005; Scheuer & Keoleain, 2002). After a thorough review of the LEED criteria for assessing the IEQ in buildings as an attempt to understand how LEED deals with occupants' needs and what the possible reasons for the several complaints found in the literature are, this researcher found that LEED IEQ is dominated by the mechanical engineering issues of indoor air quality (IAQ) and thermal comfort. However, the perceived quality of indoor environment and the occupants' experience encompass a broader range of other IEQ factors that may affect occupants' health, comfort, and productivity. This researcher also conducted a telephone interview with S.R.[3] and found that the 2008 CaGBC mission statement included more occupants' orientations than that of the 2010 CaBGC mission statement, where the points given to the IEQ category were reduced and more emphasis was given to energy consumption (See Appendix A for the IEQ category weight reduction from the earlier to the later version.). S. R.'s impression is that it was "*as if they forgot what they wanted to do in their previous mission*" (S, R., 5 Nov. 2010). The LEED 2009 criteria have five major categories for evaluating a building: Sustainable Sites, Water Efficiency, Energy and Atmosphere, Materials and Resources, and Indoor Environmental Quality (IEQ), with bonus credits for Process and Design Innovation (USGBC, 2011). The IEQ in LEED is intended to provide design criteria that create *healthy*, *comfortable* and *productive* indoor environments for building occupants (Portman, Clevenger, & France, 2006). Occupants' QoL in this research is described in terms of health, comfort, and productivity, where comfort and health are physiological as well as psychological needs (Lang et. al, 1974; Lang, 1994). However, in reviewing the three pillars of sustainable development—environmental, economical, and social dimensions and their application in the LEED rating system as IEQ criteria—we can see that while they address physiological needs, sociological and psychological needs are not well addressed within the LEED criteria. Hence, more research is required on occupants in work environments so that the IEQ factors responding to their QoL needs can be identified.

LEED 2009 IEQ criteria include only six factors that cover a limited number of factors influencing occupants' Physical Comfort and health issues. The Physical Comfort issues

[3] S.R. is currently a green building consultant in Architecture and Planning industry, a member in the CaGBC Quebec chapter and previously a project manager

include Thermal Comfort and the Controllability of Lighting and Thermal Comfort Systems. Health and safety issues encompass IAQ and Ventilation; Water Use and Efficiency; Low-Emitting Materials; Indoor Chemical and Pollutant Source Control; and Daylighting and Views.

Even when buildings are given high scores in LEED certifications, these scores do not necessarily imply a high score on the IEQ level, as other categories could be responsible for this high score. LEED 2009 gives equal points to each IEQ factor, while their respective influence on the quality of life may be quite varied. Therefore, each factor should be credited differently according to its relative weight of importance to the QoL of a building's residents. These and other shortcomings in the LEED criteria are presented in detail in **CHAPTER II Section 2.4.1**. Additional information on the IEQ factors present in LEED-certified buildings is thus needed in order to explore the IEQ factors that help to improve green building occupants' QoL. Furthermore, to understand these factors in LEED-certified buildings, a comparison between occupants' QoL experience in LEED and conventional buildings is an interesting research scope to pursue. It may help to differentiate sustainable and non-sustainable IEQ factors and determine how occupants' experience may or may not differ.

IEQ can thus encompass many factors in the indoor environment. Examples of missing IEQ factors in the LEED 2009 standard are numerous, and include such factors such as Lighting Quality, Acoustical Quality and Noise Control, Ergonomics, Space Layout, Quality of Views, Aesthetics and many other those factors that have a latent and symbolic meaning that affect the occupants physically, psychologically, socially, culturally, and functionally. For example, Aesthetics is a factor that can be addressed by the use of plants, architectonic details, artworks, colour choices, finishing materials, and all factors that embrace the culture and beauty required for a better occupants' QoL. For example in the Living Building Challenge (LBC)[4], a category (called *Petal*) is given to *Beauty and Spirit*. This Petal is concerned with the incorporation of design features that delight the human spirit, and culture, and the integration

[4] The Living Building Challenge™ (LBC) is a building certification that measures the sustainability in the built environment. It is has seven performance categories called Petals: Place, Water, Energy, Health & Happiness, Materials, Equity and Beauty. Those Petals are subdivided into Imperatives (a total of twenty) that focus on specific influence. The LBC can be applied to new buildings and existing structures with any scale and location (https://living-future.org/lbc/about).

of public art (International Living Future Institute, 2014). Hence, a more holistic approach is needed for the assessment of indoor building environments to consider these factors. It is essential to include all aspects of people's needs and functions—physical, emotional, or social—while also minimizing indoor pollution and poor indoor quality effects caused by building materials, mold, bad indoor air quality, glare, and other negative factors.

According to Vischer's (2005) model for environmental quality in offices and Rapoport's (1988) levels of meaning for environmental quality, it is clear that none of the latent, symbolic qualities or psychological concerns associated with the assessment criteria of IEQ are credited in the current LEED standard.

Rapoport (1977) explained that the quality of environments is characterized by physical-objective qualities and perceived-subjective qualities. GBRSs, however, focus much more on the physical qualities and tend to ignore the latter.

What is Required to Respond to these Problems?

A more comprehensive evaluation approach that considers humane subjective qualities to create more user-oriented and humane sustainable environments is needed for green buildings. The sustainably-built environment could be healthy and safe as well as a happy environment for a healthy community of occupants (Burnett & Yik, 2001; Lee, Kim, & Yoon, 2010).

There is a need for sustainable architectural designs that create more human-centered places rather than reducing them to mere performance optimization. To achieve this objective, sustainable criteria cannot be limited to the application of technology in reducing energy dependence, saving resources, reducing CO2 and gas emissions, etc.; both the *quantitative* and *qualitative* aspects of technological systems as well as human experience and needs require consideration.

Occupants' perception of their built environment should play a major role in obtaining a holistic assessment that gives a more complete image of human QoL in buildings. Such understanding of occupants' satisfaction and perceptions is not being addressed by the rigid schemes of the current, most-broadly implemented GBRS, LEED certification (Lee & Guerin, 2009). This current situation highlights the importance of knowing how people *perceive* sustainable green buildings' IEQ, and of testing if green buildings not only perform

environmentally better but if they are perceived as better from the occupants' point of view. Realistically, a generation's worth of highly efficient buildings that save energy and are better for the environment but have poor IEQ will not be truly sustainable; without investing in human comfort and satisfaction inside buildings, we will not satisfy the social or economic aspects of sustainability.

1.2 Research Questions

In light of the popularity of LEED-certified green buildings, as well as the researcher's concern with human needs, and lack of enough knowledge about occupants' experiences in green buildings, the research is driven by the following general question:

Are the LEED criteria for assessing green buildings' Indoor Environmental Quality (IEQ) comprehensive enough to meet the needs for creating sustainable and humane places that provide a 'healthy, comfortable, and productive' Quality of life (QoL) for building occupants?

The Sub-questions that Align with the General Research Question are as Follows:

1. What is the occupants' QoL experience in LEED certified and conventional office buildings and what IEQ factors interact with occupants?
2. How do the occupants in LEED certified and conventional office buildings perceive the IEQ factors and their QoL in their work environments, and what is the significance of these factors?
3. What does a humane work environment mean to occupants and what factors constitute it?

Not only is it of interest to understand IEQ factors, it is also of value to understand what emerges in the findings about the characteristics and salient issues revolving around a humane work environment and the relative Quality of Life (QoL).

1.3 Outstanding Key Issues and Concerns

This research classifies previous problems **(Section 1.1)** into substantial, theoretical, and methodological problems, and raises several issues and concerns based on these problems. Substantial problems are consensus-based findings and/or gaps deduced from previous studies. Theoretical and conceptual problems include the shortcomings and incomprehensiveness in the LEED criteria for assessing IEQ, as well as previous theoretical frameworks and models assessing environmental quality. Those shortcomings are either deduced from the literature or investigated by the researcher. Methodological problems are problems that have developed due to the methodological approaches used in previous studies that evaluated IEQ in either conventional or LEED office buildings.

Substantial problems include:

(1) Occupants' complaints that are associated with the IEQ in LEED-certified buildings.

(2) The lack of adequate knowledge about occupants' lived experience in LEED and green buildings. These problems indicate a possible gap between the current technical building performance measures and the perceived performance as experienced by occupants, and thus show that more research about occupants' experience with the IEQ in LEED office buildings is needed.

Theoretical problems include:

(1) The criteria used for the assessment of IEQ are not sufficient for achieving the goals of LEED and green buildings in terms of health, comfort, and productivity. There are other influential factors in indoor environments that could be utilized for this objective.

(2) The current building professional's tendency to place a high reliance on technology instead of basing their plans on how occupants actually live and work inside buildings.

(3) The quantification and measurement of building performance using prescriptive approaches that ignore occupants' subjective reality.

(4) Giving equal credit for different IEQ factors.

(5) The lack of a comprehensive assessment of IEQ in previous theoretical frameworks or GBRS that consider the missing environmental qualities in LEED criteria, such as latent and symbolic as well as some instrumental qualities.

These problems indicate the lack of integration between environmental and workspace design in current green building rating systems and specifically in LEED assessment. Viewing the work environment as an *environment-behavior* system and incorporating this understanding with *green building design* will address the social dimension of sustainability. The separation of green design from workplace design can create *conflicts* on both levels. Their integration is needed to create a more complete assessment—to become more sensitive to, and conscious of, the office space activity requirements, and thus to improve employees' QoL. These problems also show that building codes and standards address comfort issues individually, while people experience the *combined* effect of IEQ factors. Hence, studying occupants' experience is essential for setting the standards that will improve occupants' QoL. As stated by Leaman & Bordass (1999), "*Buildings are complex systems made up of physical and human elements and their many associations, interactions, interfaces and feedbacks. Because of interdependencies, it is often fruitless to try and separate out different variables and treat them as 'independent.*"' Hence, knowing the significance and relative weight of each IEQ factor on occupants' experience enables LEED and other GBRSs to set the appropriate number of credits for each IEQ factor.

Methodological problems include:

(1) The lack of workspace IEQ assessment criteria in green buildings based on occupants' own constructs.

(2) The lack of studies that address the subjective assessment of occupants in green buildings using a mixed-methods approach. These lacunae stress the need to study occupants' experience using a mixed-methods approach and to define environmental quality for a humane work environment based on their own constructs. It also indicates the importance of viewing the office work environment as an environment-behavior system that respects occupants' experience.

In summary, the current research assumption is that a sustainable building should also be humane to be able to satisfy the different dimensions of human QoL and that this can be achieved if sustainable buildings support occupants' needs and understand their QoL experience. A comprehensive QoL (health, comfort, and productivity) assessment in a sustainable and humane work environment requires an understanding and manipulation of the different levels of meaning in IEQ (instrumental, latent, and symbolic). In this research, as explained in detail in **Chapter II Section 2.3.2**, IEQ factors are categorized as Ambient, Designed, and Behavioral Environments. These IEQ factors influence occupants' comfort in terms of Physical, Psychological, and Functional Comforts. The level of comfort determined by the IEQ factors in turn constitutes occupants' QoL. This process assumes that successful humane criteria for assessing IEQ should be based on occupants' actual lived experiences and their own constructs of what composes these experiences. Furthermore, the research assumes that occupants' experience is best studied using a mixed-method approach that can both explain and explore all possible IEQ factors in relation to occupants' QoL.

1.4 Research Object and Objectives

The aim of this research is to contribute to better QoL for people by providing better work environments in green buildings. The goals are to decrease the gap between assessed and perceived building performance; to better understand occupants' experience with the IEQ in LEED office buildings; and to create more humane and comprehensive criteria for the assessment of IEQ in office buildings that integrate the different dimensions of occupants experience with all the possible IEQ factors resulting from the integration of workplace design with sustainable design criteria. Since the literature review (**see Chapter II**) reveals both satisfaction and complaints in LEED-certified buildings, the present study is an attempt to understand and document the reasons for occupants' dissatisfaction, to understand what constitutes quality for occupants in work environments, and to ensure better quality work environments in green buildings. To fill the gaps found in the literature, solve the problems, and answer the research questions (see **Section 1.2**), the following research object is formulated.

The Research Object of this Study is:

To develop an occupant-oriented, comprehensive, humane and sustainable framework for the assessment criteria of Indoor Environmental Quality (IEQ) in office work environments.

In this study, a humane environment is understood to be a supportive environment to occupants' needs to provide them with comfort and well-being. It protects human health by maintaining occupants' physical and emotional well-being, and enables better task performance for the occupants to live and work. It allows people to socialize, work, collaborate, laugh, eat, and be happy in their environment, while helping them to have self-esteem and feel self-actualized. Thus, a humane environment not only fulfills occupants' basic needs; it fulfills and supports both the objective and subjective aspects of the occupants' quality of life. The more supportive qualities the environment has, the more humane it is. It is an environment that goes beyond being acceptable to provide a healthy, comfortable, and productive environment for occupants. A humane work environment has a social goal that satisfies the social dimension of the sustainable development by improving human QoL. Conversely, a poor environmental quality may influence occupants' health and productivity, thereby negatively impacting a business's bottom line, hence, does not satisfy the economical dimension of the sustainable development.

In order to develop a humane sustainable framework for the IEQ criteria that considers all the possible factors shaping occupants' QoL experience in work environments, five objectives have been identified as follows.

The Research Objectives:

OBJECTIVE I: To document occupants' overall perceived QoL experience in LEED certified and in conventional office buildings.

OBJECTIVE II: To explain occupants' overall perceived QoL experience in LEED certified and in conventional office buildings.

OBJECTIVE III: To determine those IEQ factors that interact with occupants' QoL in LEED certified and conventional office buildings.

OBJECTIVE IV: To Identify IEQ factors' significances with occupants' QoL in LEED certified and conventional office buildings.

OBJECTIVE V: To define the constructs of a humane work environment based on occupants' own words.

1.5 The Research Methodological Approach

The study uses a mixed-methods approach to both explain and determine occupants' QoL experience and the IEQ factors required to create a humane and sustainable work environment. This approach is a pragmatic approach, in that it uses all possible methods required to solve the problem rather than adopting one methodological approach. In a pragmatic approach, it is the experiences of the occupants that drive the inquiry. Hence, a mixed-method approach is chosen, as it includes both qualitative methods (that tend to have open-ended questions, such as interviews) and quantitative methods (that tend to have closed-ended questions, such as questionnaires). The choice of mixed methods as an approach, in part, is to offset the weakness and bias in one specific method by the other method (Creswell, 2013). This research uses observations, interviews, and focus groups as qualitative method tools, and questionnaires as the quantitative method tool.

The research proceeds in three phases, as follows: Phase I - Perform observations during walk-through tours and document the environments by taking photographs and writing field notes; Phase II - Carry out interviews and conduct the questionnaires; and Phase III - Conduct focus groups.

The observations and interviews in Phases I and II, respectively, are used to investigate occupants' QoL, elicit the IEQ factors interacting with occupants' QoL, and define a humane work environment. Thus, achieving the research objectives I, III, and V. The questionnaires in Phase II are used to test the relationship between occupants' QoL and the IEQ factors. Hence, achieving the research objectives II, and IV. The IEQ factors tested in the questionnaires are

deduced from the literature. The focus groups that are conducted in Phase III further test and converge the results.

Each of the three phases is analyzed separately; subsequently, there is a triangulation of the results of both methods (quantitative and qualitative) from all the phases. This triangulation is done to corroborate results, and to achieve a high level of trustworthiness within the overall research results. The observations are analyzed using visual interpretive inquiry presented on annotated diagrams (photos). Interviews are analyzed using narrative interpretive inquiry, using elicitation of patterns, assigning codes, determining themes of constructs, and then counting the frequency of repetition. Questionnaires are analyzed using descriptive analysis of mean values, and inferential analysis of Pearson correlations (2-tailed) using SPSS V.22 mac. Focus groups are analyzed using the hierarchical cluster analysis technique of repertory grids via repertorygridtool (RGT) online software, and are presented on a dendogram.

1.6 Research Delimitation

The research reported in this thesis studies building occupants' QoL experience in relation to the perceived IEQ in work environments using a mixed-methods approach, with the aim of improving LEED certification criteria. QoL here is described in terms of the perceived health, comfort, and productivity of people working in office environments. The purpose of this study is to develop a theoretical framework for assessing IEQ in sustainable office buildings. The framework considers all the possible IEQ factors shaping occupants' experience in the work environment and seeks to identify both sustainable and humane (occupant-oriented) criteria based on the occupants' point of view. The use of data and triangulation of results from observations, interviews, questionnaires, and focus groups enables the researcher to draw a more complete picture of the human experience and interaction with the environment than would be possible by using only one specific method alone. The emergent theoretical framework links IEQ factors, their levels of meanings (instrumental, latent, and symbolic), their impact on environmental comfort (physical, psychological, functional, etc.), and hence their effect on the QoL (health, comfort, and productivity). To develop this theoretical framework, the study compares occupants' perceptions in both LEED and conventional office buildings for more profound insights on occupants' QoL experience and IEQ factors that shape it.

This research studies buildings prior to the new rating system LEED V4 released in 2014, hence only the criteria in LEED®2009 are utilized for the buildings under study. Three office buildings in Calgary, Canada are selected for the study: the Child Development Centre (CDC), the Tetranex Solutions Inc. Glenmore Workplace (GLW), and the Water Centre Building (WCB). The CDC and the WCB are LEED-certified green buildings at Platinum and Gold levels respectively, and the GLW is a conventional office building.

1.7 Thesis Structure

The thesis is composed of six chapters. **CHAPTER I: Introduction** presents the problem statement, research general and specific questions, research object, objectives, and approach to inquiry. **CHAPTER II: Literature Review** reviews the current literature on QoL approaches, indicators and measures and how the built environment influences QoL and the Quality of Work Life (QWL). The sustainable building design movement, GBRSs, LEED certification, work environments, commonly used methods for the assessment of IEQ in buildings, previous models assessing environmental quality in offices are also reviewed. This chapter ends with a proposed theoretical framework for the research inquiry that incorporates a list of suggested IEQ factors. **CHAPTER III: Research Methodology and Methods** describes the methodological approach based on the selected research epistemology, philosophical approach, paradigm and knowledge claims. The research strategies and methods used for data gathering and analysis are also detailed. **CHAPTER IV: Data Analysis and Results** presents an analysis of the results from each the data gathering tools. **CHAPTER V: Triangulation and Discussion of Results and Findings** shows the interpretation and corroboration of results from the triangulation of the different research methods. **CHAPTER VI: Conclusions:** presents the research overview, contribution, limitations, recommendations and directions for future research. Table I provides an overview of the research. The table proceeds from the research problems (**Section 1.1**) and lists how the research questions (**Section 1.2**) are formulated from the different research problems. Each research question is presented with the designed objective (**Section 1.4**) to answer it. The methods of inquiry (**Section 1.5**) are presented as QUAN and QUAL to indicate quantitative and qualitative methods respectively. Furthermore, the phases of inquiry are shown as Phase I, II, and III, to represent their sequence of order.

Table I. Research Object, Problems, Questions, Objectives, and Phases of Inquiry

Research Object: Developing a comprehensive (humane and sustainable) assessment framework for the IEQ of Green office work environments			
RESEARCH PROBLEMS	**RESEARCH QUESTIONS**	**RESEARCH OBJECTIVES**	**RESEARCH PLANNING**
Substantive Problems			
▪ Lack of enough knowledge on occupants' lived experience in green buildings. ▪ Many user complaints in LEED-certified buildings.	1.What is the occupants' QoL experience in LEED-certified and conventional office buildings and what IEQ factors interact with occupants?	1. **Documenting** occupants' overall perceived QoL experience in LEED-certified and conventional office buildings. 2. **Determining** IEQ factors interacting with occupants' QoL in LEED-certified and conventional office buildings.	Phase I, II & III (QUAL)
Theoretical & Conceptual Problems			
▪ Lack of a comprehensive assessment in the LEED system (missing factors in LEED, equal credits for each criterion, etc.). ▪ High reliance on technology and ignorance on how occupants live and work inside buildings. ▪ Lack of a comprehensive assessment of the IEQ in previous theoretical frameworks.	2.How do the occupants in LEED-certified and conventional office buildings perceive the IEQ factors and their QoL in their work environments and what is the significance of these factors?	3. **Explaining** occupants' overall perceived QoL experience in LEED-certified and in conventional office buildings. 4. **Identifying** IEQ factors' significances on occupants' QoL in LEED-certified and conventional office buildings.	Phase II (QUAN)
Methodological problems			
▪ Lack of workspace IEQ assessment criteria in green buildings; based on occupants' own constructs.	3.What does a humane work environment mean to occupants and what factors constitute it?	5. **Defining** constructs of a humane work environment.	Phase II (QUAL)
▪ Lack of studies that addressed the subjective assessment of occupants in green buildings using mixed-methods approach.	**Selection of methodological approach** (Mixed-methods approach)		Phase I, II & III (Triangulation)

2 CHAPTER II: LITERATURE REVIEW

Occupants' Quality of Life (QoL) Experience as an Outcome of Humane and Sustainable Indoor Environmental Quality (IEQ) in Office Work Environments

The purpose of this research is to develop the basis for a sustainable and humane framework for the assessment of IEQ in sustainable work environments. Thus, occupants' experiences are compared between conventional and LEED office buildings. This comparison is pertinent to identify the IEQ factors significant with occupants' QoL in green buildings. It also allows a better understanding of whether the relationships guiding the interaction between occupants' QoL and IEQ factors differ in green buildings from conventional ones. This research aims to contribute to the improvement of the quality of green offices' indoor environments with the intent to ensure they are humane, as well as sustainable, and provide a comfortable, healthy, and productive QoL for occupants.

This chapter starts with a review of literature on the sustainable development and QoL. Occupants' QoL is studied as an ultimate goal to sustainability. It is pertinent to understand the definitions and measurements of QoL in the literature. This is necessary to build the argument on whether the LEED system criteria are sufficient to achieve the QoL goals. The chapter then reviews literature on the IEQ, work environments, and LEED system, highlighting approaches used to measure occupants' responses toward the IEQ, as well as the findings of previous studies. The chapter ends with the research conceptual framework, which explains the different concepts utilized in this research, as well as the theoretical framework guiding the relationship between IEQ and occupants' QoL.

2.1 QoL as an Ultimate Goal of Sustainability

2.1.1 Definitions of Sustainability and Sustainable Development

In dictionaries the word *sustainable* means continuity and maintenance of resources.

> *"sus·tain·able, 1 : capable of being sustained, 2 a: of, relating to, or being a method of harvesting or using a resource so that the resource is not depleted or permanently damaged <sustainable techniques> <sustainable agriculture> b : of or relating to a lifestyle involving the use of sustainable methods <sustainable society>" (Merriam-Webster, 2010)*

The most well-known definition of sustainability is the one developed in 1987 by the World Commission on Environment and Development in their report on our common future. This has become the most often-quoted definition of *sustainable development* as the development that "*meets the needs of the present without compromising the ability of future generations to meet their own needs*" (Brundtland, 1987, p.43). What is significant about this definition are the *human needs* and the *limitation of resources* to fulfill human needs; both concepts focus on the human dimension involved in sustainable development. Sustainable development is also defined as improving the quality of human life while living within the carrying capacity of supporting ecosystems (IUCN, 1991). Hence, the quality of human life and needs in relation to the available resources of the ecosystem or ecological conditions (the environment) are found to be crucial and an ultimate goal in determining sustainability.

Sustainable development has been embraced by a vast range of governmental, and nongovernmental, organizations as the new paradigm of development and the latest emerging catchphrase of development (Lélé, 1991). It is said that the "*twenty-first century is widely heralded as the era of sustainability, with a rainbow alliance of government, civil society, and business devising novel strategies for increasing human welfare within planetary limits*" (Adams, 2006). This makes research on issues related to sustainable development motivating to many fields and an essential contribution to humanity nowadays.

Sustainability has three principles, which are environmental, economical, and social sustainability. Environmental sustainability means preserving ecosystems by conserving resources, energy, and water. Economic sustainability means achieving economic stability

through cost-effectiveness and economic balance across societies and the world. Social sustainability implies enhancing the quality of human life for individuals as well as society as a whole (U.S. Department of Energy, 2003).

2.1.2 Sustainable Building Design Movement and Green Buildings

In the Environmental Design, Architecture, and Interior Design fields, the design of buildings under the sustainable development paradigm is an area of great interest and concern. Buildings represent a crucial source of energy consumption that may cause problems to economical growth and prosperity. Currently, in developed countries, buildings account for one-third of greenhouse gas (GHG) emissions in the atmosphere (Brown & Southworth, 2008). Those emissions are increasingly linked to one of today's major threats: climate change and its possible effects, such as ice melting and floods. This crisis affects the sustainable life of both people and ecosystems (Gill, Handley, Ennos, & Pauleit, 2007; Banuri, 2009). Hence, sustainable development in buildings has become a vital way to help to curb current global problems, as a means to reduce GHG emissions (Brown & Southworth, 2008).

In the history of sustainable development, energy-efficient buildings started and were extremely required after the world energy crises in 1970 (Srebric, 2010). However, a new set of indoor air problems were created from the use of tight construction and novel materials (Putz-Anderson et al., 1997). Thus, a broader perspective that includes outcomes for building occupants and environmental impacts became a growing area of interest. *Sustainable building design* derived from the sustainable development movement due to the increasing awareness of the negative environmental impacts occurring from buildings on their occupants—not to mention the huge energy consumption, resources depletion, and waste production these buildings were responsible for. This movement had the goal to produce green buildings that are "*environmentally responsible, profitable and healthy places to live and work*" (USGBC, 2004). In that sense, green buildings are thought of to improve occupants' QoL.

2.2 Green Buildings

Green buildings, also referred to as *sustainable buildings*, include all concepts related to the design of buildings that emerged in the 1970s, and are based on sustainable practices. The Center for Building Performance and Diagnostics at Carnegie Mellon University (CBPD) defines *sustainable design* as

> *"a transdisciplinary, collective design process driven to ensure that the built environment achieves greater levels of ecological balance in new and retrofit construction, towards the long term viability and humanization of architecture. . .Finally, sustainable design offers architecture of long term value through 'forgiving' and modifiable building systems, through life-cycle instead of least-cost investments, and through timeless delight and craftsmanship."* (Loftness, Lam& Hartkopf, 2005)

The Office of the Federal Environmental Executive [OFE] defines green building as "*the practice of 1) increasing the efficiency with which buildings and their sites use energy, water, and materials, and 2) reducing building impacts on human health and the environment, through better siting, design, construction, operation, maintenance, and removal—the complete building life cycle*" (OFE, 2003). In addition, a similar description by Jerry Yudelson (2008) can be found in *The Green Building Revolution*: "*a high-performance property that considers and reduces its impact on the environment and human health*." Aspects in green buildings that reduce the overall impact of the built environment on human health and the natural environment include, but are not limited to, (1) the use of energy, water and resources efficiently; (2) the reduction of pollution and waste; and (3) the creation of indoor environments that protect human health, promoting comfort, well-being, and productivity (Zigenfus, 2008). The design features applied in green buildings maximizing the use of natural resources to reduce energy and improve occupants' QoL include the use of solar energy, daylight, views and natural ventilation, improved IAQ, and the use of environmentally-friendly materials in the most efficient way (Cole, 1999).

2.2.1.1 Green Building Rating Systems (GBRS)

A Green Building Rating Systems (GBRS) is a systems used to rate the performance of green buildings. As green buildings are taking the responsibility of promoting the sustainable

development concepts in building industry, GBRSs are taking the responsibility of measuring and evaluating the performance of green buildings.

In the past decade, the high environmental quality and performance of buildings and the move toward sustainable design widely developed, as a result of the increasing environmental issues in society. Knowledge about human QoL resulting from indoor environments, along with today's increasing concerns about climate change, are now part of major changes in building design worldwide. National environmental assessment methods and systems developed during the 90s are emerging to encourage the development of green buildings (Malmqvist, 2008). Examples of GBRSs include: BREEAM (UK), LEED (USA), HK-BEAM (Hong Kong), CASBEE (Japan), HQE (France), DGNB (Germany), PromisE (Finland), Green Globes (Canada), Green Stars (Australia), BCA Green Mark (Singapore), and GOBAS (China).

While GBRSs may vary in their philosophies and approaches, they all have shared goals that measure, assess, and ensure the practice of sustainable development principles. There is no doubt that they are useful for promoting sustainable development in the building industry, disseminating awareness in the community for more sustainable behavior and practices, identifying how sustainable green buildings are, and evaluating their environmental impacts through their life cycle. They also help set standards for measuring green buildings' performance, and they may provide means of communication and help to define the field of sustainable building design between different stakeholders, such as building owners, managers, architects, and community planners (Todd, Crawley, Geissler & Lindsey, 2001). However, existing GBRSs tend to be prescriptive (based on checklists) that promote building design practices to reduce the life-cycle costs of buildings and their environmental impacts (Srebric, 2010). This matter is of specific importance when we talk about the quality of indoor environments in current rating systems, where the criteria are set only on the objectively measurable variables of the indoor environments and ignore occupants' subjective assessments of how they actually experience and perceive their indoor environments.

2.2.1.2 Leadership in Energy and Environmental Design (LEED)

Leadership in Energy and Environmental Design (LEED) is a rating system used to evaluate the performance of green buildings by giving them a level of certification based on the number of credits achieved on a given checklist. It is defined as "*a framework for identifying, implementing, and measuring green building and neighborhood design, construction, operations, and maintenance*" (USGBC, 2009). LEED was developed by the U.S. Green Building Council (USGBC) in 1998 (Pilot Project Program) and first released in March 2000 as the US government response to encourage the reduction of buildings' negative environmental impacts (Lee, 2007). The USGBC is a non-profit organization; its mission is to "*to transform the way buildings and communities are designed, built and operated, enabling an environmentally and socially responsible, healthy, and prosperous environment that improves the quality of life*" (USGBC, 2011).

LEED is the national standard for sustainable design in the United States of America—the first developed, most popular and referenced rating system in North America. It is widely accepted as an international standard for measuring the performance of green buildings (BIM, 2005). LEED is considered as one of the most significant GBRSs that contribute to the assessment of building performance, and there is a general agreement that LEED has brought sustainability into the mainstream of building design and construction (CBE, 2006).

LEED is used by the Canada Green Building Council (CaGBC) and known as *LEED Canada*. LEED Canada is an adaptation of the original U.S. LEED system, but tailored specifically to suit the Canadian climates, construction practices, and regulations. In 2003, the CaGBC was created as a national non-profit organization to accelerate the design and construction of green buildings and communities across Canada.

2.2.2 Quality of Life (QoL) and Quality of Work Life (QWL) and the Indoor Environment

2.2.2.1 Quality of Life Definitions

Quality of life (QoL) definitions, what composes it, and how it is measured are essential understandings elements to investigate occupants' QoL and improve green buildings accordingly. QoL is a broad concept that is concerned with the society's overall well-being, and its importance has increased in social research studies since the 1970s (Alber & Fahey, 2004). It overlaps with many meanings or terms such as *well-being, social indicators*, and *way of life*, but they are not its synonyms (Andrews, 1980). QoL indicators may include aspects such as housing, education, employment, and household finances (NRC, 2009). Other indicators may also include social life, marital status, job satisfaction or quality of work life (Noll, 2002, Elizur, 1990).

There are two approaches to studying QoL: *objective* and *subjective* approaches. Objective approaches of measuring the QoL depend on following the standards set and specified by experts who believe that these standards will satisfy human needs and wants. In the development of modern societies in the west, economic monetary indicators, such as income, expenditures, and production of goods and services, were used in national and regional statistics gathered for measuring the well-being of people (Kerce, 1992).

However, many investigators opposed the use of such indicators as the only and ultimate criteria assessing QoL (Campbell, 1976). Hence, the social indicators, such as statistics about marriage, divorce, birth, crimes, and education, were developed (Kerce, 1992). Subjective approaches rely on the individuals themselves in defining their own qualities of life, and accounts of their wants and needs, with a different possible multitude of orientations that might emerge (Blishen & Atkinson, 1980). Thus, governmental agencies, codes, and standards have preferred objective approaches, while researchers, survey organizations, and academic affiliations have also incorporated subjective approaches (Kerce, 1992).

Each of these QoL approaches has developed its own QoL measures. QoL measures are increasingly recognized in medical and psychological literature as important indicators of physical and social well-being (Utsey, Bolden, Brown, & Chae, 2001). Objective and

subjective QoL measures definitions were proposed by Rice (1984), who defined objective quality of life (OQoL) as "*the degree to which specified standards of living are met by the objectively verifiable conditions, activities, and activity consequences of an individual's life,*" and defined subjective quality of life (SQoL) as "*a set of affective beliefs directed toward one's life.*"

OQoL measures are those focusing on the general standards of living, such as financial resources, number of amenities, available facilities, as well as objectively measurable environmental quality (Jackson, 2002). The objectively measurable environmental QoL questionnaires may include physical safety and security, health and social care, home environment, opportunities for recreation/leisure activities, air pollution, noise, traffic density, climate, transport facilities, and opportunities for acquiring new information and skills (WHO Group, 1998).

SQoL measures focus on people's general satisfaction with their current lives. In most QoL studies, emphasis was given to subjective well-being, whether this is related to health, living and working conditions, recreation, or even intellectual stimulation (Moser, 2009). According to Campbell (1981) the only direct way of having knowledge on an individual's feelings about his or her QoL is by going straight to the individual who is undergoing this life experience. The subjective experience is always affected by personal expectations and social comparisons (Moser, 2009). It is no surprise that some studies show that personal relationships (with friends, family, or significant other) affect life satisfaction and happiness (Donovan, Halpern, & Sargeant, 2002). Hence, these factors may alter subjective well-being. SQoL assessments "*measure perceptions of well-being—how people feel about their lives—with quality of life being operationally defined in that manner"* (Kerce, 1992). Thus, we could say that SQL measures the *perceived quality of life* (PQoL), where the PQoL is defined as "*a set of affective beliefs directed toward the totality of one's life (overall PQoL) or toward specific domains of life (e.g., perceived quality of work life or perceived quality of family life)"* (Rice, W. R., McFarlin, B. D., Hunt, G. R, & Near, P.J, 1985). This definition is derived from the work done by Andrews and Withey (1976), as well as Campbell and his colleagues (Campbell, 1976, 1981; Campbell, Converse, & Rodgers, 1976; Locke, 1969, 1976). *Affective beliefs* are central to this PQoL definition. *Affect* is defined by Naylor, Pritchard, and Ilgen,

(2013) as a variable "*psychological state, or feeling—and therefore a cognition—of pleasure, happiness, well being, or satisfaction*." Literature on SQoL include *cognitive judgments* and *affective reactions* as a result of their concern with how and why are people experiencing their lives positively (Diener, 1984). Satisfaction/dissatisfaction and positive/negative affect are the most frequently-used measures of QoL in the subjective approach (Kerce, 1992). Hence, the SQoL approach includes two components: the *affect component* and the *cognition component* (Kerce, 1992).

The Affect Component of SQoL (happiness): Affect has two dimensions, which are positive affect and negative affect. Bradburn (1969) suggests that an increase of positive affect over the negative affect creates happiness. However, he found that the two dimensions of affect are not dependent on each other, yet they are correlated with different personality variables. In addition, Herzberg, Mausner, and Snyderman (1959) proposed a two-factor theory of job satisfaction, where they also found that factors affecting people's satisfaction with their jobs are independent from factors making people dissatisfied with their jobs. Furthermore, Diener, Larsen, Levine, and Emmons (1985) suggest that the intensity and frequency effects of affect combine in an additive way. Thus, no overall relation could be found between the affect dimensions, as they tend to nullify each other. However, Cheng (1988) noted that people could experience an increasing ratio of positive affect in relation to negative affect without having an increase in the overall happiness of their lives, pointing out that there is a basic difference between affect measures and appraisal measures of overall happiness. Such difficulties of using affect to form SQoL index is what caused numerous researchers to use a more cognitive measurement (Kerce, 1992).

The Cognitive Component of SQoL (satisfaction): The Cognitive component of SQoL is commonly used as a measure of satisfaction. Satisfaction is temporal and cross-situationally stable, despite affect changes (Diener & Larsen (1984). This might be due to the changes that occur in one's standards of comparison, by which people could make adjustments to maintain self-esteem. Hence, planned interventions might not have an effect on satisfaction measures (Kerce, 1992). However, these conclusions refer to the overall feeling of satisfaction with one's life, in that while satisfaction has a more cognitive component than happiness, it is also thought to have an affective component. Hence, in an effort to find a purer cognitive measure,

Campbell et al. (1976) developed a gap measure that measures the difference between the assessment of current situations and the ideal, best experienced, or expected standards of comparison. Researchers using SQoL approach believe that the only way to know about feelings regarding life is through the individual living that life (Kerce, 1992). Thus, typical methods of research used in PQoL studies include direct self-report survey questions, where respondents are asked to indicate their current levels of satisfaction, happiness, anxiety, worry, or general sense of well-being, or describe their life on semantic differential adjective pairs, or report their feelings about life along a scale with two opposite adjectives as the end points (Rice et al., 1985).

In the past, while investigators were divided by focusing on either subjective or objective QoL measures; however, later on researchers acknowledged that the two types of indicators could provide complementary information (Kerce, 1992). Cheng (1988) suggested that the combination of both types of variables even increases their usefulness and power. Bradburn (1969) proposed that in order to execute effective social policies, a greater understanding of people's QoL subjective assessments—as well as the objective conditions related to those subjective judgments—will put us in better positions for formulating such policies. Furthermore, Andrews and Withey (1976) stated, "*Only when both types of measures (subjective and objective) are concurrently measured will it be possible to know how demonstrable changes in living conditions are affecting peoples' sense of life quality and, conversely, whether changes in people's sense of life quality can be attributed to changes in external conditions.*" Examples of using both measures include the OECD task force on quality of life when they included perceptions along with the objective measures (Verwayen, 1980). Moreover, Solomen et al. (1980), in reporting on the UNESCO quality of life project, stated that they believe subjective or attitudinal variables must be considered with objective measures.

There are usually four areas related to public policy, along with applied psychological research, associated with the term "quality of life." Those areas are health, individual life satisfaction, objective standards of living, and sustainable development (Uzzell & Moser, 2006).

Generally and more commonly, QoL is defined as a measurement of well-being. The collective feelings of how well people feel about their environments can be thought of as their quality of life (NRC, 2009). Some relate this to a total well-being that includes physical, mental, social, and spiritual components (Eckersley, 1998). Hence, the GBRSs or LEED IEQ criteria can compromise occupants' QoL if they focused only on the physical components of occupants' well-being. The LEED IEQ criteria are addressed in detail in **Section 2.4.1 in this chapter.** According to WHO (1994), the QoL definition consists of an ''*individual's perception of their position in life in the context of the culture and value system in which they live and in relation to their goals, expectations, standards and concerns.*'' This definition also emphasizes the importance of cultural aspects in occupants' QoL, an issue that needs to be addressed in the quality assessment of indoor environments in buildings, and is not among the GBRSs evaluation of green buildings. How to promote the means for people to live in the best ways in their environments is an ideological thrust to the QoL concept (Alber & Fahey, 2004). Rice (1984, p.157) proposes a broader definition of QoL, and states that "*the quality of life is the degree to which the experience of an individual's life satisfies that individual's wants and needs (both physical and psychological)*." This definition is relevant to this study as it focuses on occupants' experience of QoL. It can be used to determine how green buildings meet occupants' living and working needs for a healthy, comfortable, and productive work environment. This research uses this definition of QoL, but in a broader context that considers the building type (office buildings), where occupants' wants and needs are not only physical and psychological, but also functional.

2.2.2.2 Quality of Life domains

The lives of people can be described in terms of domains. Domains of life can be divided, identified, and evaluated separately (Andews & Withey, 1976). Those domains of life are related to people's activities, places, roles, and relations with others (Kerce, 1992). In a particular domain the degree or extent by which the people's wants and needs are satisfied determines the QoL of that domain (Rice, 1984).

Life in total can be thought of as a group of domains forming the whole picture like mosaic pieces, where individuals participate in these domains (Rice et al., 1985). Examples of life

domains include work, family, housing, neighborhood, religion, and friendship. Thus, a PQoL results from the perception of an infinite number of additive life experience domains; i.e., the total PQoL is the summation of PQoL for each domain. In environmental quality, IEQ factors can be viewed as the different domains forming the whole quality of the environment, therefore asserting that occupants' PQoL in this environment results from the summation of the perceived quality of IEQ factors in the environment they occupy.

2.2.2.3 Quality of Work Life (QWL)

Work is one of the QoL domains, and much research was done in the area of QoL as related to workers and organizational work[5] in the late 70s and 80s of the past century. This area of research is called the *quality of work life* (QWL). During that period, the improvement of QWL was the aim of several undertaken research efforts (Davis & Cherns, 1975; Hackman & Suttle, 1977; Lawler, 1982). QWL is a multi-dimensional construct and includes a comprehensive relationship between people, work, and organizations. This is with the intention of satisfying and fulfilling employees' needs and well-being, in order to contribute to job satisfaction and increase productivity to achieve organizational success and effectiveness (Nayak & Joshi, 2014). The study and investment on QWL to attain human satisfaction and organizations' long-term efficiency, adaptability, and effectiveness will in turn contribute to the national performance (Kast & Rosenzweig, 1974). Also, the improvement in QWL will make organizations more attractive to potential employees and better at retaining current employees (Saraji & Dargahi, 2006).

According to behavioral scientists, QWL represents the satisfaction of workers with their work and work environment (Taylor, 1974). This satisfaction can include a variety of needs stemming from occupants' participation in the workplace (Sirgy, Efraty, Siegel, & Lee, 2001). Several factors are found to affect QWL, including job satisfaction, working conditions, human relations, homework interface (work-life balance), management, compensation and salary (Phan & Vo, 2016). It is important to differentiate between QWL and job satisfaction.

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5 Based on the work of many philosophers and social scientist (Kahn, 1972, 1981; Neff, 1977; Tilgher, 1931) Rice, W. R., McFarlin,B. D., Hunt, G. R, and Near, P.J, (1985) suggested that "*Organizational work refers to human activities, in the context of formal organizations, performed with the intention of producing something of acknowledged social value*."

Job satisfaction can be one of the measures indicating QWL (Sale & Smoke, 2007; Boonrod, 2009), but it is not the only measure, as most authors agree (Davis & Cherns, 1975). However, it is the most used measure and even a sole outcome in several QWL studies (Mirvis & Lawler, 1984, Seashore, 1975; Sheppard, 1975).

Elizur and Shye (1990) suggested a comprehensive definitional framework for the concept of quality of work life (QWL) and tested its structure empirically using samples from Hungarian workers. They defined QWL and proposed a relation between it and QoL based on action systemic concepts (Shye 1979, 1985). In the action system approach, "*human life is regarded as an interactive organic action system whose functional components can be mapped out*" (Elizur & Shye, 1990). This definition goes well with the researcher's viewpoint of conceptualizing the work environment as an environment-behavior system, where occupants' behavior can indicate issues with the IEQ. Their framework suggests that "*efforts to improve the quality of work life of employees may also affect their sense of quality of life,*" and that "*QWL and QoL are similar and that they constitute parts of the same domain*" in a way that one could affect the other (Elizur & Shye, 1990). According to their study, a reduction in QWL and QoL may reduce employees' quality of work performance. Therefore, occupants' perception of the level of QWL is fundamental to the economical dimension of sustainability in office buildings. To avoid the confusion with job satisfaction and focus on the work itself, and to give more emphasis on the occupants' perspective, this research uses the term QoL in work environments rather than QWL.

This research focuses only on the environmental conditions or the quality of work environment (also called indoor environmental quality) that can affect QWL (Rethinam & Ismail, 2007) and, in turn, QoL (Shye, 1976, 1979). The quality of the work environment may include physical conditions, such as the building, material, and technology; economic conditions, such as services, pay, and benefits; and organizational conditions, such as social conditions, organizational structure, and job design (Elizur & Shye, 1990).

2.2.2.4 What are Office Work Environments?

The definition of office work environment changes through time, depending on the changing nature of work, new managerial strategies, and the new technologies impacting work life. The traditional meaning of an office focused on the physical and functional space:

> *"The office is where individuals or groups of individuals congregate for handling information and making plans and decisions. It is a place where individuals are likely to be required to read and to think and to talk with others. It is a place where groups or teams are required to communicate and collaborate . . .The office is typically a physical place with features and properties that provide both functional opportunities and multiple levels of meaningful interaction and feedback for the people who work in them."* (McCoy, 2002, p.443)

The office workplace is changing and currently is more innovative, thanks to collaborative and flexible designs. Four main drivers have contributed to the work environments and their transformation: technology, globalization, changing organizational structures, and economic considerations (Voordt, 2004; Heerwagen, Kelly, & Kampschroer, 2007). Due to these rapidly changing factors, work has become more complex, and how and where work is done has changed. The transformation in the nature of work also changed the design of the work environment. New work environments may include open workplaces, formal discussion areas, concentration workplaces, and coffee corners (Voordt, 2004).

Technology advancements such as the Internet and mobile devices have facilitated the accessibility to data, connectivity all over the globe, and the emergence of new work patterns (virtual teams, distributed cross-cultural teams, and so on) (Lee, 2015; Burke & Ng, 2006). Yet the easiness and pace of obtaining an overwhelming amount of data has created an overdose of data. This means that employees must understand and select information in a timely fashion; time pressure may lead to what psychologists name *cognitive overload syndrome (COS)*. Symptoms associated with COS include stress, difficulty to focus and concentrate, as well as the tendency to choose information that is easier to obtain rather than important information (Heerwagen et al., 2007). Also, new technology has allowed people to work remotely (provides flexibility), but at the same time be connected to work-related information and e-mails 24/7. This new work reality (a 24/7 tie) may cause problems in the work-life balance (Lee, 2015).

Globalization has increased the need for collaborative work, encouraged telecommuting, and generally instilled a reliance on technology (video conferencing, conference calls, etc.). As a result, workers were required to not just perform their tasks, but also to work efficiently in a team, deal with social conflicts, competitions, and the stress of having a collective success (in a team) rather that an own success (that might be unrecognized) (Heerwagen et al., 2007). The increased interest in work patterns that require teamwork and collaboration led to the need for more communication spaces and better information flow. This caused the work environment to have more meeting rooms, more variety in spaces size and type (opened, closed), smaller individual workspaces, etc.

Organizations became less hierarchical and more concerned with employees' QWL. The organizational restructuring (also a result of globalization, new economic information, the focus on clients and supporting innovations) led to more flexible infrastructure and mobile furniture. The concern with improved QWL to attract new workers (as a result of competition) led to the provision of more equitable amenities, such as daylighting, views, and workspace features, and the creation of amenities that may reduce stress and provide a quiet relaxing environment, such as lounges and gyms (Heerwagen at al., 2007).

The economic constraints required cost reduction, more efficient spaces, and less floor space (Voordt, Ikiz-Koppejan, & Gosselink, 2012). This led to the emergence of shared or unassigned workspaces, smaller workstation sizes, and spaces that can accommodate different kinds of work (Heerwagen et al., 2007).

However, it is important to study the effects of new or traditional work environments on employees and to know how the aspects of the work environment may affect occupants' QoL.

2.2.3 Descriptors of Quality of Life (QoL) in Sustainable Work Environments

In terms of sustainability, QoL is addressed by researchers and policy makers alike, in the sense that sustainability is meant to provide people with the satisfactory living conditions to have a positive relation with their environment (Moser, 2009). In the work environment, the living conditions are considered as the quality of the environment where employees work. In

this research QoL is described in terms of occupants' health, comfort, and productivity. This description of QoL is based on the interpretation of sustainability in the IEQ of LEED, where it intends to provide design criteria that create *healthy*, *comfortable,* and *productive* indoor environments for building occupants (Portman et al., 2006). Health, comfort, and productivity are defined in the following sections.

2.2.3.1 Health

"*Health is a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity*" (WHO, 1948). The physical environment may affect people's health in the short or long term. On a physical level, it could affect the immune system and cause problems such as asthma, hypertension, back and neck pain, eyestrain, dry skin, and runny nose. Psychological (mental health) problems could also manifest: stress, anxiety, fear, happiness, mood swings, etc.

> *"Recent research has shown that certain factors present in the architectural environment affect the human immune system, and as a result, the health of the occupants. Factors such as the chemical components in building materials, mechanical systems, and furnishings affect the immune system on a physical level. Factors, such as feelings of comfort or stress in a space, perhaps related to childhood experiences, affect the psycho/emotional component of the immune system, and thus, the relationship of the occupant to the built environment."* (Mirkine, 1996, p.6)

2.2.3.2 Comfort and Satisfaction

(i) Comfort

> *"Comfort as a basis for setting environmental standards has developed out of recognition of people's need to be more than simply healthy and safe in the buildings they occupy. Building users need environmental support for the activities they are there to perform, and this state of environmental support is what is meant by comfort*." (Vischer, 2007)

Environmental comfort is a concept used usually to describe the relation between human experience and the quality provided by the environment the person occupies. Historically environmental comfort "*is a conceptual approach to the different ways in which humans in various climates and cultures have controlled, adapted and managed their environment in*

order to ensure well-being" (Vischer, 2005). In engineering fields designing of building systems determine comfort levels based on objective measures and set building codes and standards. Objective measures of Indoor Environmental Quality (IEQ) are usually composed of four IEQ factors that are the IAQ, Thermal Comfort, Acoustic Quality, and Lighting Quality. These IEQ factors are measured instrumentally. For example, the indicators or measuring indices of objective IAQ in offices are the concentration of key indicators, such as formaldehyde, carbon monoxide, and carbon dioxide. Thermal Comfort is indicated by air temperature, radiant temperature, air speed, humidity (Brown, 2008), and the season (winter or summer); the type of clothing and activity type are also considered (Olesen, 2004). Light Quality is typically measured by the amount of illuminance on the working plane, measured in lux. Noise is measured in decibels, and the recommended amount of noise for private offices is 35–40 dB and less than 40–45 dB for open-plan offices (Brown, 2008). However, human experience is complex and encompasses psychological dimensions. As stated by Vischer (1989), the "*technical aspects of building performance do not provide a complete picture of building quality for the person working in the same building every day*." Human health and comfort are influenced by many other qualitative factors, such as qualities influencing human psychological comfort or emotional well-being. Occupants' perceptions make people judge their environments subjectively.

According to Preiser (1983), human needs from the physical built environment can be classified into three broad categories called the levels of habitability. Those three levels in Preiser's habitability framework are greatly analogous to the human needs hierarchy developed by Maslow (1943), namely self-actualization, love, esteem, safety, and physiological needs. Preiser's three categories of human needs in the built environment are (1) *health and safety level*, where the built environment should prevent accidents and injury, disease, vandalism, etc.; (2) *functional and task performance level*, where the built environment should provide conditions conducive to the efficient performance of a job; and (3) *psychological comfort and satisfaction level*, where the built environment should support and provide integrity, speech and visual privacy, access to valued resources, expression of individuality, status, identity, etc. (Preiser, 1983). Thus, further knowledge about the person-environment relationship is needed for the design of sustainable buildings. The type of tasks

and activities is crucial to building design, because solely focusing on increasing occupants' comfort level does not always guarantee a better QoL. This is to say that buildings of very high comfort levels might make the occupants sleepy (Vischer, 1989). This is inappropriate for office buildings, where employees require a high degree of concentration and alertness to work. Hence, a balance is required, because low levels of comfort are considered inhabitable (Vischer, 1989).

(ii) Satisfaction

Satisfaction is the cognitive component of occupants' experience and assessment; it involves comparing the objective conditions to one's internal standards (Cheng, 1988). The difference between happiness and satisfaction is that happiness is an appraisal state of an emotional experience. The feeling of satisfaction depends on expectations and standards as important aspects in the evaluation and comparison of current circumstances, while the affect is an immediate feeling state that has no reference and is not tied to cognitive frames (Campbell et al., 1976; McKennell, 1978; McKennell & Andrews, 1980). Satisfaction is the notion of how satisfied or not users are with the space they occupy, where satisfaction has guided environmental evaluation since its earliest efforts (Craik, 1966; Friedman, Zimring & Zube, 1978; Little, 1968). It is usually considered in the literature as the desirability or feeling of liking as judged by subjects (Lee, 2007). It is a subjective measure of the cognitive component of occupants' experience, representing how much the occupants like the quality of their environment as a whole or with each IEQ factor specifically. The user-satisfaction approach reflects the beliefs that users' satisfactions indicate the quality of buildings, and that the more satisfied the users are, the better the building is. Good environmental design should meet specific human needs (Vischer, 1985). Fulfilling human needs is a main target in environmental design as well as in sustainable development, which "*meets the needs of the present without compromising the ability of future generations to meet their own needs"* (Brundtland, 1987, p.43). Hence, in work environments satisfaction is an outcome of occupants' different levels of comfort (physical, functional, and psychological) being met and provided by the environment. Studies held on occupants' satisfaction imply that this concept is a de facto measure of the building quality when users feel positive (satisfied); however,

when they feel dissatisfied, then the place is not performing well or has somehow failed (Vischer, 2008).

Since the 1980s, several building evaluation studies have been conducted in office environments with the aim to determine the effect of certain environmental characteristics on users' satisfaction or dissatisfaction (Marans & Spreckelmeyer, 1981; Ornstein, 1999; Stokols, 1978; Wineman, 1986). Extensive survey questionnaires were used to measure occupants' judgments of their work environment. These types of surveys were based on the assumption that measuring users' self-rated satisfaction with individual features helps in understanding the effect of the built environment on building occupants (Vischer, 2008).

2.2.3.3 **Productivity**

Productivity is defined as a measure of the ratio between the input and output, yet it is less accurate to measure in small environments, where each individual's result could contribute greatly to the total results (Bell, Bergman, Garcia Hansen, Mabb, & Morawska, 2003). A more commonly-used alternative to productivity in the environment-behavior and environmental quality research is the self-reported performance, where employees assess and rate their perceived performance. Since it is hard to find a universally-accepted measure for office productivity (Haynes, 2008), the self-assessed measure of productivity is accepted by several researchers as better than having no measure of productivity (Whitley, Makin, & Dickson, 1996; Oseland, 1999, 2004).

The literature measuring the possible impact of the office environment on occupants' perceived productivity generally studies only the physical components of the work environment (Clements-Croome, 2006). However, Haynes (2008) studied both the effect of the Physical and Behavioral Environments of office buildings on Occupants' Perceived Productivity. His study found that the Behavioral Environment has a greater impact on Office Productivity and more specifically the factors contributing to Interaction (affects positively) and the factors causing Distraction (affects negatively). Indicators of Interaction included social interaction, work interaction, layout, creative environment, and location from colleagues or equipment. Indicators of Distraction included noise, crowding, and interruptions.

Finally, occupants' satisfaction with the indoor environmental conditions (air, lighting, temperature, etc.) affect their perceived productivity (Leaman, 1995).

2.3 Indoor Environmental Quality

2.3.1 Defining Environmental Quality

Environmental Quality can be defined as *"the combination of environmental elements that interact with users of the environment to enable that environment to be the best possible one for the activities that go on in it"* (Vischer, 1989). Environmental quality as a concept seems to be too general, yet is commonly used as a tool for the evaluation of the built environment (Rapoport 1990, Elzeyadi, 2001, Khattab, 1993).

2.3.1.1 Indoor Environmental Quality (IEQ)

Indoor Environmental Quality (IEQ) is the quality of the indoor physical environment, with all it can encompass from factors affecting the physical features. Those physical features can be physically felt, or they can convey non-physical meanings that can be perceived by the occupants. To explain the buildings' indoor environmental quality, it can be said:

> *"The meaning of IEQ can be very broad and general including functional space layout, indoor air quality, thermal comfort, illuminance, acoustics, ergonomics, and aesthetics. These features affect the occupants' productivity, health, comfort, safety, security, and sense of well-being and community."* (Lee, 2007)

2.3.1.2 Physical and Perceived Indoor-Environmental Quality

The assessment of IEQ was originally approached from a technical or medical viewpoint, where the assessment of IEQ relied on measurements and observed physical effects rather than occupants' perceptions (Engvall, Norrby, & Sandstedt, 2004, Bluyssen 2009). In the real world, people experience their environments while being influenced by both objective and subjective measures of quality. In the built environment this is reflected as the physical and perceived qualities of built environments (Rapoport, 1977). Physical qualities are the material aspects that are measurable, such as air quality, lighting, and temperature; the perceived are the material and immaterial subjective qualities, perceived by occupants as supporting their

social and cultural structures. It is the perceived qualities that make people feel satisfied or not with their physical settings (Rapoport & Hardie, 1991). Human perception is a crucial factor in the person-environment relationship, and *"most managers know that environmental quality does not exist outside the context of users' perceptions"* (Vischer, 1989). As inspired by the words of Merleau-Ponty (1964), architecture is meant to make visible how the world touches us. Also, Clements-Croome mentions that

> *"Architecture is an extension of nature into the man-made realm and provides the ground for perception, and the horizon to experience from which one can learn to understand the world. Buildings filter the passage of light, air and sound between the inside and outdoor environments."* (Clements-Croome, 2006)

Field research has shown that the actual measurements of a building's environmental performance or quality may differ from its occupant's perceptions (Leaman & Bordass, 1999, Sekhar, Tham, & Cheong, 2003). For example, the IAQ evaluation includes carbon dioxide (CO_2) levels, chemical pollutants, airborne bacteria, and so on, while people perceive IAQ according to their subjective evaluations, such as fresh, smelly, still, dry, stuffy, etc. (Vischer, 2005). Hence, gaps may occur between what is satisfactory in terms of numbers and physical measurements and what is satisfactory from occupants' perspectives. This example shows that the field of environmental psychology needs to incorporate the methodology of environmental comfort research in order to fully measure the IEQ (De Dear, 2004). A better understanding of the dominant components of IEQ from the occupants' point of view could be a solution for satisfying environmental comfort.

2.3.2 Levels of Meaning in Indoor Environmental Quality

According to Rapoport (1988), environmental quality can be classified into three levels of meanings: the instrumental, latent, and symbolic. The instrumental level contains the qualities that can be measured. The latent level contains the hidden qualities that are not visible in the physical appearance of the environment. The symbolic level contains qualities that affect our perception of meaning, such as our interpretation of symbols (related to our culture and value system).

2.3.2.1 Indoor Environmental Quality: The Instrumental level

This level represents the physical properties and functional qualities of the environment enabling the occupants to perform their tasks. Examples include the ambient comfort conditions and ergonomics (Brill, 1984; Davis, 1984; Donald, 1994; Utzinger & Wasely, 1997). Most of the existing literature on green buildings measures the influence of such factors on environmental quality as an outcome or as the impact of these variables on employee satisfaction, productivity, and comfort (Vischer, 1989; Heerwagen, Kampschroer, Powell, & Loftness, 2004; Lee, 2007).

2.3.2.2 Indoor Environmental Quality: The Latent level

This level represents the subjective qualities of the physical environment, such as the psychological, socio-cultural, and socio-psychological qualities—privacy, safety, territoriality, wayfinding, personalization, crowding, etc. (Becker, 1990; Ornstein, 1992; Fischer, 1997). This level of qualities supports the identity, appropriate behavior, and subjective value to employees (Rapoport, 1990; Genereux, Lawrence & Russel, 1983). Most of the literature on work environments and environment-behavior studies have focused on this level of qualities (Rapoport, 1988). However, it is ignored in green buildings' literature, except for some studies measuring the psychological benefit of green buildings on occupants (Heerwagen et al., 2004; Okhovat, Amirkhani, & Pourjafar, 2009).

2.3.2.3 Indoor Environmental Quality: The Symbolic level

This level represents the qualities of the physical environment that compose the higher level of meanings and values related to traditions, beliefs, historical values, status, pride, culture, etc. (Rapoport, 1983; Turner 1990; Doxtater, 1994). This level has usually been ignored, whether in work environment research or green buildings research, except for some research on status in work environments (Doxtater, 1994; Sundstrom & Sundstrom, 1986). Vischer (2011) has suggested that there is a *socio-spatial* relationship between organizations and the people working in them, and that this relationship contains the promises about the physical work conditions. Hence, organizations reflect their objectives and culture via

buildings, workspaces, and technology. She also suggests that the understanding of the interdependencies in this relationship could make organizations get a greater value from their human capital.

2.3.3 IEQ in Work Environments

2.3.3.1 Definition of IEQ in Office Work Environments

Based on Vischer's (1989) definition, in work environments, environmental quality is *"the combination of environmental elements that interact with users of the environment to enable that environment to be the best possible one for the activities that go on in it."*

2.3.3.2 IEQ factors in Office Work Environments

The quality of the physical features in the work environment forms the IEQ factors of the physical work environment. Those IEQ factors have physical and non-physical traits. The physical IEQ factors are those that have an instrumental meaning. The non-physical IEQ factors are those that have a latent or symbolic meaning. In this research, a further classification is created, where the physical work environment is classified into three categories: (1) the *Ambient Conditions*, (2) the *Designed Environment*, and (3) the *Behavioral Environment*. The Ambient Conditions and the Designed Environment encompass the instrumental qualities, such as IAQ, Illumination, Thermal Comfort, Acoustics, Layout, and Spatial Organization. The Behavioral Environment represents the latent and symbolic qualities in the environment, such as Privacy, Territoriality, Control, Status, and Pride.

(i) IEQ in Relation to Ambient Conditions

Ambient Conditions in the office work environment encompass any quality that creates the atmosphere and environmental conditions of the space, such as illumination, air quality, thermal comfort, and sound. McCoy's (1996) comprehensive review of previous *post occupancy evaluation* (POE) studies showed that they are the most commonly-measured features of the office environment. Nevertheless, occupants' personal preferences and satisfaction with the Ambient Conditions may differ according to the tasks they are performing and their personal traits. However, Gerlach (1974) concluded that the control over

Ambient Conditions is what makes people most comfortable, and the lack of control over Ambient Conditions to suit individual comfort levels is likely to cause an increase in stress (Cohen, Evans, Stokols & Krantz, 2013).

(a) Illumination

Illumination is light that comes from the light sources, that can be classified into natural and artificial light. The quality of illumination cannot be evaluated separately from the task requirements, where each type of activity requires different illumination specifications. Illumination quality may include the colour of the light source itself, the source type, the amount of luminance, and the position, distribution, and effectiveness of the lighting, while ultimately determining how well it suits the task required.

The quality of illumination in a space primarily affects the visual ability of occupants. However, behavioral outcomes are also found to be associated with lighting quality, such as task performance, mood, health, and safety, as well as aesthetical judgments (Veitch & Newsham, 1998). For example, flickers caused by fluorescent lamps have effects on visual performance, neural activity, saccadic eye movements, and reading ability (Kuller & Laike, 1998; Veitch & McColl, 1995; Veitch & Newsham, 1998). Inadequate lighting may also result in glare and shadows, further causing eyestrain and discomfort. Therefore, the quality of lighting may affect occupants' physical and psychological health and well-being, as well as physical and functional comfort.

(b) Air Quality

Modern office buildings are commonly covered with curtain walls, and in many cases the windows are non-operable in an effort to save energy and suit the architectural image. This could compromise the IAQ if inadequate air ventilation systems are used. Offices also have printers and other materials that can release toxins into the air. Poor air quality is not only uncomfortable in the sense of stuffiness or odors, but it can be harmful and compromise occupants' health, performance, and satisfaction. *Sick building syndrome* (SBS) and *building related illness* (BRI) are common afflictions that an occupant could end up suffering from as a result of the poor IAQ of buildings (Lindvall, 1992; Hedge, Burge, Robertson, Wilson, & Harris-Bass, 1989). Symptoms may include asthma, headaches, a runny nose, red irritated

eyes, itchiness and dryness of the skin, and a sore throat (Kemp, Dingle, & Neumeister, 1998). Such symptoms increase occupants' psychological stress and hence can significantly affect the job satisfaction and work performance (McCoy, 2002).

(c) Thermal Comfort

Thermal comfort, or what is known as the *effective temperature*, is an index composed of three indicators: air temperature, humidity, and air movement (Yaglou, 1927; McCoy, 2002). Other factors may also affect our feeling of thermal comfort, such as the activity level or work being done, the amount of clothing being worn, the time spent in the space, the age of the occupant, and the health of the occupant (McCoy, 2002).

(d) Sound

Sound is classified into desirable and unwanted/undesirable sound, where undesirable sounds are called *noise* (Gifford, 2007). Noise from other people, ringing phones, mechanical systems, printers, and the street can be distracting and disturbing. Noise may affect occupants' ability to focus on work and may influence their performance. It can also be tiring, causing health problems such as headaches and anxiety. Uncontrolled noise is considered a detrimental stressor that affects work performance (Brill, Weidemann, Alard, Olson, & Keable, 2001; Cohen et al., 2013). To the contrary, the Buffalo Organization for Social and Technological Innovation (BOSTI) studies reported that the technological advancements using highly absorptive ceilings, carpets, and panels, resulted in too little noise, which as well was a complaint to some occupants (Brill, 1997).

*(ii) **IEQ in the Designed Environment***

The Designed Environment encompasses any IEQ factor that is related to the design of the space, such as Views, Personal Workspaces, Office Layout, Spatial Organization, Furniture and Ergonomics, and Architectonic Details. Some of these qualities are discussed below.

(a) Views

Views encompass both the quality of the scene viewed, as well as the opportunity of accessing natural daylight with the benefit of engaging with the weather changes. It is evaluated in terms of scale and content (McCoy, 2000). Research on environment-behavior

has indicated that views may have several influences on people, such as health and well-being (Ulrich, 1984), symbol of status (a privilege) (Becker & Steele, 1995; Brill, Margulis, & Konar, 1984; Duffy, 1992), morale and environmental satisfaction (McCoy, 2000), and may also have a restorative value for stress at work (Heerwagen & Orians, 1990; Kaplan, Talbot, & Kaplan, 1988).

(b) Spatial Organization

Spatial organization involves size, shape, allocation, and division of office space; it is one of the most important and most-researched features in the physical work environment. It is one of the major influential factors influencing occupants' experience in their workspaces, as it may alter people's feelings of the level of enclosure, proxemics, crowding, territoriality, privacy, control, variety and adaptability, flexibility and legibility, communication, and collaboration. It may also affect organizations' efficiency and effectiveness, and even status. Traditionally the office location, furniture quality, and features represented the structure and hierarchy of the people working in the organization (McCoy, 2000).

The BOSTI did an extensive long-term study and research program in 80 different organizations, with a sample size of more than 13,000 office workers (Brill et al., 1984; Brill et al., 2001). The study measured the influence of the Physical Environment on Workers and Control Groups using a quasi-experimental research design. They manipulated the Physical (office) Environment by conducting pre- and post-test questionnaires. Features of the workspaces included the Physical Enclosure, Aesthetics, Privacy, Furniture, Status, communication, temperature control, and lighting. Results of the study showed that changes in the features of the Physical Environment affected Job Performance, Job Satisfaction, ease and quality of Communication, and Satisfaction with the environment. It also showed that Job Satisfaction and Job Performance had measurable economic influences on the organization.

McCoy (2000) performed an in-depth study on seven teams in office buildings. The study found that Spatial Organization and allocation supports occupants' satisfaction and performance. It is also significant with team collaboration and communication. Also, it encourages social activities, such as informal communication and extended collaboration that in turn help in higher levels of creativity and performance.

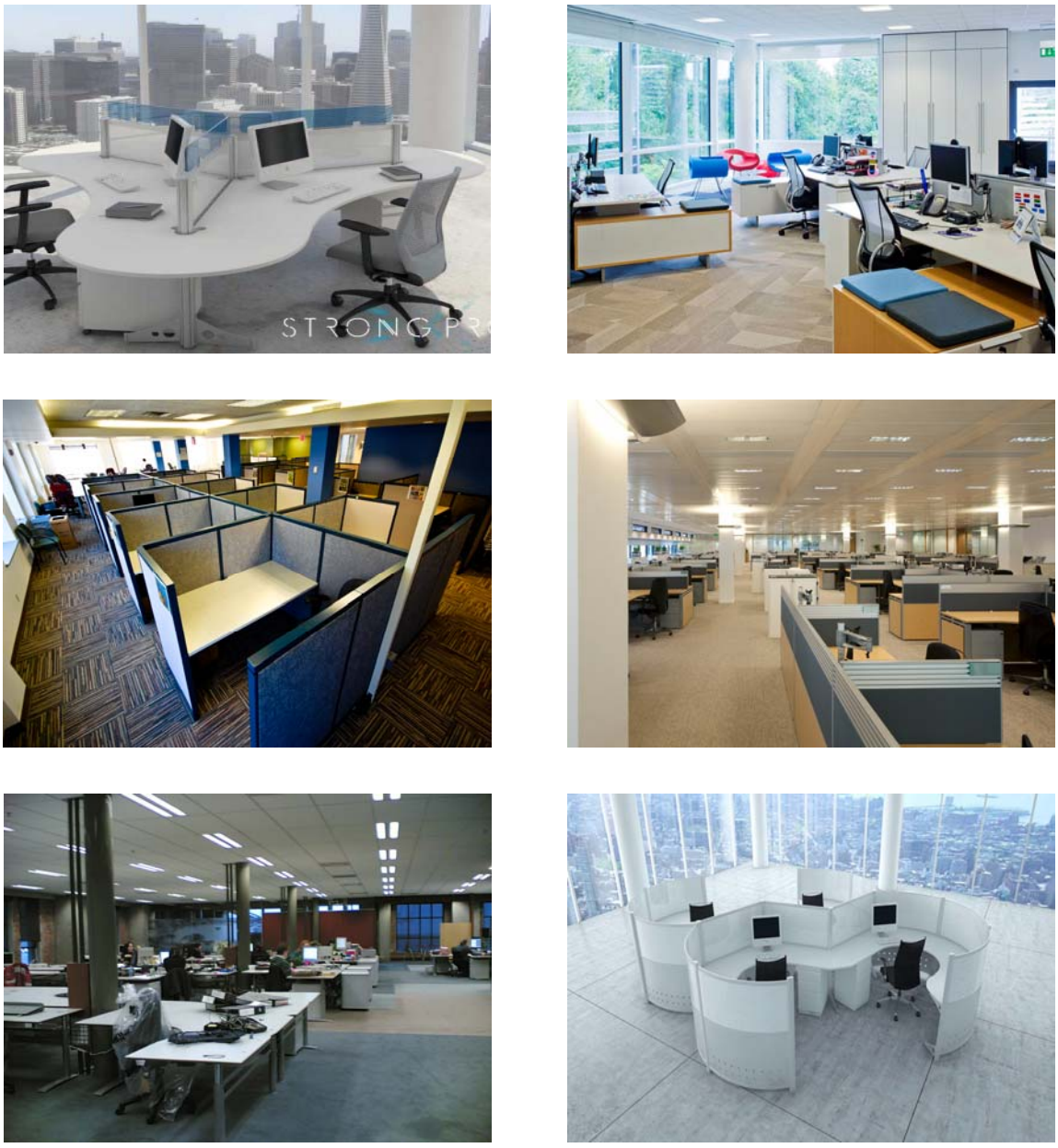


Figure 1. Examples of different spatial organization
Source: found on Google images.com, all pictures are labeled for reuse.

One of the significant qualities in regards to the organization of space involve where the resources are located and how accessible they are. Resources in the workplace may include equipment, facilities, people, and funds (Amabile, 1988, 1993). Adequate access to resources can save time and frustration, making the work process more efficient and less stressful. In turn, that may affect work productivity and employees' job satisfaction, thereby improving

their QoL experience. In the interviews of office workers done by Amabile (1988, 1993) 52% of the respondents stated that access to resources was very important to them—in comparison to the other nine qualities encouraging creative teamwork. Furthermore, the BOSTI report suggests that the office should be reconceptualized as a tool and not as a place to house tools (Brill et al., 1984).

(c) Architectonic Details

Architectonic details represent the decorations, artworks, artifacts, use of style, colour, ornaments, and so on. Architectonic details are rarely studied in research on the physical work environment. However, Becker and Steele (1995) suggest that they may support occupants' sense of identity and purpose. They consider the idea that displaying such details may act as a *non-verbal communication system*, conveying different messages of status, identity, organizational history, and organizational expectations. The Bosti's report also indicates that the image or appearance of the environment may reflect values and norms of the organization and employees (Brill et al., 1984). Thus, architectonic details can provide valuable symbolic qualities that play a role in supporting the social dimension of sustainability by fulfilling occupants' social and cultural needs, hence improving their QoL.

(iii) ***IEQ in the Behavioral Environment***

The Behavioral Environment encompasses any feature or IEQ factor related to occupants' social, psychological, or cultural aspects. Examples include Personalization, Territoriality, Personal Space, Wayfinding, Control, Status, and Pride. They may occur from the features of the physical work environment, which belong in either the Ambient or the Designed Environments. For example, architectonic details are part of the features in the Designed Environment, but their quality influences the IEQ factors in the Behavioral Environment because they convey a symbolic meaning to environmental quality. Other features of the designed space, such as heights of partitions, the organization of space, views, and desk locations can have impacts on IEQ factors in the Behavioral Environment, such as privacy, crowding, and territoriality.

(a) Territoriality

Territoriality is a non-verbal type of communication used to claim ownership and control. There are several psychological definitions for it, and most of them stress that behavior and cognition are both involved in territoriality when related to a place (Gifford, 2007).

A working definition offered by Gifford, (2007) states, "*Territoriality is a pattern of behavior and attitudes held by an individual or group that is based on perceived, attempted, or actual control of a definable physical space, object, or idea that may involve habitual occupation, defense, personalization, and marking*[6] *of it*." For example, putting a fence around one's house is an act of territoriality. In work environments, the use of personal items (personalization) and furniture can be used to indicate possessiveness and territoriality of the workspace.

(b) Personalization

"*Personalization means marking in a manner that indicates one's identity*" (Baumeister & Vohs, 2007). Simply put, it means to use personal items. Personalization of space and self-expression is performed to indicate and support individual and group identity, territoriality, environmental stimulation, and symbolizes place commitment and purpose; in the end, that is correlated with environmental and job satisfaction (Brill et al., 1984). A McCoy study in 2000 also found that personalization was more related to highly creative teamwork, where artifacts were more likely used to set team goals and achievements.

Figure 2. Examples of workspace personalization by using personal photos, pictures and artifacts.
Source: found on Google images.com, all pictures are labeled for reuse.

[6] "Marking means placing an object or substance in a space to indicate one's territorial intentions." (Gifford, 2007)

(c) Wayfinding

Wayfinding refers to the systems used to give information and guide people through a physical environment. Those systems facilitate the understanding and navigation inside buildings. It makes occupants' experience easier, especially in complex public buildings such office buildings and hospitals. According to Downs & Stea (1973) wayfinding has four stages, namely orientation, route decision, route monitoring, and destination recognition. Signs, colours, patterns, and artificial lighting are used for wayfinding (see Figure 3 and Figure 4).

Figure 3. Wayfinding signs, patterns, and colours.

Source: found on Google images.com, all pictures are labeled for reuse.

Figure 4. Kaiser Permanente Orchard Medical Office, in Downey, CA, USA Janet Rhee, DLR Group WWCOT Interiors

Source: found on http://www.armstrong.com/commflooringna/Kaiser-case-study.html

(d) Crowding

Crowding is a psychological feeling perceived due to a lack of enough space and that things are jammed. It is different than density, which can be measured, and depends on the physical number of subjects and space available for them. Crowding is defined as the negative affect toward perceived density (Eroglu & Machleit, 1990). Kalb and Keating (1981) conducted a study to test the difference between the feeling of crowding and the environmental rating of crowding (as perceived by subjects). The study found that the two measures are different. The *feel* of crowding is more related to perceived density and people's behavioral experience, such as stressfulness, self-perceived hindrance, restriction, and confinement. The *rating* of crowding was related to the perceived density and general negative affect. The feel of crowding relates more related to changes in the physical density than in the rating of environmental crowding.

2.3.4 Influences of IEQ in Office Work Environments

Influences of IEQ in General

People spend most of their time indoors, where the effects of the indoor environment on their QoL could be numerous. Even though we can be unconscious of our surroundings if we are busy with tasks, there is a general agreement that buildings' indoor environments affect occupants in many ways: Places affect us "*beyond their biological effects, they make us feel uncomfortable and ill-at-ease, energetic and stimulated or relaxed and at peace. . .They can work so deeply into our being that they affect our state of health"* (Day, 2002).

Several factors may alter the quality of the indoor environment, such as Connectivity with Nature (through views, indoor plants, daylighting); IAQ; Lighting; and Thermal Comfort (temperature) are also responsible. Studies concerned with Connectivity with Nature show that exposure to nature affects our mental fatigue (Kaplan, 1995). Kuo and Sullivan (2001) suggested that vegetation in public housing could reduce crime and aggressiveness; according to them, the greener the surrounding, the lower level of fear, violence, and incivility within residents. Vegetation and water could reduce stress (Schroeder, 1991) and are "natural tranquilizers" (Berg, van den Top, & Kranendonk, 1998). Other studies showed an influence of nature on restorative ability: Ulrich's (1984) hospital study found higher rates of recovery for patients with windows in rooms that had natural views. Daylighting is found to affect the emotional well-being of people; a study conducted by Heschong, Wright, and Okura (2002) in a school building suggested that students in day-lit classrooms were found to be happier. IAQ also impacts occupants' health, and improved Light and Temperature can increase productivity (Fisk, Price, Faulkner, Sullivan, & Dibartolomeo, 2002).

Influences of IEQ in Workspaces

> *"Specific features of office space, such as temperature, lighting, noise, privacy, physical comfort (i.e. furniture), and aesthetics such as the colour and texture of surfaces can affect the productivity, satisfaction and overall well-being of office workers. It may even affect their health or perceived health, as reflected in the number of sick days taken by an employee (further impacting productivity)."* (Andrew, Chang, & Nicholson, 2008)

The IEQ of office workspaces is particularly essential, as the majority of the labor force in North America works in offices (Vischer, 1989), and people may spend more than 50% of their time in office spaces. Offices are the primary focus of understanding a workplace in the Information Age (McCoy, 2002). The influence of these offices could have both direct and indirect impacts on the community: employees' QoL might be directly affected, and the quality of work done by them might influence the quality of services provided to the rest of the community. To the contrary, well-performing work environments can promote health, comfort, and productivity (Ochoa & Capeluto, 2006; Vischer, 2007). A high-quality work environment provides many enriching merits to workers' social lives, such as autonomy and responsibility, development of human capacity, promotion of positive work, supervision, and opportunities for advancement.

Years ago (in 1979), a popular multi-story conventional office building in Canada—the Terrasses de la Chaudiere near Ottawa—faced the problem of office workers who refused to work because they felt that the interior air was polluted and that they had suffered from repeatedly getting sick. Their complaints about the indoor air were announced to the public (The Citizen, 1979). Later, in 1980, another complaint was made about a pervading "stench" in the same building and that people suffered from nausea, dizziness, and headaches (The Citizen, 1980, 3). In Melbourne, Australia, a group of workers refused to go to their work at video display terminals due to their feeling of discomfort from bad lighting, uncomfortable furniture, muscle pain, repetitive strain injury, and joint swelling in different body areas, such as their wrists, arms, and necks (Vischer 1989). In another modern office building, a woman suffered from repeated headaches and eyestrain, keeping her unproductive and unwell; several attempts to solve the problem were undertaken, and finally it was discovered that the culprit was the glare caused by the artificial lighting reflected on her desk cover (Vischer 1989). Those results emphasize the importance of listening to the occupants and realizing that their lived experience may need to be addressed by altering codes, standards, and GBRSs assumptions about occupants' health, comfort, and productivity. Such findings also give insights that can guide design decisions in the workplace, as well as focus on the need of incorporation of IEQ factors that depend on occupants' lived experiences as indicators of quality.

In 1998, the popular cartoonist Scott Adams illustrated the office environment in his *Dilbert* cartoons. As shown in Figure 5, he presented (very well) several occupants' responses toward their cubicles, underlining their complaints about the inadequate work environment. Influences of the IEQ in work environments on occupants' QoL can be classified into physical, psychological, and functional influences.

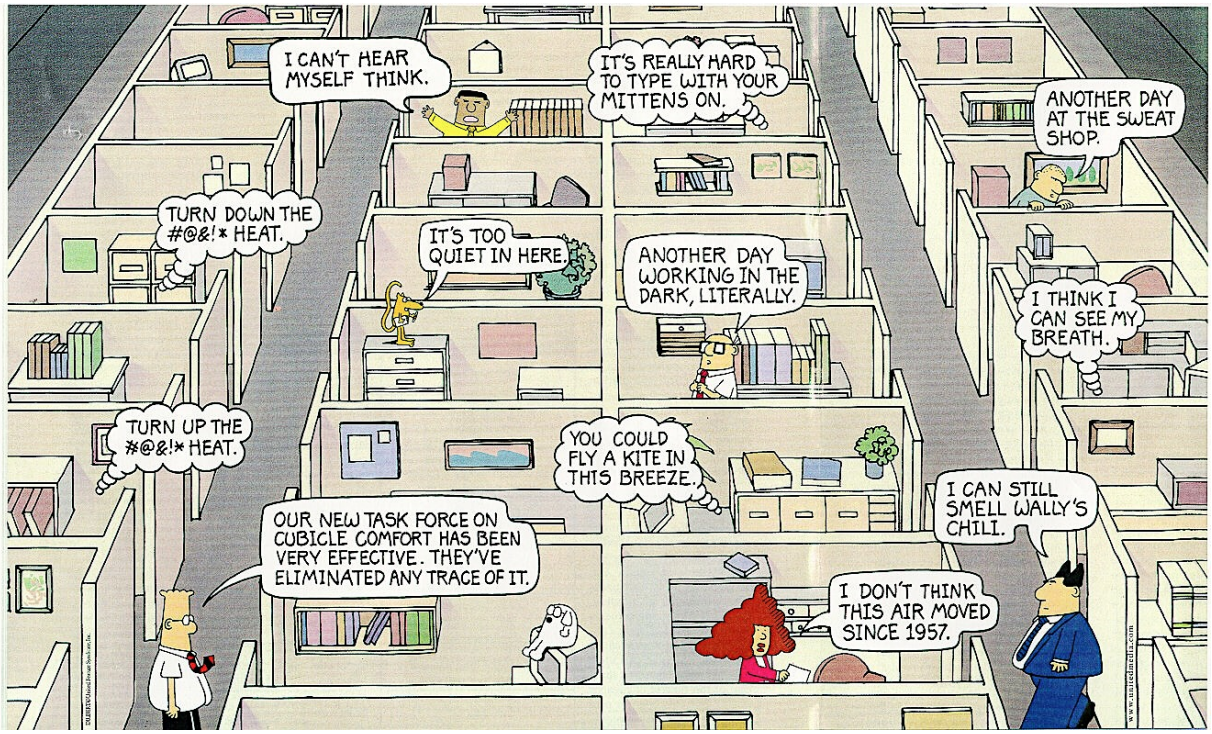


Figure 5. The office environments in Scott Adams' "Dilbert" cartoons

Source: Bauman, F. (2013). Thermal Comfort Research at the Center for the Built Environment, Center for the Built Environment, University of California, Berkeley, May 2013

2.3.4.1 Physical Influences of the Work Environment on Building Occupants

The physical influences of work environments include any impact on occupants' physical health and safety. Many findings have identified links between employees' health and aspects of the physical environment at work, such as IAQ, Ergonomic and Furniture, and Lighting (Dilani, 2004; Milton, Glencross, & Walters, 2000; Veitch & Newsham, 2000). Examples include nausea, runny nose, and irritated eyes, which are caused by toxins in the finishing

materials, furniture, contaminated indoor air, or lack of sufficient natural ventilation and circulation of indoor air. Similarly, the presence of toxic materials seems to cause building occupants to experience more headaches, dizziness, and tiredness (Wargocki, Wyon, Baik, Clausen, Fanger, 1999). Fisk et al. (2002) suggested that 16–37 million cases of colds and flu per year could be avoided by improving IAQ, resulting in $6–$14 billion in annual savings in the United States. Also, the symptoms of SBS could be reduced by 20–50%, resulting in $10–$30 billion in annual savings in the United States (Milton et al., 2000). Other influences of the physical work environment also include back and neck pain due to bad posture from uncomfortable furniture.

2.3.4.2 Psychological Influences of the Work Environment on Building Occupants

Psychological influences caused by the indoor environments of workspaces are multiple, and they include stress, anxiety, depression, and lack of motivation; theories about the cause of stress due to environmental conditions have their origin in psychological studies undertaken several decades ago (Vischer, 2003).

A commonly-known psychological problem associated with the high-rise buildings (which constitute a popular component of modern office building complexes) is people's complaint of being separated from nature (Haber, 1977). Kaplan et al. (1988) had earlier reported that office workers who have outdoor views of natural scenery like trees and grass have less job stress than workers whose views consist of built components like roads or buildings. Stress is one of the most common psychological influences caused by the indoor environment of workspaces (Vischer, 2003). Other features in the built environment that could affect occupants have been found to affect emotional well-being; Daylighting, for example, appears to make people *happier* (Heschong et al., 2002).

2.3.4.3 Functional Influences of the Work Environment on Building Occupants

The quality of work environments and how they influence employees' productivity is an area of research that concerns architectural, environmental, and interior designers, managers and business owners, as well as the employees themselves. People are more likely to quit their jobs if they cannot bear their physical work environment (Vischer, 1989). Unsatisfactory

work environments not only affect employees; they also affect their organizations' bottom-lines directly and indirectly. There is increasing evidence regarding the time and energy wasted by employees in coping with poorly-designed workspaces; this is of obvious interest to employers, who want their employees to invest their time and energy in work (Vischer, 2008). In addition to negative impacts caused by higher rates of absenteeism due to illness (asthma, eye strain, back & neck pains, etc.), there are other negative consequences to consider: low morale, less place-attachment, higher employee turnover, reduced motivation, stress, anxiety, reduced performance, less effective collaboration and communication. All contribute to difficulty in getting the work done, and any one of these factors is likely to affect organizational productivity (Vischer, 1989, 2003, 2008; Haynes, 2007; Arnold, 2004; Heerwagen et al., 2004; Sundstrom, Town, Rice, Osborn, & Brill, 1994). Studies have shown that improved light and temperature can increase productivity (Fisk, 2000). Further impacts on the workers' performance or productivity include having an unsupportive work environment for the tasks performed; for example, difficulty in accessibility to equipment and resources and inefficiency accompanied with the length of time spent to fix uncomfortable situations.

2.4 IEQ Assessment

The evaluation of the physical environment has taken various names in the literature, ranging from post occupancy evaluation (POE) to building performance evaluation (BPE), environmental design evaluation, Building-In-Use (BIU) assessments, facility assessment, and facility performance evaluation (Shepley, 2011). The terms used to describe building evaluation or assessment of quality or performance have been used interchangeably—there seems to be no universally-accepted definition (Steinke, Webster, & Fontaine, 2010). However, building performance or quality evaluation can be classified into two broad categories: first through the examination of the technical performance of the building systems, such as the electrical and mechanical systems, second through occupants' responses (perceptions).

The first approach uses instrumental measurements for the IEQ and refers it to the building codes and standards, where *"technical aspects of building performance do not provide a*

complete picture of building quality for the person working in the same building every day" (Vischer, 1989). Current GBRSs use codes and standards to assess their performance; such codes and standards include the American Society of Heating, Refrigerating, and Air-conditioning (ASHRAE) standards used in the LEED criteria for IEQ. These standards are based on occupants' health, safety, and comfort levels. However, designing green buildings to provide better QoL should not only rely on building codes and standards. Further knowledge on occupants' relationship with the building (feedback from occupants) is needed to validate the codes and standards and to give a comprehensive view of occupants' experience. Moreover, the type of activity done in buildings should be taken into consideration. Building standards could offer an acceptable QoL regarding human health, safety, and comfort, but there is a difference between being acceptable and being of good quality for the occupants' experience.

2.4.1 LEED Assessment (Physical-Objective IEQ Assessment Measurement)

The LEED system's mission is to *"encourage and accelerate global adoption of sustainable green building and development practices through the creation and implementation of universally understood and accepted standards, tools and performance criteria"* (USGBC, 2010). LEED provides designers, builders, and people who operate buildings with an organized, consensus benchmark for defining and evaluating green buildings (USGBC, 2009).

LEED systems address different project development and delivery processes that exist in the building design and construction market, through rating systems for specific building typologies, sectors, and project scopes. LEED V4 is the most recent version of LEED released (2014), and there are five current available systems: LEED V4 BD+C (Building Design and Construction), LEED V4 ID+C (Interior Design and Construction), LEED V4 O+M (Building Operations and Maintenance), LEED V4 ND (Neighborhood Development), and LEED V4 Homes (USGBC, 2015). LEED Canada uses the same international system, but some options can be tailored using Alternative Compliance Paths (ACP) for various credits (CaGBC, 2014).

LEED 2009's system criteria for measuring building performance have five major

categories for evaluating a building: Sustainable Sites (SS), Water Efficiency (WE), Energy and Atmosphere (EA), Materials and Resources (MR), and Indoor Environmental Quality (IEQ). There is bonus: Credits for Design Innovation (DI) and Regional Priority (RP) (USGBC, 2009; CaGBC, 2012), where credits and prerequisites are given, based on these five categories (in the form of a checklist), to accredit scores in each category. LEED rating systems credits have 100 base points and 10 bonus credits are awarded for Innovation in Design (or Operations) and Regional Priority. In the newest version, LEED V4, a sixth major category was added for Location and Transportation (LT) separate from sustainable sites. Other additions are the separation of Innovation, and a Regional Priority into two bonuses categories instead of one bonus category. Integrative Project and Planning Design (prerequisite for hospitals) and Integrative Process (IDP) credit are added as a requirement rather than a credit category to promote integration between disciplines and incorporate diverse team members during the pre-design period (USGBC, 2015).

A LEED project must satisfy the required prerequisites **(**required elements must be met before a project can be considered for LEED certification) and Minimum Program Requirements (MPR) that qualify for a minimum number of points to be eligible for the project ratings. Building performance is certified as: Certified, Silver, Gold, or Platinum, as shown in Table II (based on the number of points earned by the project) **(**USGBC, 2011).

Table II. Certification Rating in LEED

40–49 Points	Certified
50–59 Points	Silver
60–79 Points	Gold
80 + Points	Platinum

2.4.1.1 LEED IEQ Category

The assessment criteria for the IEQ category in LEED 2009 includes Minimum IAQ Performance and Environmental Tobacco Smoke (ETS) Control as two prerequisites, as well as credits for the following criteria: Outdoor Air Delivery Monitoring, Increased Ventilation, IAQ Management Plan, Low-Emitting Materials, Indoor Chemicals and Control of Pollution

Sources, Lighting Controllability of Systems, Thermal Comfort, Daylighting, and Views. Each element in the criteria is worth one credit weighting. Therefore, covering only six factors affecting occupants' experience and affecting their health, comfort, and productivity: IAQ, Low-Emitting Materials, Indoor Chemical and Pollutant Source Control, Controllability of Systems, Thermal Comfort, and Daylighting and Views as shown in Table III. The table shows how different credits would be categorized to cover the criteria for the six factors, as well as the equal value given to each credit. Other factors seem to be missing: Acoustics, Lighting Quality, Layout Quality, Spatial Organization, Privacy, etc. The Minimum IAQ Performance and ETS control as prerequisites are done to ensure a minimum IAQ necessary for health based on how health symptoms are fundamentally influenced by the IAQ. However, other factors, such as the Excessive Air Temperature, also cause an increase in upper respiratory tract problems and skin dryness (Reinikainen, Jaakkola, & Heinonen 1991; Reinikainen, Jaakkola, & Seppänen, 1992).

Thus, Thermal Comfort should also become a precondition, not just a credit, to address those issues (Woo, 2010). Even though Controllability of Systems has credits in the criteria, Karjalainen and Koistinen (2007) pointed out that in reality there are some practical considerations needed in the Controllability of Systems, as building occupants do not tend to use the thermostats and thermostatic valves to control the temperatures responsible for thermal discomfort. They suggested that the control device is not recognized at all, or the purpose of the equipment is unclear. Hence, building users may consider that these devices are for service personnel only. Therefore, the control systems need to be planned, located, and constructed from a realistic view of the building users.

The current version of LEED (V 4 in 2014) added other credits, including Acoustics, and separated the Views from Daylighting in an attempt to improve occupants' QoL experience. Yet depending on prescriptive standards such as the ASHRAE, to reference their normative requirements requires validation in terms of occupants' subjective assessment to know whether they provide better occupants' health, comfort, and productivity than conventional buildings as promised by LEED. It is a good indicator that now LEED is improving by adding further credits that emphasize the importance of research in better understanding occupants' experience, improving guides and evaluation of building performance in the process.

Table III. IEQ Category in LEED 2009

	CI :Indoor Environmental Quality category Possible Points:	**17**	**Assessment criteria**
Prereq 1	Minimum IAQ Performance	—	**IAQ (prerequisites)**
Prereq 2	Environmental Tobacco Smoke (ETS) Control	—	
Credit 1	Outdoor Air Delivery Monitoring	1	IAQ
Credit 2	Increased Ventilation	1	
Credit 3.1	Construction IAQ Management Plan—During Construction	1	
Credit 3.2	Construction IAQ Management Plan—Before Occupancy	1	
Credit 4.1	Low-Emitting Materials—Adhesives and Sealants	1	Low-Emitting Materials
Credit 4.2	Low-Emitting Materials—Paints and Coatings	1	
Credit 4.3	Low-Emitting Materials—Flooring Systems	1	
Credit 4.4	Low-Emitting Materials—Composite Wood and Agrifiber Products	1	
Credit 4.5	Low-Emitting Materials—Systems Furniture and Seating	1	
Credit 5	Indoor Chemical & Pollutant Source Control	1	Indoor Chemical & Pollutant
Credit 6.1	Controllability of Systems—Lighting	1	Controllability of Systems
Credit 6.2	Controllability of Systems—Thermal Comfort	1	
Credit 7.1	Thermal Comfort—Design	1	Thermal Comfort
Credit 7.2	Thermal Comfort—Verification	1	
Credit 8.1	Daylight and Views—Daylight 75% of Spaces	1	Daylight & Views
Credit 8.2	Daylight and Views—Daylight 90% of Spaces	1	
Credit 8.3	Daylight and Views—Views 90% of Spaces	1	

Limitations in the Criteria of LEED are Summarized as Follows:

The following is a summary of the researcher's own conclusions, drawn from her investigations on the LEED system IEQ criteria, as well as criticism found in previous published literature.

This list summarizes the shortcomings in the IEQ criteria of the LEED system:

1. The total score doesn't necessary imply a good score in the IEQ category.
2. There is no threshold for an accepted level of quality from each IEQ factor, so some factors can be ignored.
3. There are no follow-up plans to ensure a continuous level of certification and performance.
4. Some important instrumental qualities are not considered, such as

a. Noise Control
b. Lighting Quality
c. Views Quality (it is limited to Daylighting and not the quality of the viewed scene itself)
d. Cleanliness and Maintenance
e. Layout Quality and design aspects, such as storage areas, social gatherings, means for collaboration

5. Latent qualities are not considered (e.g., Privacy, Personalization, and Territoriality).
6. Symbolic qualities (e.g., Pride and Status, Congruence with Beliefs) are not considered.
7. Subjective quality of each criterion (e.g., the beauty of views), not just the technical measurement (e.g., the presence and absence of a window), should be considered.
8. Green buildings are commonly known to possess features that emphasize connectivity with nature by incorporating, plants, water, and daylighting. However, LEED IEQ criteria do not add credits for the incorporation of natural items such as plants, views of natural scenes, or water.
9. The LEED system is not sensitive to the difference between an office building and other different commercial building interiors (e.g., hotels, restaurants, and shopping malls).

2.4.2 Occupants' Assessment (Perceived-Subjective IEQ Assessment Measurement)

Occupants' assessment is essential to the building performance evaluation to ensure the quality of the indoor environment of LEED-certified buildings (Gonchar, 2008; Heerwagen & Zagreus, 2005; Marlin, 2003; Mendler, Odell, & Lazarus, 2005; Mendler, Woolford, & Bannon, 2006). "*While physical metrics aim to assess the key indicators of IEQ, it is considered that the complexity of IEQ and the environment-occupant interaction are such that a direct feedback of occupant experience must also be part of IEQ assessment*" (Brown, 2008).

Occupants' assessment became more and more important as a key element in the current sustainable building movement in order to assure the quality of indoor environments of sustainable buildings. The main reason is the insufficient available information on how buildings that are designed and constructed according to sustainable building standards and

guidelines, including LEED, actually perform to satisfy occupants' health, comfort, and productivity. Occupants' assessment is an effective tool to evaluate the Designed Environments to identify the weakness and strengths of the sustainable design practice, hence enhancing any future design practice (Marlin, 2003). Therefore, to study occupants' QoL in LEED-certified buildings and know what IEQ factors are influencing their health, comfort, and productivity, it would best done through the occupants' themselves by asking them about their lived experience.

2.4.2.1 Post-Occupancy Evaluation (POE)

The most common approach to studying occupants' responses and assessments is the POE. The POE is a systematic evaluation of the effectiveness of design components in the built environment, based on occupants' responses after a building has been built. Its major purpose is to measure the appropriateness of the design to offer solutions for a better quality of life (Preiser, 2001). The evaluation is conducted by finding the difference between intended performance criteria and actual building performance perceived by occupants; hence, POE can provide some insights on the consequences of past design decisions and their result on building performance (Woo, 2010). This knowledge can eventually form a sound basis for creating better buildings in the future by influencing codes, standards, and design decisions (Preiser, Rabinowitz, & White, 1988). Results from POEs are also used "*to inform decisions on whether to make corrections or changes so that the building, its spaces or its systems to better suit the needs of the users or occupants*" (Zimmerman & Martin, 2001). Thus, POE helps in inferring whether peoples' current needs are met or not.

Common data collection tools used to conduct a POE include questionnaires, structured interviews, direct observations, participant observations, video recording, and demographic data (National Institute of Building Science, 2005). POE was mainly used as a tool to assess the work environment design components' influence on occupants' satisfaction (Lee & Kim, 2008). However, now its use has expanded to measure occupants' performance in workplaces as well (Kooymans & Haylock, 2006). The very first POE study was conducted by Marans and Spreckelmeyer (1981) to evaluate a federal office building in Michigan and was conducted from the building users' perspective. The most common tool used in POE is a self-

report questionnaire that records users' satisfaction and comfort ratings with IEQ factors and other aspects of the physical work environment (e.g., Carlopio, 1996; Cohen, Standeven, Bordass, & Leaman, 2001; Vischer, 2005; Abbaszadeh et al., 2006, Huizenga, Abbaszadeh, Zagreus, & Arens, 2006). Yet, to allow the investigation of all the possible IEQ factors impacting occupants QoL, the research should integrate questionnaires with occupants' own words using interviews, focus groups, and open-ended surveys. Those qualitative methods would allow the elaboration of the reasons beyond occupants' assessments on rating scales, as well as potentially eliciting other factors not tested in the questionnaires.

2.4.3 Occupants' Experience in LEED and Conventional Work Environments

This thesis is only concerned about the IEQ assessment from the occupants' (perceived) viewpoint. Therefore, literature about occupants' experience is presented and classified into studies on conventional work environments, studies on green/LEED-certified buildings, and studies comparing both conventional and green/LEED-certified buildings.

2.4.3.1 Previous Studies of Occupants' Responses to IEQ in Conventional Work Environments

Conventional office buildings are those typical modern office complexes that are non-green, in the sense that they are designed without sustainable building design intentions. They may not encompass environmentally-responsible design features and are not certified under a GBRS or any environmental certification. A conventional modern office building interior is usually characterized by an open-plan layout, fluorescent lights lined up in rows, cubicles for individual workstations, and some private offices for managers, with a centrally-controlled mechanical ventilation system (Vischer 1989, Woo, 2010). In addition to the previously mentioned design and layout features, nowadays, modern offices are also characterized by the use of smart technology, motion sensors, automatically-controlled building systems, Wi-Fi, shiny interior finishes like stainless steel, curtain walls, etc. As stated by Vischer (1989), "*Regardless of the way an office looks from the outside, for those who occupy it, the modern office can be an anonymous, uncomfortable, discouraging, and sometimes unsafe*

environment." Thus, research on office work environments help to build knowledge about inadequate physical work and unfavourable environmental conditions, as well as occupants' experience with technological changes. Unsuitable office environments may vary from being actual threats to health to being uncomfortable and not optimally desired by the employees as a place of work.

Marans and Yan (1989) conducted a study on about 1000 occupants and 13 office buildings to investigate the IEQ factors that influence occupants' Overall Satisfaction with their workspace. Results showed that workspace satisfaction is correlated with Lighting Quality, Noise Level, IAQ, Heating and Drafts, Amount of Space, Furniture Quality, Privacy, Colour and the Area of Partitions and Walls.

Humphreys (2005) studied 4655 occupants' responses in 26 office buildings from five different European countries. The results showed that the satisfaction with warmth, IAQ, air movement, noise, humidity and light are positively correlated with the overall comfort of the workplace as perceived by their occupants.

Veitch, Charles, Farley, & Newsham (2007) studied the satisfaction with their workstation of 779 occupants in nine office buildings in Canada and in the US. They found that the level of Satisfaction with the indoor environment was positively correlated with the Satisfaction with Noise, Air Movement, IAQ, Temperature, Lighting, Privacy, Views, Workspace's Size, and Aesthetic Appearance.

Schakib-Ekbatan, Wagner, and Lus- sac. (2010) investigated Workspace Satisfaction of 867 occupants in 14 office buildings and showed that the Occupants' Satisfaction was positively correlated with the Temperature, Lighting Conditions, IAQ, Acoustics, Spatial Conditions (Privacy and Individualization of Workspace), Office Furniture, and Office Layout.

2.4.3.2 Occupants' Responses to IEQ in Green/LEED Office Buildings

The focus given to occupants' perception of buildings' IEQ is a relatively new issue initiated by Heerwagen (2000) when she explored the wider context of sustainable design by

integrating methods of organizational effectiveness with human factors. Heerwagen (2000) suggests that green buildings provide economic and organizational benefits for businesses.

A study conducted by Heerwagen and Wise (1998) investigated the influence of sustainable buildings on their occupants and showed that 30% of employees indicated that their social well-being improved in their new, green building (Heerwagen & Wise, 1998).

Evidence from the Rocky Mountain Institute study indicates a relationship between green buildings and worker productivity, as workers were able to generate more output due to better performance. The study documented eight businesses that saw productivity increases after the implementation of energy-efficient building techniques (Romm & Browning, 1994). Some specific examples were productivity increases of close to 15%, observed by Lockheed Martin, and of about 16% for West Bend Mutual (Wener, & Carmalt, 2006).

Another review (Wise & Betch, 1999) concludes that providing *green environments* such as good Air, Lighting, Natural Views, and Thermal Comfort can significantly increase Satisfaction, reduce Absenteeism, and improve Productivity. However, a meta-analysis by Kats, Alevantis, Berman, Mills, and Perlman (2003) for California's Sustainable Building Taskforce suggested further evidence for the positive effect of green building elements on productivity.

A paper presented by Heerwagen, Winn, and Hase (1999) argues that sustainably-designed buildings that incorporate features and elements favoring natural settings and nature-based stimuli can have a significant impact on human well-being and productivity. In addition, the U.S. EPA *"estimates that poor indoor environmental quality leads to productivity loss and health care costs of more than $2 billion per year"* (NRDC, 2004).

Heerwagen and Zagreus (2005) performed an empirical study to prove the hypothesis that because sustainable building design strategies are believed to create improved IEQ, they should therefore also be associated with improved occupants' Comfort, Satisfaction, Health, and Work Performance relative to buildings designed around standard practices. Their findings showed high levels of occupant satisfaction from green buildings as a whole, as well as satisfaction with the IAQ, Daylighting, Amount of Light, and Access to Views. Ratings for the psychosocial outcomes were also very positive, and about 80% of the green building

occupants experienced high levels of morale, a sense of belonging and of well-being at work. However, the study did indicate complaints about the Acoustics.

Turner (2006) also made a Post-Occupancy Evaluation (POE) study on 11 LEED-certified buildings, seven of which were offices. The IEQ criteria used in the study were Temperature, IAQ, Lighting, Noise, and Plumbing Fixtures. Satisfaction ratings for most categories, with the exceptions of Noise Level and Sound Privacy, were positive. Dissatisfaction with the Noise in LEED-certified buildings was reported. Light levels and IAQ were both generally perceived as being somewhat helpful in getting work done.

Lee and Guerin (2009) conducted the Centre for Built Environment questionnaire (CBE) in a study to examine the effect of seven IEQ criteria (Office Layout, Office Furnishing, Thermal Comfort, IAQ, Lighting, Acoustics, and Cleanliness and Maintenance) on occupants' Perceived Satisfaction and Performance in relation to the Overall Workspace Satisfaction and Performance. The study was conducted on 15 LEED-certified office buildings in the U.S. using POE. Findings of the study showed satisfaction with all IEQ criteria except for Acoustics and Thermal Comfort. Cleanliness and Maintenance showed the highest satisfaction mean scores. For occupants' Performance measures, most of the mean scores were positive except for the Acoustic Quality; Cleanliness and Maintenance Quality had the highest Performance Enhancement mean scores. The study showed a relation between Satisfaction and Performance; when the mean scores of occupants' Satisfaction with an IEQ criterion were high, the occupants' Performance mean scores were also high.

A study conducted by Baird (2010) on 30 sustainable buildings in 11 countries (from different climates) surveyed 2,035 respondents about their perceptions regarding physical features in their built environments. This large study used structured interviews with a key architect or environmental engineer in each building, photographing key features, collecting relevant documents, and administering questionnaires (developed by the Building Use Studies (BUS) in 2004). The survey examined 45 IEQ factors grouped into four major categories: Operational (such as Image to Visitors, Space in Building, Space at Desk, and Furniture), Environmental (such as Temperature, IAQ, Lighting, and Noise), Personal Control (such as Heating, Cooling, Ventilation, Lighting, and Noise), and Satisfaction (such as Design, Needs, Comfort Overall, Productivity, and Health). Baird also invited about 35% of the respondents

to comment on 12 aspects in the building. Ten aspects of them were the Overall Design, Overall Needs, Meeting Rooms, Storage, Desk/Work Area, Overall Comfort, Overall Noise, Overall Lighting, Productivity, and Health. Results showed that 26.8% of comments were positive, 13% were neutral, and 60.2% were negative, giving a ratio of 2.25:1 of negative to positive comments. In regards to the negative comments, it was found that Noise and Storage issues were the most common sources of complaints, although the direct Glare from the sun was frequently mentioned. Furthermore, Temperature issues were found. Several of the naturally-ventilated or mixed-mode temperature buildings were perceived as too warm in the summer. To the contrary, buildings that were fully air-conditioned were perceived as too cold in the summer, and surprisingly many of the buildings in the warm-temperature zones were deemed as cold in the winter. It should be noted that not all the sustainable buildings used in this study were under the certification of the LEED rating system. However, they give an overall indication of green buildings' performance from the occupants' point of view. Thus, occupants' complaints are in part describing the presence of a problem, but researchers should be aware of the subjective attributes related to other aspects affecting people's perception and evaluation. Hence, give the researcher comprehensive evaluation of building quality.

2.4.3.3 Comparative Studies between Occupants' Responses to the IEQ in Green/LEED and Conventional Office Buildings

Several studies have compared the effect of IEQ on occupants and the assessment of occupants regarding their Satisfaction, Health, Comfort, and Perceived Performance in conventional and green buildings.

Since 2000, a very significant institutional effort by the CBE at the University of California, Berkeley has been initiated with an investigation of occupants' satisfaction and performance toward the IEQ in buildings using a web-based survey using a self-assessment questionnaire. The survey was designed to evaluate the IEQ from the occupants' point of view in sustainable and non-sustainable buildings using a large database of 35,000 buildings. Of these, 200 were office buildings, and 14 were LEED-certified. A self-rated evaluation was implemented with users, with regard to their Perceived Satisfaction and Performance with the Overall Workspace and the Overall Building. The IEQ is limited to the quality of Office

Layout, Office Furnishings, IAQ, Thermal Comfort, Lighting, Acoustics, and Cleanliness and Maintenance of the space (Lee, 2007). In 2005, the CBE conducted a study to compare sustainable buildings, including LEED-certified buildings with conventional buildings. The study revealed that there were no differences between sustainable and non-sustainable buildings when it came to elements such as the Office Layout, Lighting, and Acoustics; other IEQ factors, such as IAQ, Thermal Comfort, and General Satisfaction with the building, had significantly higher ratings and were perceived as more satisfying and more conducive to higher occupants' perceived performance in the sustainable buildings. The study was limited to specific IEQ factors and did not differentiate between the different standards and guidelines for sustainable building design criteria (Huizenga et al., 2005).

Abbaszadeh et al. (2006) conducted a study to investigate occupants' satisfaction with the IEQ in green buildings compared to non-green buildings. On average, occupants in LEED/green buildings were more satisfied with Thermal Comfort, IAQ, Office Furnishings, Cleaning and Maintenance, and Overall Satisfaction with their workspace and the building. However, there were no significant increases in the average Satisfaction scores for the green buildings in comparison to non-green buildings in terms of Lighting and Acoustic Quality. Surprisingly, and contrary to what was expected, the LEED/green group results showed less Controllability on Light, as well as more complaints about building Acoustics.

Leaman, Thomas, and Vandenberg (2007) made a comparative POE study by surveying the occupants of 22 *green design intent* buildings and 23 conventional buildings in Australia, aiming to investigate the performance of green buildings from the occupants' perspective, with the objective of highlighting lessons for developing successful green buildings. Their study used the BUS questionnaire with over 60 variables covering aspects of Overall Comfort, Temperature, Air Movement and Quality, Lighting, Noise, Productivity, Health, Design, Image, and Workplace Needs. The study's results identified significant associations between Perceived Productivity and Overall Comfort (Lighting, Ventilation, Thermal Comfort, and Noise) and between Perceived Productivity and Thermal Comfort in particular. It was found that users' perceptions of the *physical* variables (Temperature, Air/Ventilation, Lighting, and Noise), were, on average, lower in green buildings, with the exception of Overall Lighting (which showed improvements, especially in dealing with the problems of artificial lights and

glare). Meanwhile, for *soft* variables (Design, Image, Needs, Health, and Perceived Productivity), the results were, on average, generally better in green buildings, or about the same as those in conventional ones. Complaints about Thermal Comfort performance were also greater in green buildings, as they were perceived as too hot in the summer and too cold in the winter.

Leaman and Bordass (2007) also investigated whether or not green buildings are better than conventional buildings, as perceived by their users. Their study used occupant surveys from 177 UK buildings. The survey was developed in the UK by BUS and used for the Probe series of post-occupancy studies. They first explored some sources of occupant dissatisfaction, then compared the results from buildings designed with *green* intent with results from conventional buildings, and analyzed the degree of tolerance that green building occupants have toward shortcomings. Their findings point to green buildings being perceived as better by their occupants in some areas, such as Image, Design, Health, and how Needs are met. Summertime Thermal Comfort was an issue in green buildings, although conditions in winter tended to be better than in conventional buildings. The study concluded that green buildings tend to be better than conventional buildings in overall qualities such as Overall Comfort or Overall Lighting qualities, while for individual IEQ factors, the responses were not clear-cut. The study concluded that occupants in green buildings tend to tolerate deficiencies more than the occupants in conventional buildings, and that green buildings are in danger of repeating past mistakes, especially if they are too difficult to manage.

Paevere, Brown, Leaman, Luther, & Adams (2008) conducted a POE study on IEQ and Occupants' Health, Well-being, and Productivity in the Council House 2 (CH2) building, a Green Star–rated building in Australia. Their methods included the BUS survey as well as a focus group. Results of the study for the IEQ physical measurements and occupants' satisfaction showed higher Occupant Satisfaction with the Overall Building, Thermal Comfort, and IAQ than was indicated for the Australian BUS benchmarks and their previous accommodation (CH1), with the exception of the Airflow, which was perceived to be too still. Lighting and Noise Levels and Reverberation Times were considered as sufficient but generally worse than the benchmarks, and rated as average to poor by the occupants. As for the effect of IEQ on Perceived Productivity in CH2, the results showed significant

improvements due to the enhanced IEQ, such as Thermal Comfort and IAQ, despite the Lighting and Noise Level dissatisfactions that were perceived as hindering Productivity. Results of the IEQ effects on Occupants' Health showed that the CH2 occupants' perceived Health ratings were very high, which was confirmed by the low levels of occupant-reported rates for building-related health symptoms when compared to the general population levels.

Paul and Taylor (2008) tested the hypothesis that there are higher perceptions of comfort by the occupants in green buildings as a result of better IEQ than for conventional ones, and that greater comfort leads to higher overall satisfaction with the workspace environment. In turn, green workspaces provide a more productive workforce. Included in the aspects of Comfort measured in the study results were Aesthetics, Serenity, Lighting, Acoustics, Ventilation, Temperature, Humidity, and Overall Satisfaction. The study showed no significant differences for Aesthetics, Serenity, Lighting, Ventilation, Acoustics and Humidity, and they found that the evidence was not sufficient to support their hypothesis.

Lee and Kim (2008) conducted a study to compare seven IEQ criteria between LEED-certified buildings and non-LEED-certified buildings in relation to occupants' Satisfaction and Performance, using data from the CBE web-based survey, analyzed by descriptive statistics. The seven IEQ criteria included Office Layout, Office Furnishings, Thermal Comfort, IAQ, Lighting, Acoustics, and Cleanliness and Maintenance. Surprisingly, the results showed higher Satisfaction and Perceived Performance in non-LEED-certified buildings with the Office Layout, Light and Acoustics; LEED-certified buildings scored higher Satisfaction than non-LEED-certified buildings only in association with Office Furnishings, IAQ, Cleanliness and Maintenance, and higher occupants' Performance than non-LEED-certified buildings in Office Furnishings, Thermal Comfort, IAQ, and Cleanliness and Maintenance quality. Though this study did not differentiate whether the non-LEED-certified buildings are completely conventional buildings or if they meet other green standards, at least the emphasis on LEED was useful against other buildings.

Brown and Cole (2009) set out to explore the influence of Knowledge on occupants' Behavior and Comfort, and the nature of the gap between assumed and actual Comfort and Behavior in green buildings and conventional buildings. Their study used the BUS satisfaction survey and added separate Knowledge and Behavioral components to it. Their

results suggest that, though the availability and use of Personal Controls were higher in the green building, the quality of Personal Control in terms of responsiveness, the absence of immediate and relevant feedback, and poor user comprehension may have led to suboptimal indoor environmental conditions.

Woo (2010) conducted a comparative POE study on nine green and conventional office buildings in Seoul, South Korea. The study investigated the influence of IEQ on occupants' Comfort and Performance. The IEQ factors measured were Thermal Comfort, IAQ, Acoustic Comfort, Visual Comfort and Spatial Comfort. Data was collected using the measurements of physical environment checklist items and an occupant questionnaire. The results of the objective physical conditions of the IEQ did not seem to be significantly different between green and conventional buildings, regardless of the more green features in green buildings. However, subjective evaluations of occupants' perceived IEQ environment did not always seem to be correlated to the objective measurements of building conditions. Thermal comfort and IAQ were found to be the most influential factors among the IEQ components, contributing to overall environmental comfort. Health symptoms showed no significant differences between the green and the conventional buildings; however the occupants in green buildings tended to give higher rating for the evaluation of the indoor environment than those of the conventional buildings.

The reasons for comparing occupants' responses in conventional office buildings with LEED/green buildings are as follows. First, to know the occupants' positive feedback or complaints from each case separately. Second, to know the strength and significance of the positive or negative feedback when compared to previous comparative studies. This helps to identify the common IEQ favorable or problematic features in the IEQ of both conventional and LEED/green buildings and then see whether they improved or actually worsened in LEED/green buildings. A conclusive summary of the IEQ areas of difference can be seen in Table IV, where some factors are shown to have improved in LEED-certified buildings, while others have no significant difference, and some also are perceived as less satisfactory when compared to occupants' responses in conventional office buildings.

Table IV. Summary of Differences between LEED and Conventional Office Buildings

Work Environment IEQ	Conventional	LEED
IAQ	•	√
Lighting Quality	√	•
Acoustic Quality	√	•
Thermal comfort	√ or no difference	—
Space Layout	—	—
Control	√ (more comprehensible)	•
Overall satisfaction	•	√
Perceived performance	•	√
Health	•	√
Overall Comfort	•	√
√ Better	— No significant difference	• Worse

2.5 Environmental Psychology and the Indoor Environmental Quality: Toward Humane Work Environments

The ultimate goal of this research is to improve occupants' QoL in their work environments through the development of a humane and sustainable framework for the assessment of IEQ in office buildings. In order to propose such framework, it is pertinent to understand the person-environment relationship. Hence, this research is based on the field of *Environmental Psychology* to develop better understanding of human perception and needs.

2.5.1 What is Environmental Psychology?

Environmental psychology is the study of human's interrelationship with their physical setting (*built and the natural environments*) and the transactions that occur between them (Bell, Greene, Fisher, & Baum, 2001; Gifford, 2007). Considering environmental psychology as both a basic and applied multidisciplinary behavioral science (Veitch & Arkkelin, 1995) helps create a criterion in determining the influences resulting from a certain environment on its users.

Proshansky's (1976) defines Environmental psychology as follows: *"Environmental psychology is defined as the attempt to establish empirical and theoretical relationships between the behavior and experience of the person and his built environment."*

Environmental psychology studies the physiological, psychological, and behavioral responses of people toward their environments. Physiological responses include the heartbeats rate and health; psychological influences include stress, mental images, satisfaction, and preference; and behavioral responses include aggression, adaptation, changing the environment, and performance. This field of research is built on certain principles, such as the capability of improving the environment and considering the person and the setting as a holistic entity; it also views the person as active and dynamic, capable of coping or changing the environment, rather than being a passive receptor (Gifford, 2007, Vischer, 2008). This is why environmental psychology is often combined with other disciplines.

An environmental psychologist's job is to try to determine what makes people comfortable and how surroundings could be adjusted to reduce stress and enhance people's QoL. Ultimately, environmental psychology could change the way the building industry approaches its buildings for more user-oriented approaches. "*Practicing environmental psychologists are motivated by the conviction that they can help create more humane buildings or improve the way people interact with nature*" (Gifford, 2007). With the growing investments made in the physical environment and natural resources, environmental psychology forms a key component between human and environmental welfare (Gifford, Steg & Reser, 2011), especially in the paradigm of sustainability. However, it is important to know that peoples' environmental perception varies with personal and cultural differences, and that people can interpret things differently (Gifford et al., 2011).

2.5.2 Person-Indoor Environment Relationship

The relationship between humans and their environment has been described in the literature of environment-behavior and environmental psychology in many terms. Terms that refer to relational concepts of comfort and satisfaction of building occupants include but are not limited to *person-environment congruity, person-environment fit, compatibility, harmony, adaptation, performance,* and *habitability*, and some of them are briefly presented in this thesis.

Person-environment congruity is defined as *"the interrelation between the individual and his/her environment, considering the match between individual life satisfaction and*

objective standards of living" (Moser, 2009). That is to say that in order to achieve a congruent situation, a positive relationship between the environment, with its objective qualities, and the person, with his/her expressions of satisfaction concerning this environment, is needed. According to Wandersman and Hallman (1993, p. 681), ''*To respond effectively to environmental problems, policy makers must know as much about the social, emotional and behavioral impacts of environmental threats as they do about the biological effects of such hazards.*''

Habitability is defined by Preiser (1983) as follows: *"Habitability refers to those qualitative and quantitative aspects of the built environment which support human activities in terms of individual and communal goals"* (see the levels in Preiser's habitability framework, **Section 2.2.3.2**).

2.5.3 Models of Person-Indoor Environment

There are several models in the literature that describe people in their environment (Canter, 1991, Guerin, 1992, Elzeyadi, 2001, Vischer, 2005, Lee, 2007). However, this thesis will only present the two most pertinent models for the study of occupants' relationship with the IEQ in offices. Those models are the Environmental Comfort Model (Vischer, 2005), and the Interior Ecosystem Model (Guerin, 1992). Guerin's model explains the system of interaction between human and the interior space. Vischer's model explains the effects of the quality of the indoor environment on humans (resulting from their interaction), and her model is designed for office buildings in particular. The two models are not contradictory; as a matter of fact, they can complement one another.

Furthermore, Vischer's model can be used as a diagnostic tool to assess and locate the problems in work environments for further intervention. Both models do not address sustainable development; however, Guerin's model was thereafter tested in sustainable environments and his model was adapted to match the three dimensions of the sustainable development (Lee, 2007; Freihoefer, 2012).

2.5.3.1 Environmental Comfort Model, Vischer (2005)

Vischer (2005) developed a hierarchy pyramid classifying the environmental quality in offices into three levels based on the habitability framework first developed by Preiser (1983). Vischer's Environmental Comfort Model (Figure 6) describes occupants' comfort in work environments as composed of Physical, Functional, and Psychological Comfort in ascending order.

(1) Physical Comfort is at the base of the pyramid. It is what most people think of as comfort. It is affected by the building design, operation, meeting health and safety standards, and construction standards (Vischer, 2003). In work environments, the health and safety standards mostly address extremes, such as too much heat, cold, or noise. Hence, they assure that people at work are not placed under extreme environmental conditions (Vischer, 2007).

(2) Functional Comfort is located midway between meeting the basic needs of physical comfort and increasing the habitability level to reach Psychological Comfort. It focuses on workspaces designed with environmental elements that support or fail to support work (Vischer, 2007).

(3) Psychological Comfort is the highest habitability level, positioned at the top of the pyramid. It is also considered the hardest to identify, measure, and control (Vischer, 2007). Psychological Comfort includes feelings like territoriality, privacy, satisfaction, environmental empowerment, and control (Vischer, 2003).

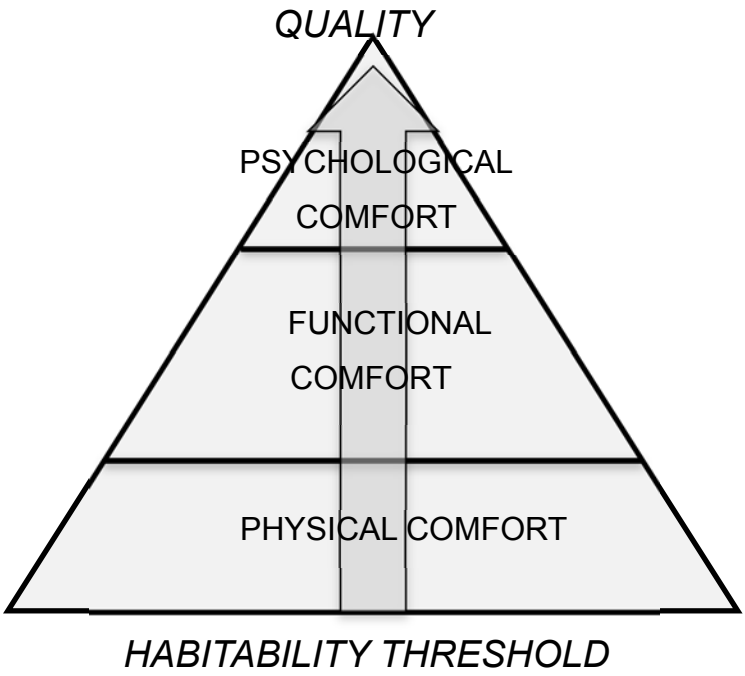


Figure 6. Vischer's Environmental Comfort Model, Vischer (2005).

2.5.3.2 Interior Ecosystem Model, Guerin (1992)

Guerin (1992) proposed a model of a human ecosystem approach in interior design. The Interior Ecosystem Model suggests a relationship between interior design and occupants as a system of interaction. As shown in the model (see Figure 7), it uses an interaction network to show the relationship between the *Natural Environment* (NE), *Behavioral Environment* (BHE), *Built Environment* (BTE), and *Human Organism* (HO); it is multi-directionally and equally connected. This model can be used to conceptualize the relationship between occupants and the built environment in a sustainable manner. Lee (2007) and Freihoefer (2012) also previously used this model to study green buildings.

Lee (2007) superimposed the sustainable development dimensions, namely the environmental, social, and economical on Guerin's model. Lee uses (1) the Natural Environment to represent sustainable environmental IEQ factors, such as Natural Light, Views, and Non-Toxic Interior Finishes; (2) the Behavioral Environment to represent the indoor social and economical sustainability, such as workers' Performance, Satisfaction, Turnover, and Absenteeism; and (3) the Built Environment to represent the Ergonomic Setup,

Furniture, etc. (Lee, 2007). All three environments interact with the Human Organism at the center, which represents the building occupants.

To Freihoefer (2012), the Natural Environment represents the outdoor surrounding environment, such as Weather Conditions, Location, Construction, Pedestrians, and Traffic. The Social Environment represents the satisfaction, activities, and behaviors of occupants, such as Overall Satisfaction, Length of Time Spent at Work (workspace and building), and Personal Electronics (heaters, radios, lighting, etc.). Designed Environment represents the office type (open or closed) and IEQ: Thermal, Acoustic, Lighting Conditions, Building Orientation, Floor Occupied, and Workspace Characteristics. The Human Organism represented the office employees' gender, age, role, years employed, etc.

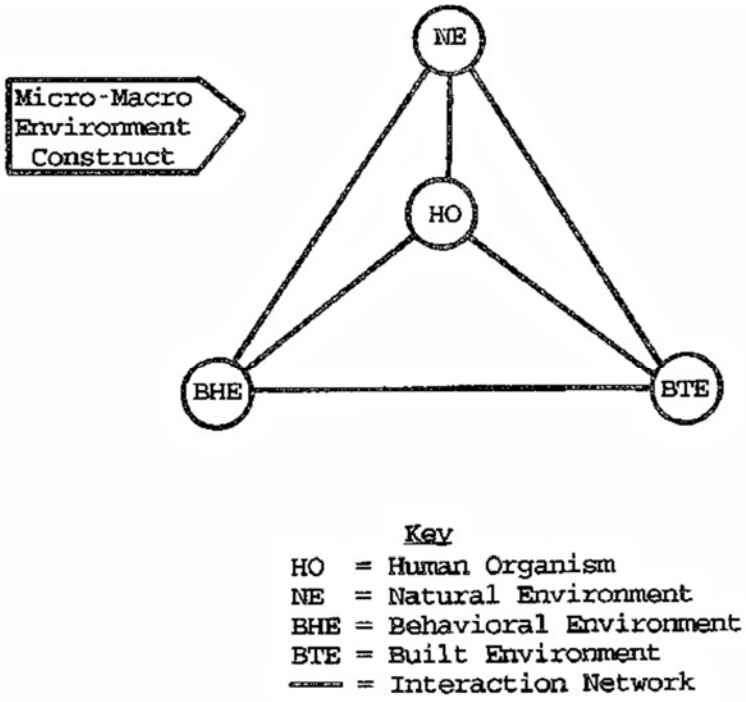


Figure 7. Interior Ecosystem Model, Guerin (1992)

2.6 Summary of Lessons Learned and Limitations in Previous Literature

This literature review enables the researcher to define the concepts used in this study, such as QoL, QWL, and IEQ. It also helps to review the GBRSs and the LEED-criteria in the context of QoL, environment-behavior, and environmental psychology; hence, criticize the IEQ criteria of LEED, address its shortcomings, and question whether it is addressing sufficient measures to improve occupants' QoL. The literature also led to the determination of IEQ variables and measuring indicators that will be investigated in this study. The relevant theories provide a better understanding of what to expect from a quality work environment. They provide an understanding of what aspects to be considered to propose a theoretical framework that could potentially guide the assessment criteria of IEQ in office buildings. This theoretical framework aims to provide a sustainable and humane work environment for a better QoL than what is already applied in conventional or LEED-certified office buildings.

Studies indicate that QoL is composed of several life domains, where QWL is one of them, and that the work environment may influence the QWL and the quality of work done (productivity). Hence, investment in comfortable work environments builds the premises for occupants' health, comfort, and productivity (overall QoL), fulfilling the social and economical dimensions of sustainable development.

There is mounting evidence that the IEQ of buildings can affect their occupants physically (e.g., with Ambient Conditions like temperature, humidity, light, acoustics, and IAQ), physiologically (e.g., especially with Sick Building Syndrome symptoms of asthma, eyestrain, headache, nausea, etc.), socially (e.g., with the amount of interaction and collaboration, etc.), psychologically (e.g., by producing stress, anxiety, emotions, etc.), and functionally (e.g., by affecting the ability to get their work done). All of these aspects impact occupants' satisfaction, health, comfort, and productivity (Herbst. 1962; Lawler, 1975; Walton, 1980; Haynes, 2007; Arnold, 2004; Heerwagen et al., 2004; Ochoa & Capeluto, 2006; Vischer, 2007; Fischer & Vischer, 2004).

Occupants' favourable features in green building design include views, natural light, natural ventilation, high quality of air, and control over their environment (Leaman & Bordass,

2007). However, these features are not measured in the LEED checklist and credit score, as the LEED IEQ category is composed mainly of six main factors: IAQ, Low-Emitting Materials, Indoor Chemical and Pollutant Source Control, Controllability of Systems, Thermal Comfort, and Daylighting and Views. Hence, aspects such as control of glare and connectivity with nature (views, plants, water, etc.) are examples of favorable design features in green buildings that are not addressed in LEED.

Studies on the IEQ of green buildings, and LEED-certified buildings specifically, have shown many user complaints. Light and acoustic qualities were a standout complaint with most of the reported studies. Other complaints included lack of visual privacy and difficulties with controllability of systems. Another issue was the increased use of daylight, and that while it saves on energy consumption and there is a psychological benefit, it does, however, create more glare, produces thermal gain, and may result in insufficient lighting on days with cloudy sky conditions (Abbaszadeh et al., 2006; Lee & Guerin, 2009; Turner, 2006).

Furthermore, studies comparing green/LEED-certified buildings to conventional buildings do not seem to corroborate that green buildings are superior, despite improvements perceived by occupants in some areas related to the IEQ in green buildings. There are still some areas in the IEQ where conventional buildings showed better results and were more favorable by the occupants, such as in the Acoustics Quality, Lighting Quality, and more comprehensible Control of Systems or over the environmental conditions (Abbaszadeh et al., 2006; Leaman & Bordass, 2007; Lee & Kim, 2008). Moreover, some studies didn't show significant differences between occupants' responses regarding the IEQ in LEED or conventional office buildings (Paul & Taylor, 2008; Woo, 2010). The objective of green buildings' design is to improve occupants' health, comfort, and productivity, which are supposed to provide a better QoL than conventional buildings. Hence, it is required to know whether buildings designed with a green intent, and especially those evaluated under the LEED GBRS, are actually performing as expected, and whether the sustainable building design goals and targets are achieved in practice.

By reviewing the previously comparative studies between green/LEED and conventional buildings, the following aspects were found: The major sources of improvements found in LEED/green buildings were mainly associated with the IAQ, Furnishings, Image, Cleanliness

and Maintenance (Abbaszadeh et al., 2006; Lee & Kim, 2008). IAQ is an essential quality influencing occupants' Health and Physical Comfort, which in turn is expressed in occupants' Satisfaction and Perceived Performance. The improved IAQ in LEED/green buildings was mainly due to design features that encourage natural ventilation and the minimization or improved control of toxic or volatile materials. Regarding the Furnishings, Image, Cleanliness and Maintenance, it has been suggested that LEED/green buildings are relatively newer than conventional ones and hence their newer furnishings and design look better, which could easily explain occupants' higher level of satisfaction with these aspects.

Occupants' perceptions of Thermal Comfort range from satisfactory, insignificant improvement, to unsatisfactory in green buildings. Studies that showed less comfort with Thermal Comfort in LEED-certified buildings found it perceived by occupants as either too hot or too cold (Paul & Taylor, 2008; Leaman et al., 2007; Leaman & Bordass, 2007). This might be due to systems operating ineffectively in green buildings, raising the important issue of maintenance and regular checks. Notably, LEED-certified building ratings are given at the time of certification, but there is no guarantee for their performance afterwards.

Furthermore, there is a gap between occupants' overall assessment of Comfort, Satisfaction, or Performance and the individual assessment of each IEQ in LEED-certified buildings. The overall assessments were perceived as better in LEED/green buildings. However, when individual IEQ factors are broken down, there were no significant improvements in many IEQ factors such as Acoustics, Lighting, Layout, and Thermal Comfort (Huizenga et al., 2005; Abbaszadeh et al., 2006, Lee & Kim, 2008).

Gaps and limitations in the literature show a need for more studies about occupants' experience in LEED-certified buildings. The number of IEQ factors tested in previous literature is limited. There is a lack of studies that address occupants' responses using qualitative methods or mixed-methods approaches; the most common tool used was questionnaires. This limits the results of previous research into the testing of prescriptive IEQ factors without having an opportunity of exploring and documenting other influential factors on occupants' QoL—or listening to the occupants' justifications of assessment. In addition, there is a lack of models that consider the levels of meaning of IEQ in green buildings. There is a necessity for having a comprehensive assessment framework for the IEQ in green

buildings that can consider both humane and sustainable aspects for an improved inclusive occupants' QoL. As stated by Scott,

> "*Should green buildings not only work differently, but also look, feel, and be conceived differently?. . . Sustainability is as much about enhancing culture, livability, health, and place-making as it is about the development and application of technology for reducing energy dependence, CO2 production, and mitigating the abundant use of resources.*" (Scott, 2006)

2.7 Conceptual Framework of Research Context Variables

Based on previous literature, a conceptual framework has been developed to frame the concepts of the context variables functioning in this research and reported in this thesis. This conceptual framework identifies the key concepts relevant to this research and the relationships among these concepts. The concepts most pertinent to this research are (1) the **QoL**: health, comfort, and productivity, and (2) the **IEQ**: humane, ambient conditions, designed environment, behavioral environment, sustainable environment, work environment, physical comfort, functional comfort, psychological comfort, instrumental qualities, latent qualities, and symbolic qualities.

The research object of the study reported in this thesis is to develop a framework for IEQ assessment criteria in green buildings that is both sustainable and humane. The research argues that current GBRSs and LEED ratings, in particular, evaluate sustainability issues from an environmental dimension represented in ambient conditions affecting health and physical comfort, and from an economical dimension represented by less waste and greater energy savings. These criteria emphasize minimizing life cycle costs, but they ignore some of the social dimensions that create a humane environment by satisfying human behavioral aspects in their environment. Those social dimensions in turn affect occupants' Psychological Comfort, and so may affect their health, comfort, and even productivity. As "*some line managers know in their bones that a humane workplace is a productive workplace*" (Hartshorn, 1997). Hence, a humane space affects the economical dimension of sustainability too. To clarify the concept underpinning this research, the logic connecting all of the research

concepts utilized to obtain a sustainable and humane framework for IEQ in work environments is explained in the following conceptual model schematic representation.

Schematic Representation of Conceptual Model for Research Context Variables

The first model (see Figure 8) represents the logic sequence by which concepts are connected and ordered, so as to enhance the Quality of life (QoL) and to provide a sustainable physical work environment described as a combination of the (1) Ambient Conditions, (2) the Designed Environment, and (3) the Behavioral Environment. It is crucial to design the work environment in a way that considers all the three levels of meaning in environmental quality: instrumental, latent, and symbolic qualities. Therefore, occupants' physical, functional, and Psychological Comforts would be achieved.

Creating a sustainable and humane environment that provides a healthy, comfortable, and productive IEQ for building occupants fulfills the objective of green building design. As previously mentioned (see **Section 2.2.3**), Quality of Work Life (QWL) is defined as the satisfaction of workers with their work and work environment. Hence, the improvement of work environments (IEQ), improves QWL, and in turn, the QoL, which is the ultimate goal of the sustainable development.

The second model (see Figure 9) describes the relationships among the concepts utilized in this research. The first concept explains how the work environment is composed of physical and non-physical IEQ factors. Physical IEQ factors are qualities that can be measured instrumentally and are a result of the Ambient Conditions and the Designed Environment, such as the quality of Illumination, Thermal Comfort, IAQ, Acoustics, Spatial Organization, or Access to Resources, etc. These physical IEQ factors influence occupants' physical and Functional Comfort, and hence their health (physical health), comfort (Physical Comfort), and productivity, which would provide a better QoL inside the work environment.

The non-physical IEQ factors are those qualities that derive from the physical features of the environment, whether ambient or designed. They offer qualities beyond their physical sense, as they provide latent and symbolic qualities, such as the sense of Territoriality, Control, Personal Space, Pride, and Status factors. These non-physical IEQ factors influence

occupants' psychological state, which may in turn affect their Functional Comfort, and hence affect their health (mental health) and productivity.

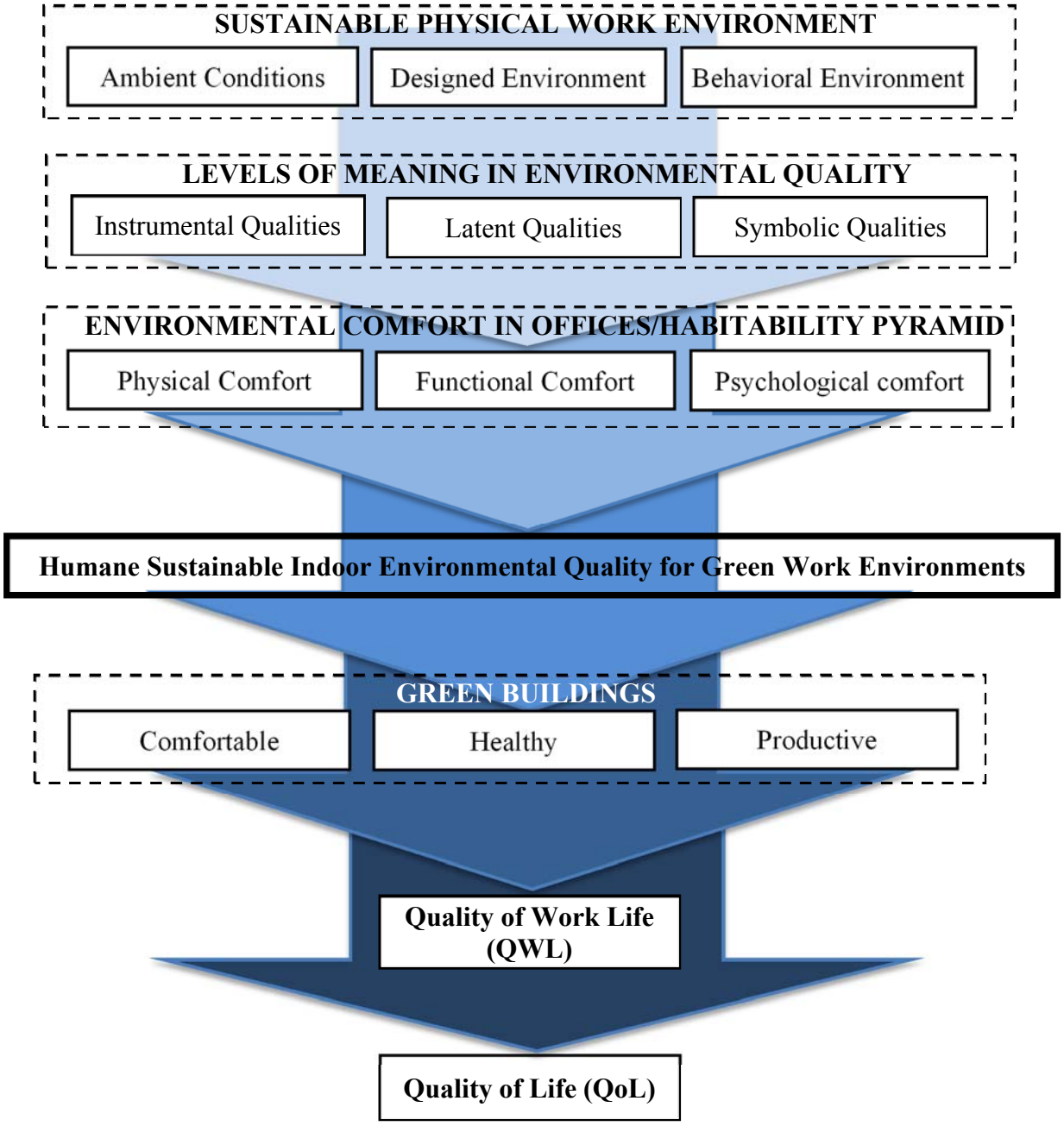


Figure 8. The logic sequence in the conceptual model of research context variables

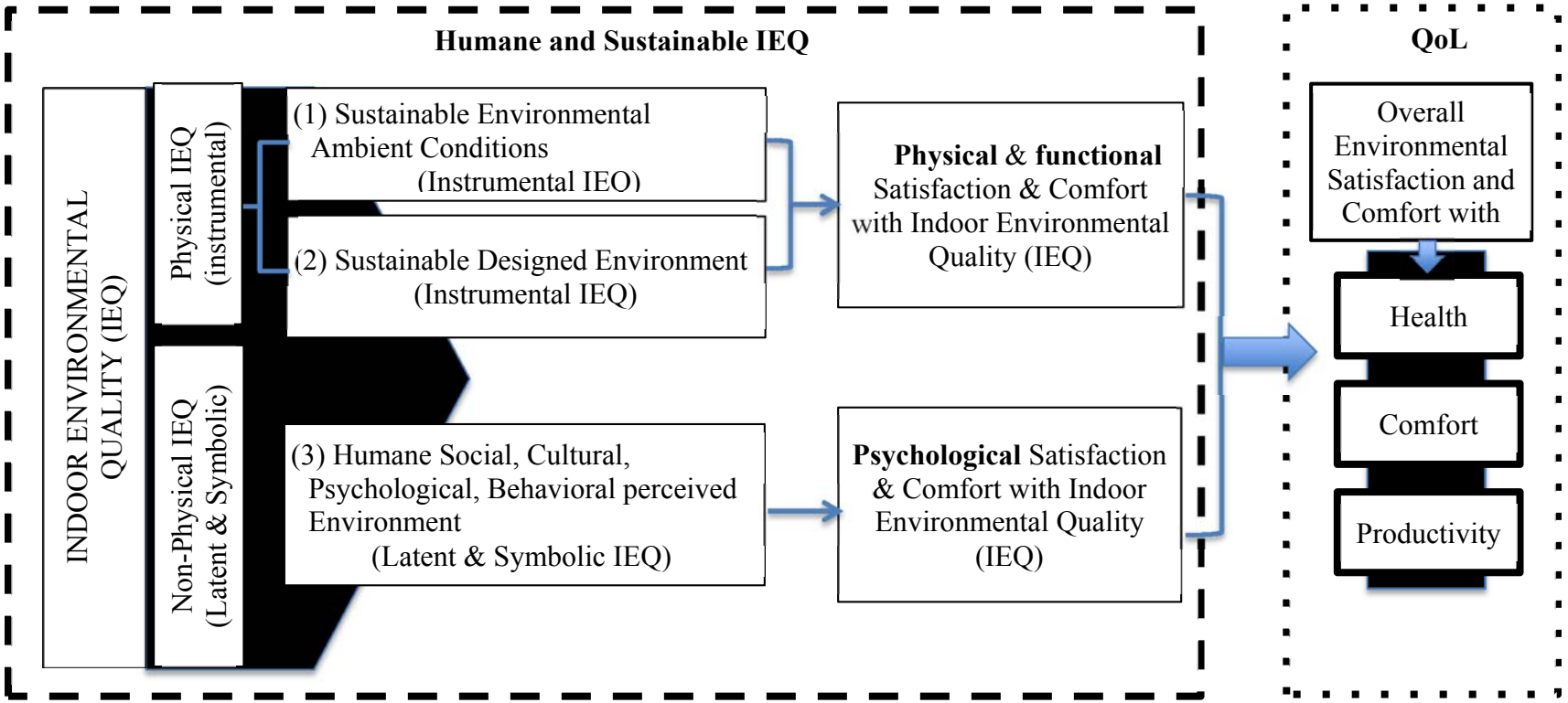


Figure 9. Analysis of the conceptual model representing the research context variables

2.8 Proposed Theoretical Framework

The proposed theoretical framework presented here guides the relationships among the variables and outcomes, thereby building a map of these relationships and that helps to answer the research questions (**Chapter I; Section 1.2**).

This study seeks to understand the relationship between occupants' QoL resulting from their lived experience and the IEQ of work environments in order to develop a comprehensive assessment criteria for work environment IEQ that is both sustainable and humane. The theoretical framework guiding the study is based on the following theories:

(1) Systems theory and the interactive theory to conceptualize the workspace as an environment-behavior system;
(2) Rapoport's (1988) levels of quality in the built environment: instrumental, latent, and symbolic qualities;
(3) Vischer's (2005) Environmental Comfort Model;
(4) Guerin's (1992) Interior Design Human Ecosystem Model, which is built on the Human Ecosystem Theory; and
(5) The sustainable development dimensions.

This research is based on earlier conceptualizations of the work environment as an environment-behavior system (Sundstrom, 1987; Weisman, 2001). The work environment is viewed as a complex system composed of many relationships between the people and the organization via the management, organizational culture, the building, its site, etc.

There is no single theory for the person-environment relationship; as a matter of fact they vary but do not necessarily contradict each other. This research adopts an environment-centered approach that deals mostly with the quality of the environment, while not ignoring the people and the factors that affect them the most. Theorists in this approach "*raise the issue of the environment's own welfare and its ability to support our welfare*" (Gifford, 2007).

The systems approach "*is a framework of thought that helps us to deal with complex things in a holistic way*" (Flood & Carson, 2013, p. 4). Using the term *system* means that it is formed by a group of interconnected components that altogether form a whole, rather than by an

assembly of individual components. It is an approach that seeks unity, in the sense that it places the user and the elements of the environment with which they interact in a single system, and in this sense it is dynamic. Since it is a system, this means that each user's act changes the environment, and each change in the environment has an effect on the user.

The definition of system according to Melson (1980) is an interaction with a set of interdependent components, where a change in one element affects other elements. This is compatible with conceptualizing the work environment as a human-behavior system and viewing the relationship between the user and the environment as dynamic, interactive, and reciprocal (Vischer, 2008). Also, the dimensions of the sustainable development follow the system theory, as the change in one dimension changes the whole system.

The interactive theory has taken a systems approach to the building in use (Marans & Spreckelmeyer, 1981; Vischer, 1985). It considers a place's physical features and the actions of the user as interactive and mutually independent, yet one that can be observed and described as separate and interdependent (Vischer, 2008). Hence, it moves even further away from the cause-effect relationship.

The Environmental Comfort Model (Vischer, 2005) indicates the workers' degree of comfort as a result of physical, psychological, and functional needs' fulfilment (see **Section 2.5.3.1**). It will be the first time for this model to be tested in sustainable workspaces, and after reviewing the literature, it is found to be the most suitable at describing environmental quality and at indicating how to improve the indoor environment to provide one that achieves human needs, giving a practical application, rather than just describing the relationship between man and his environment.

The human ecosystem can define sustainable development dimensions, as it includes the environmental and social aspects that affect building occupants, and hence the economical dimension too. The ecosystem approach is also a system theory that focuses on complex interactions and diverse components in ecological fields where the components are living organisms and their environment. When an ecosystem considers human behavior and their environment, then it is called a human ecosystem. Central to the human ecosystem is the

human organism's continuous interaction with his or her environment (Bubolz, Eicher & Sontag, 1979).

The proposed framework of this present study will build on Guerin's (1992) categories (see **Section 2.5.3.2)** and name them Building Occupants (BO) to superposition Human Organism, Ambient Conditions (AC) to superposition Natural Environment, Designed Environment (DE) to superposition the Built Environment, leaving Behavioral Environment untouched. In this research, the *Ambient Conditions* represents the instrumental factors (which can be measured objectively) that form the overall atmosphere in the work environment and that is connected to occupants' Physical Comfort, to impact their (physical) Health and Comfort, factors included are IAQ, Lighting Quality, Thermal Comfort and Acoustics. The *Designed Environment* includes the instrumental factors that form the physical design in the work environment, that is linked to Functional Comfort, and may affect occupants' Productivity, such as Office Layout, Personal Workspace, Ergonomics and Furniture, Hygiene and Cleanliness, Maintenance, Aesthetics and Décor. The *Behavioral Environment* has the latent and symbolic factors that affect occupants' QoL experience from social, psychological, or cultural perspectives that are linked to Psychological Comfort and may impact their (mental) Health. The factors in the Behavioral Environment include Personal Control, Privacy (visual and sound), Territoriality, Personalization, Wayfinding, Crowding, Social Interaction, Safety and Security, Connectivity with Nature, Status, Pride, Cultural Identity, Image and Value, and Congruence with Beliefs. The factors used in each category are derived from the literature.

The presence of the three environmental categories mentioned above—Ambient Conditions, Designed Environment, and the Behavioral Environment—is required for a humane level of indoor environment quality and to make it possible to achieve the three levels of meaning in environmental quality: instrumental, latent, and symbolic (see **Section 2.3.2)**.

The theoretical framework proposed by this current study aims to connect all the previously mentioned theories and introduces and describes the relationships among the variables and outcomes. The theoretical framework proposes that the

- Indoor Ambient Conditions of a sustainable work environment represents the Natural Environment in the human ecosystem;

- Indoor Designed Environment of a sustainable work environment represents the Built Environment;
- Indoor Behavioral Environment represents the indoor social, socio-cultural and psychological environment; and
- Building Occupants/Employees represent the Human Organism.

The relationships between comfort and qualities in the IEQ are shown interacting in the framework presented in Figure 10. The latent and symbolic qualities deriving from the Ambient Conditions or the Designed Environment of the workspace affect the Behavioral Environment, so that the social, psychosocial and cultural aspects connect with the Psychological Comfort of occupants (employees). In a similar way, the instrumental qualities of the Ambient Conditions or Designed Environment of the workspace interact to obtain the Physical and Functional Comfort of building occupants.

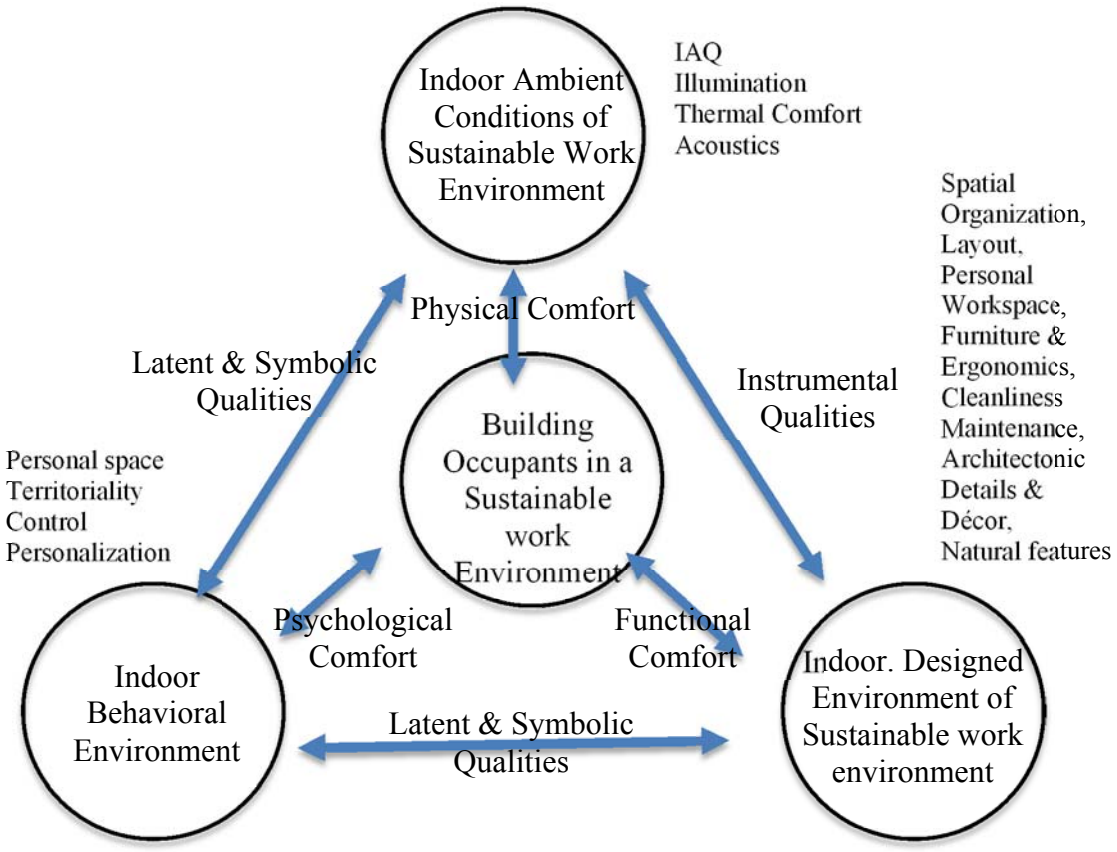


Figure 10. The theoretical framework schematic presentation

3 CHAPTER III: RESEARCH METHODOLOGY & METHODS

3.1 Research Methodology

In order to carry out a field study of existing occupied LEED-certified and conventional office buildings, a comprehensive understanding of all the relationships guiding occupants' QoL experience with the IEQ factors in the physical office work environment is needed. This includes creating a list of all the possible IEQ factors engaged in this phenomena. A mixed-methods approach is utilized to comprehensively understand the phenomena, which the research breaks down into five objectives to answer the three research questions, as follows:

Research Question 1: What is the occupants' QoL experience in LEED-certified and conventional office buildings and what IEQ factors interact with occupants?

OBJECTIVE I: To document occupants' overall perceived QoL experience in LEED-certified and in conventional office buildings **(qualitative)**.

OBJECTIVE III: To determine those IEQ factors that interact with occupants' QoL in LEED-certified and conventional office buildings **(qualitative)**.

Research Question 2: How do the occupants in LEED-certified and conventional office buildings perceive the IEQ factors and their QoL in their work environments, and what is the significance of these factors?

OBJECTIVE II: To explain occupants' overall perceived QoL experience in LEED-certified and in conventional office buildings **(quantitative)**.

OBJECTIVE IV: To identify IEQ factors' significances with occupants' QoL in LEED-certified and conventional office buildings **(quantitative)**.

Research Question 3: What does a humane work environment mean to occupants and what factors constitute it?

OBJECTIVE V: To define the constructs of a humane work environment based on occupants' own words (**qualitative)**.

The study applies both quantitative and qualitative methods, along with their deductive and inductive inquiry reasoning. Following a pragmatic paradigm of *what works* to solve problems (Patton, 1990), the researcher uses both types of approaches (quantitative and qualitative) to understand the problem (Rossman & Wilson, 1985). A pragmatic point of view freely chooses methods, techniques, and procedures that best meet the object and objectives of the research (Creswell, 2013). In the 90s it was agreed that the perceived benefits of mixing methods in *getting research done* outweighed the importance of the philosophical difficulties in their use (Miles & Huberman, 1984). Patton (1990) states, "*Research, like diplomacy, is the art of the possible.*"

This mixed-methods approach is best thought of as complementary and may be used in various types of research (Amaratunga, Baldry, Sarshar, & Newton, 2002). Das (1983) states that "*qualitative and quantitative methodologies are not antithetic or divergent, rather they focus on the different dimensions of the same phenomenon*," since "*blending qualitative and quantitative methods of research can produce a final product which can highlight the significant contributions of both*" (Nau, 1995). Mixed methods are very useful in research about the built environment (BE), as "*BE research involves affective characteristics, as well as overall behavioral aspects"* (Amaratunga et al., 2002). Mixed methods are therefore used in this research to enrich the understanding, confirm conclusions, extend knowledge, and to offer new ways of thinking about occupants' experience with IEQ in work environments.

The theoretical framework (**Section 2.8**) proposed and deduced from the literature is used to develop the relationships tested in the quantitative methods. It is also used as a guide in the qualitative methods. In qualitative approaches the researcher studies the phenomena in its natural setting and records the results and findings. The theoretical framework can also guide qualitative methods and work as a broad construct to guide the exploration of occupants' experience with IEQ factors. Theory in the qualitative inquiry can still be located at the beginning of the study:

> *"Much like in quantitative research, it is used as a broad explanation for behavior and attitudes, and it may be complete with variables, constructs, and hypotheses . . .This approach is popular in qualitative health science research in which investigators begin with a theoretical model, such as the adoption of health practices or a quality of life theoretical orientation."* (Creswell, 2013)

Furthermore, Eisenhardt notes that researchers can benefit from "*a priori specification of constructs,"* [which] "*can help shape the initial design of theory building research"* (Eisenhardt, 1989, p. 536). In fact, starting with a completely clean slate is considered to be very rare (Ali & Birley, 1999).

3.1.1 Strategy of Inquiry

The strategy of inquiry represents the way the methods will be used in terms of sequence, priority, and integration. This research uses both qualitative and quantitative research strands with sequence multiphase combination timing (Creswell & Clarck, 2011) and equal priority, and integrates them using triangulation at the end, after the results of each separate strand.

3.1.1.1 **Phases of Inquiry:**

The study proceeds in three phases: The first, PHASE I, contains the walk-through tours for observations and non-formal interviews. This phase is designed to observe all of the occupants' behaviors, such as any adaptation means, changes, and modifications or coping measures they use to accommodate to their environment. The building characteristics are also observed in order to gather information about the instrumental, latent, or symbolic qualities already used in the environment, and their quality conditions. Photographs and field notes are used to document the researchers' observations, as well as to document the current environment. The observation durations varied among buildings according to the time it took for a walk-through tour based on the size of the building. PHASE II is where the questionnaires and interviews were conducted. The questionnaire is a quantitative tool that has some open-ended questions (qualitative) embedded or nested in it. The rest of the qualitative tools were used sequentially after the walk-through tour, starting with the interviews that began in PHASE II, and ending with the focus groups as a final effort in PHASE III. This hierarchy in using the qualitative tools sequentially was followed so that the latter could benefit from the former, focusing and refining the research questions. The observations guided the interviews questions, and both the interviews and questionnaires were used to select the sample for the focus group. These phases of inquiry are presented in Figure 11.

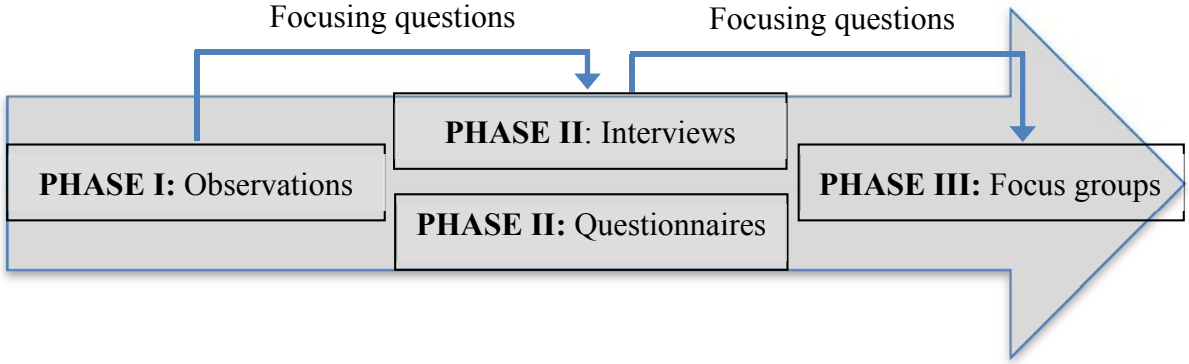


Figure 11. Phases of inquiry

3.1.1.2 Triangulation

Triangulation is considered the most familiar and well-known strategy (Creswell, 2013), in which quantitative and qualitative approaches are used in parallel and given the same priority. The main focus for the *concurrent triangulation strategy* is to offset a weakness in one method with a strength in the other and to use two different methods as an attempt to confirm, cross-validate, or corroborate findings within a single study (Creswell, 2013). In general, concurrent strategies take less time for data collection than sequential strategies, and this Concurrent Triangulation Strategy can result in well-validated findings. This strategy is best used in research where it is necessary to understand the problem when different strengths underlie different methods, without overlapping their weakness (Clark & Creswell, 2011) so that the different methods compensate for each other.

Data collected from quantitative and qualitative methods are collected and analyzed separately. The results and findings of both quantitative and qualitative methods are then triangulated at the end to compare, interpret and conclude on the occupants' experience with the IEQ of LEED certified and conventional office buildings. The integration and mixing of the different methods is useful in validating, explaining, illuminating, and reinterpreting each other, as shown below in Figure 12.

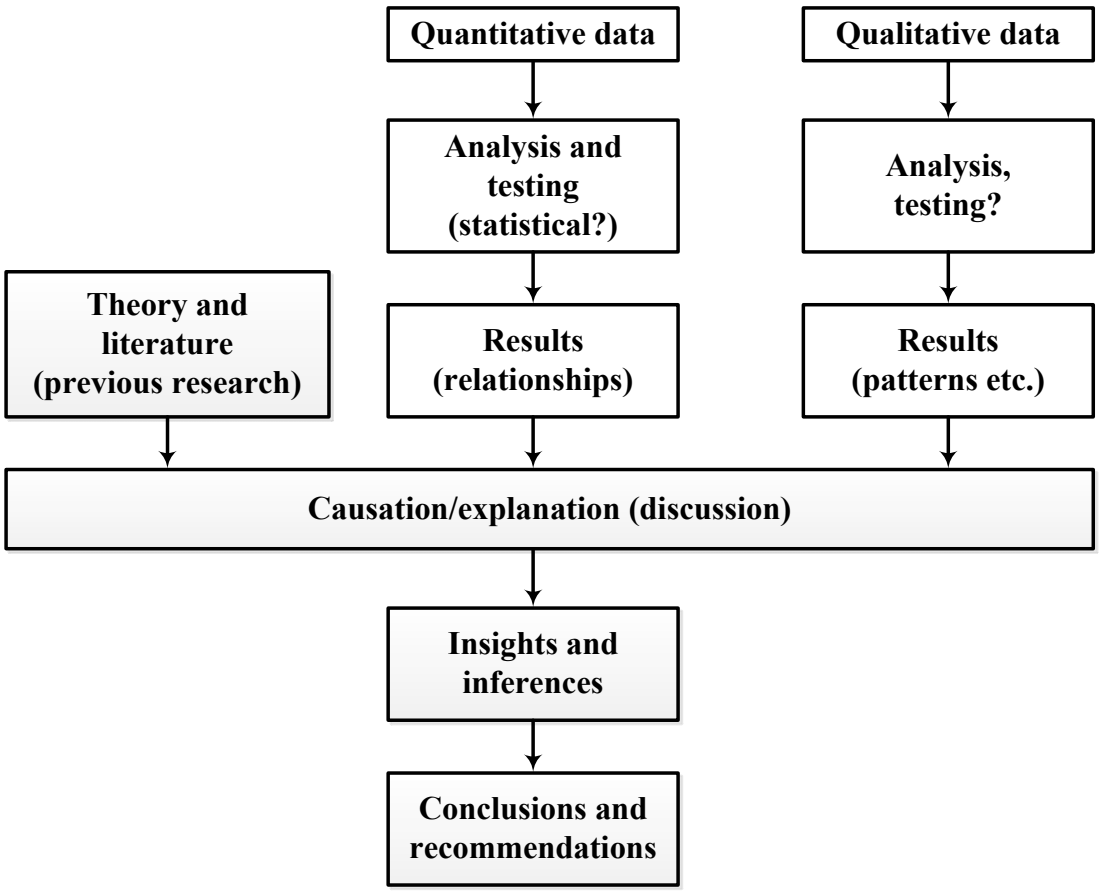


Figure 12. Triangulation of quantitative and qualitative data.
Source: Fellows & Liu, 1997.

3.2 Research Methods

In the mixed-method approach both quantitative and qualitative methods are used; the researcher uses multiple methods for data gathering in a belief that *"by using more than one method within a research program, we are able to obtain a more complete picture of human behavior and experience. Thus we are better able to hasten our understanding and achieve our research goals more quickly*" (Morse, 1991). Quantitative methods are used to explain and test relationships, as well as to allow the generalization of results from larger samples.

Qualitative methods are utilized to explore the phenomena and deepen the understandings among relationships.

The focus on peoples' *lived experience* in qualitative methods is very fundamental for *interpreting* the meanings *people give to events,* processes they go through, and their life structures: that are their *"perceptions, assumptions, prejudgments, presuppositions"* (Van Manen, 1977). Qualitative inquiries give a holistic perspective on the problem and can provide rich descriptions (Amaratunga et al, 2002).

The multiple methods used to gather the data in this research are observations, interviews, and focus groups in the qualitative strand and questionnaires in the quantitative strand. Observations were done in phase I; these include recording behavioral patterns, noting building features observed during walk-through tours, and documenting through photographs and field notes. Some informal interviews were also conducted during the walk-through tours. Interviews, both unstructured and semi-structured, were conducted in phase II. Questionnaires with both closed- and open-ended questions were also distributed in phase II. Focus groups were used in phase III to validate and solidify the findings of the IEQ constructs and occupants' QoL experience. The human QoL experience has both cognitive and affective components; the research seeks a comprehensive procedure that encompasses all aspects of human experience. Scharf and Margulies (1992) differentiated between a *judgment*, where the object rated is external to the rater, such as "*Please rate or assess or evaluate the following quality on a scale*," and a *sentiment* or *feeling*. The questionnaires were thus used to better cover the judgmental side, while the interviews dealt more with the emotional and feeling side of occupants' lived experience. The methods are shown in Figure 13 and presented in the phases in which they were used. Each data gathering method is analyzed separately and triangulated together at the end.

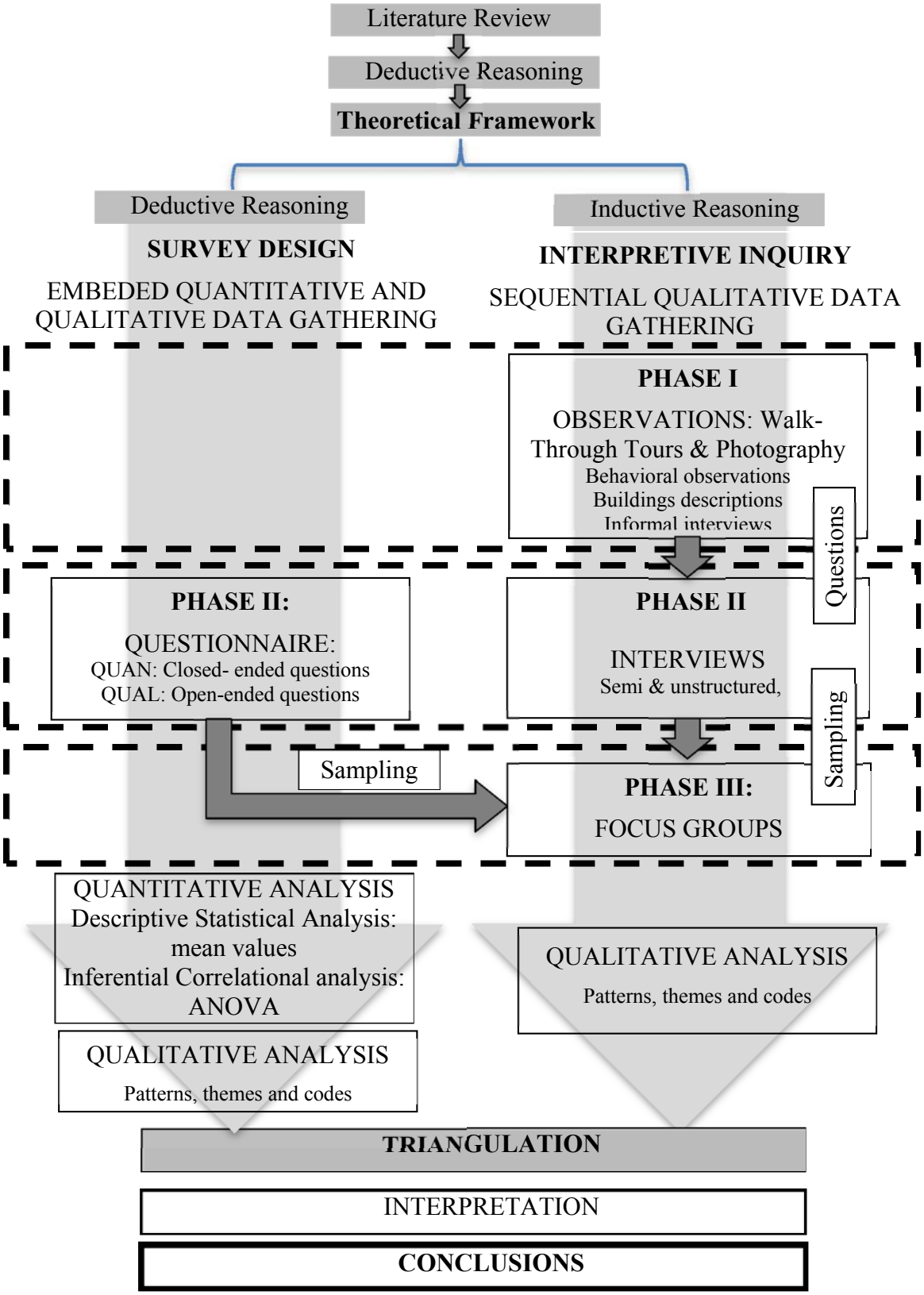


Figure 13. Research strategies, data gathering, and analysis methods in phases.

3.2.1 Data Collection

A survey is used as the quantitative method in this research to find the significances and strength of IEQ factors (independent variables) on occupants' perceived overall QoL and QoL descriptors (dependent variables). The IEQ factors were deduced from the literature and proposed as a list of IEQ factors in the physical work environment that may affect the occupants' perception of their QoL. Occupants' perceptions are measured on a rating scale from 1–5, where each occupant is asked to give an assessment value (rating) for each IEQ factor tested in the survey. The relationship between IEQ factors and occupants' perceived QoL tests the theoretical framework that guides occupants' experience with the physical work environment in this research, namely the **occupants' QoL** (health, comfort, and productivity); **environmental comfort** (physical, psychological, and functional); the **levels of meaning in IEQ factors** (instrumental, latent, and symbolic); and the **IEQ factors' category in the work environment** (ambient, designed, and behavioral).

Observations, interviews, and focus groups are the qualitative methods used to investigate the overall QoL experience, exploring and understanding in-depth the IEQ factors that interact with occupants' QoL and how they may influence their lived experience. These methods are also utilized to define the constructs of a humane work environment based on the occupants' own words, so that this framework will be a practical guide to future assessment criteria for IEQ in sustainable office buildings.

Three buildings in the city of Calgary were selected for this study, representing both conventional and green office buildings. Two of the buildings were subject to the following steps over a two-week period in 2014; the same steps and two weeks were taken in the third building but in 2015:

- 85 questionnaires in total were distributed (in hand and online) to occupants and 48 were returned;
- 10 key informant interviews with occupants and managers or team leaders were conducted;
- 2 focus groups were formed and met, with 4 participants in each group;

- 1–2 hours (depending on the building's size) of walk-through tours were taken, documenting building features with photographs and field notes; and
- 1–2 hours (depending on the building's size) of behavioral observations of building occupants were taken during walk-through tours, documented with photographs and field notes.

3.2.1.1 Quantitative Data Collection: Survey Design

The survey is a self-report questionnaire with both closed- and open-ended questions. The closed-ended questions are considered as a quantitative method, while the open-ended questions represent a qualitative method nested (embedded) in the quantitative one (Creswell, 2013). Those open-ended questions are used for comments and as a means of justifying the assessment. The closed-ended questions ask for the occupants' assessments on a 5-point semantic differential scale, with 1 as uncomfortable to 5 as comfortable and 3 signifying a neutral response. These questions use the list of IEQ factors derived from the literature and are designed to test the relations among the IEQ factors and occupants' experience as presented in the theoretical framework. The open-ended questions provide the opportunity for a better understanding of occupants' assessments of each IEQ factor, its indicators, and interpret the reasons behind their experience. They also help to explore other factors that may not have been included in the questionnaire and to obtain occupants' feedback together with the more in-depth interviews in the qualitative inquiry.

In order to construct a standardized questionnaire, Stokols and Scharf (1990) have four suggestions for addressing the physical work environment using standardized research instruments: (1) The questionnaire should enable the participants to complete it in a straightforward manner by providing a streamlined design in length and wording. (2) It should have a broad scope so as to not overlook important aspects of the work environment/facility design. (3) Other variables should be added, such as participants' biographic characteristics, job status, and ratings of job satisfaction, in addition to the variables in the physical work environment. (4) The anticipated results should be directly related to the organizational and environmental design problem and be useful for suggesting strategies that can be implemented to resolve the identified problems.

3.2.1.2 The Questionnaire Design and Structure

As mentioned above, the questionnaire is composed of closed- and open-ended questions that were distributed by the researcher in person or online; the managers sent a copy of the questionnaire to their employees via e-mail. Those employees then filled questionnaires and sent them directly to the researcher's e-mail account. The questionnaire was based on five questionnaires in the field: the Center for the Built Environment (CBE) at the University of California, Berkeley survey (CBE, 2006); the Probe project BUS survey (Leaman, 2010); the Building-In-Use Assessment questionnaire (Vischer, 2005); the Workplace comfort-performance questionnaire (Woo, 2010); and the Physical Work Environment Satisfaction Questionnaire (PWESQ) (Carlopio, 1996). A copy of the questionnaire is provided in Appendix B.

The need for integrating other data gathering tools with the questionnaires:

Despite the relative ease of use of questionnaires in terms of their low cost, high turnaround rates, and quick responses, using only questionnaires might be insufficient to completely explain and explore the IEQ factors affecting occupants' QoL. Questionnaires are useful in testing, and explaining the relationship between the IEQ factors in the physical work environment and occupants' responses to their quality. Questionnaires depend on prescribed variables (the IEQ factors) and specific answers; hence, a comprehensive understanding of people's actual lived experience cannot be obtained. Exploring other IEQ factors that are not predetermined and prescribed require explorative survey tools (in qualitative data collection methods), such as interviews.

3.2.1.3 Qualitative Data Collection Methods: Interpretive Inquiry

Interpretive inquiries are interwoven into the core of qualitative research, as they focus on the researcher as an interpreter of data and presenter of the information. They embrace the self-reflective nature of qualitative research. The interpretive methods allow a systematic structuring of the data, making it possible to select emerging themes, and simultaneously record thoughts and processes (Vaikla Poldma, 2003). Both visual and narrative inquires are

conducted.

(i) Visual Interpretive Inquiry:

This includes multiple observations that the researcher does during his/her walk-through tours to observe the building's features and occupants' behaviors. Photos and field notes are taken to document the spaces as well as the people-environment interactions. Furthermore, journals and other documentation forms capture the conditions of the study as accurately as possible (Vaikla Poldma, 2003). As Patton (1990) states,

> *"In participant observation the researcher shares as intimately as possible in the life and activities of the setting under study. The purpose of such participation is to develop an insider's view of what is happening. This means that the evaluator not only sees what is happening but feels what is like to be a part of the setting*." (p. 207)

Walk-Through Tours

This method is useful for the researcher to observe, with the intent of documenting the buildings' features and occupants' behaviors toward the environment. Tours allow researchers to construct some impressions about the environmental conditions of the workspace and create the opportunity for some informal interviews with building occupants that can help to elicit both positive and negative qualities in their environment. Since it is the same researcher that walked through all the three case studies, this will allow her to make an *expert walk-through analysis* of each setting (Hartkopf, Loftness, & Mill, 1986), and to compare them (Steele, 1973). The length of time (1–2 hours) for each tour varied according to the buildings' sizes and the amount of details to be reviewed. The data gathered in walk-through tours include behavioral observations of the building occupants, the building features, and information from informal interviews. The data gathered are documented using photos and/or field notes as follows:

Behavioral Observations: A qualitative method used for participant observation that can provide insightful data for exploratory investigations (Gans, 1967; Whyte, 2012). These observations are important as they focus on naturally occurring events in their natural settings; thus, they offer a view of the real life experience because "*through participation the researcher is able to observe and experience the meanings and interactions of people from the*

role of an insider" (Jorgensen, 1989, p. 21). The researcher observes occupants' behavioral actions toward the environment, such as changes or adaptive measures they have done to their environment to fulfill their comfort needs, and document the characteristics of the work environment.

Building Features: The researcher observes the building features space-by-space, according to their order of location during the walk-through tour. Details about the appearance, condition, materials used, and other aspects are documented using photography and field notes.

Informal Interviews: Informal interviews are presented here because they occur during walk-through tours, and during which the researcher performs several informal interviews with the building occupants. In this study, many occupants were excited by the privilege of being heard and were able to convey the messages they wanted to express.

Tools used to document behavioral observations, informal interviews, and building features: photos and field notes:

1. Photography

Photographs are very important qualitative tools in building evaluation and human behavior studies, providing a snapshot technique that helps the researcher to record observed physical traces of activities (Zeisel, 1984). According to, photographs can help the researcher to construct the overall ambiance of a setting and its activities in a process called the *narrative visual theory*, which is a "*narrative organization of photographs in which implicit elements of social theory are clearly acknowledged*" (Wagner, 1978; p. 18). Pictures of the work environment were taken during the walk-through tours.

2. Field notes

The researcher always documented her notes during the walk-through tours. She gathered all the possible sorts of data during her visits; she took note of her own impressions to help her to discuss them later with occupants in the interviews (and test how they are actually experienced and felt by the occupants), as well as the phrases stated by the occupants during the informal interviews that took place during the walk-through tours. Field notes are a very

useful method to document the researcher's varied thoughts and avoid missing any ideas or information.

(ii) Narrative Interpretive Inquiry: Interviews

> *"The study of narrative is the study of the ways in which humans experience the world. It is as "old as the hills." As a mode of thinking and feeling, narrative uses storied knowing to attempt to give meaning to ways in which humans understand the world and communicate that understanding to others."* (Hart, 2002)

Narrative interpretation depends on the stories told by the occupants, where the language and discourse are pertinent to interpretive inquiries. It is considered "*a way of characterizing the phenomena of human experience and its study which is appropriate to many social science fields"* (Connelly & Clandinin, 1990). An interview is the most widely-used qualitative method in built environment research (Amaratunga et al., 2002). It has a high flexibility, low cost, and a rapid return of responses; it enables the researcher to know people's feelings based on their own words, which can deepen the researchers' understanding, as this method has high reactivity and enables the researchers to have direct contact with the respondents. Its results thus have high validity and are capable of producing great in-depth data (King, 1994). According to Kvale (1996), the qualitative research interview is defined as "*an interview, whose purpose is to gather descriptions of the life-world of the interviewee with respect to interpretation of the meaning of the described phenomena.*"

Following basic ethical considerations, each individual's interview was recorded by permission and saved on the researcher's computer, wherein each participant was given a code to mask his or her identity and the building they worked in. The questions varied from unstructured to semi-structured questions, and the interviews of 3–4 participants lasted approximately 30–45 minutes. (See Appendix C.)

The researcher also had multiple informal chats with employees during site visits and walk-through tours. Those talks were found to include lots of information, eliciting some new IEQ factors or indicating the importance of known factors.

(a) Unstructured Interviews

The unstructured interview technique, sometimes referred to in the literature as *informal interviews*, was developed in the disciplines of anthropology and sociology as a method to elicit people's social realities. According to Minichiello, Aroni, Timewell, & Alexander (1990), in an unstructured interview neither the questions nor the answers are predetermined, because they depend on the interaction and the flow of the discussion. Patton (2002) described informal interviews as a natural extension of participant observation that often occurs as part of a walk-through and other field observations.

In this type of interview, the questions are more flexible than other types of interviews; they can be changed according to the discussion and the intelligence of the respondent. It is more like a conversation than the asking/answering of a specific set of prepared questions.

(b) Semi-structured Interviews

These types of interviews have semi-directed questions. In this technique the researcher talks with the interviewee about his/her viewpoint on the subject matter of the meeting. It is performed in a conversational format, but the focus is decided by the researcher. The questions asked are open-ended questions, and questions that naturally arise (responsive follow-up questions) during the interview are used. This method is flexible, and the responsive questions may differ from one respondent to another depending on his/her comfort level and the opportunities created in the conversations. These semi-structured interviews are preceded by observations and unstructured interviews. This sequence allows the researcher to develop a profound understanding of the occupants' QoL experience and the IEQ factors interacting with it.

(c) Focus Groups

Focus groups are the most natural technique for collecting data and information about human behavior and interaction in an organizational setting (Steyaert & Bouwen, 1994). Using repertory grids (as explained in detail **Section. 3.2.2.2 (iii)**, and **Section 4.4**), the focus groups are expected to produce the most important constructs and determine the final list of IEQ factors for this study, as they will be conducted in the final phase of the qualitative inquiry; also, when people sit together in a focus group they may remind each other of certain aspects and encourage

each other to communicate. The discussion is recorded for transcription and analysis.

Focus groups are conducted after the first two phases (phase I observations and phase II interviews and questionnaires), wherein the preliminary results have been determined and a *purposive sample* of 4–5 participants for each building are selected. However, the researcher was not able to gather any participants for focus groups in the CDC. Hence, only occupants from the GLW and WCB have participated in the focus groups. The researcher selected occupants of unique responses (either too comfortable or too uncomfortable with their work environment) and agreed to participate in a focus group in the consent form. The identity of the participants are known only to the researcher and preserved anonymously in the research documents and thesis.

The researcher prepared the discussion topics, based on the preliminary results from the analyzed observations, interviews, and questionnaire, and chaired the group discussion. The analysis of the interviews and of the open-ended questions in the questionnaire identified themes and patterns that led to the need for further verification and better understanding. The ideas that emerged were discussed with the focus group participants to better understand the meanings and factors explored and to allow the elements in the repertory grids to be further refined.

3.2.2 Data Analysis

Quantitative and qualitative analytic methods were used in this study. In Phase I, the observations of building characteristics and occupants' behaviors were documented in field notes and photos. Then they were interpreted visually to guide the interview's questions. In Phase II, the researcher conducted the interviews to elicit the IEQ factors from the occupants' words. Themes for the categories of IEQ factors, their influence on occupants' QoL experience, and their level of meaning were determined and given codes. The frequencies of repeated patterns were counted to determine the significance of IEQ factors on occupants' QoL experience. Simultaneously, the results of the questionnaires in Phase II were analyzed using mean values for each questionnaire item, as scores higher than 3 indicate a positive assessment. Furthermore, correlational analyses (Pearson correlations) were performed using SPSS 22 Mac software to determine the IEQ factors that are significantly associated with

perceived QoL ratings. For the focus groups in Phase III, the researcher used repertory grids for all the constructs that were elicited during interviews and tested them to find further convergences and validate the findings.

3.2.2.1 Questionnaire Analysis

The questionnaire is divided into three main categories. In Table V, the variables (IEQ factors) are shown under each category. The matrix between workplace attributes (features) and the levels of meaning of environmental quality indicate how they combine to form the three categories: Ambient Conditions, Designed, and Behavioral Environments.

Table V. The Analytical Framework of the Questionnaire Categories

Workplace Attributes / Meaning of Qualities	Ambient Conditions	Designed Environment
Instrumental Qualities	**CATEGORY I** Instrumental/Ambient Conditions Indoor Air Quality Lighting quality Thermal Comfort Noise and auditory quality Daylighting	**CATEGORY II** Instrumental/Designed Environment Personal Workspace quality Office Layout Furniture Cleanliness & maintenance Indoor décor/Architectonic details Natural features, Views
Latent Qualities	**CATEGORY III** Latent/Ambient Conditions Personal Control Sound Privacy Security and safety Connectivity with Nature Aesthetics	Latent /Designed Environment Territoriality Personalization Wayfinding Crowding Social Interaction Safety and Security Aesthetics Visual Privacy Connectivity with Nature Personal Control
Symbolic Qualities	Symbolic/Ambient Conditions Image and Value	Symbolic/Designed Environment Status, Pride, Identity Image and Value Congruency wih Beliefs

(i) Statistical Analysis: closed-ended questions

The closed-ended questions in the questionnaire were analyzed using statistical descriptive analysis using mean values and statistical inferential analysis (correlational analysis) using two-tailed Pearson correlations.

The Ambient Conditions and Designed Environment are rated on a 1–5 scale, where 5 indicates a comfortable quality and 1 an uncomfortable quality. Each IEQ factor in these two categories is questioned, first as an overall assessment, and then to assess its sub-qualities (measuring indicators) that may affect the overall assessment of this IEQ factor. For example, Light Quality includes sub-qualities or measuring indicators such as the amount, reflections, glare, shadows, colour, etc. The Behavioral Environment is measured with a set of questions indicating the IEQ factor tested and the occupants' agreement or disagreement with the statement on a scale of 1–5, where 1 indicates disagreement and 5 indicates full agreement. The **behavioral questions** are rated on a Likert scale and written such that agreeing with each statement means being comfortable, and so that the less one agrees, the less comfortable one is with a quality. For example,

"*I am comfortable with the amount of visual privacy between me and co-workers.*"

"*I am comfortable with having personal or private conversations at my desk.*"

Hence, "*I agree with being comfortable with the visual or sound privacy*" means there is a comfortable quality of visual and sound privacies.

Choosing from the scale of "Disagree to Agree" and their correspondence on the "Uncomfortable-Comfortable" scale is as follows:

Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Agree
Uncomfortable	Somewhat Uncomfortable	Neutral	Somewhat Comfortable	Comfortable

Occupants' overall experience regarding their Overall Health, Comfort, and Productivity; General Satisfaction with the workplace; and Meeting Needs are also measured on a scale from 1–5, where 1 is a negative experience and 5 is positive. The questionnaire also includes

checklist questions for workspace features, demographic information, and information about certain adaptation behaviors or means for achieving comfort.

The mean values are presented in bar charts comparing the different occupants' responses. Pearson correlations (2-tailed) are used to correlate the overall assessment of each IEQ with the occupants' Overall QoL Experience (Overall Health, Comfort, and Productivity), as well as their General Satisfaction with the workplace and with Meeting Needs. The sub-question results for each IEQ factor are used to strengthen the understanding of which indicators are associated with the overall assessment of its IEQ factor. In this research we are looking for qualities that can be explored or explained based on occupants' experience. That is why the rating of an IEQ factor is not taken as an average from the summation of those sub-qualities and correlated with the QoL or as the general level of satisfaction with the workplace. This is because using a list of prescribed indicators would limit each IEQ factor to those prescribed measuring indicators or sub-qualities, even though there might be other indicators for occupants' experience with this IEQ, which could be determined via the open-ended questions in the questionnaire, as well as through the interviews, observations, and focus groups. Hence, the value of the overall assessment would be more accurate and enable the researcher to better understand on what basis this overall assessment is rated: Is it due to the suggested indicators or because there are some missing qualities that are not questioned?

To measure and test the cause-effect relationship between the IEQ factors and occupants' perceived QoL descriptors, the variables in the questionnaire are classified into dependent and independent variables. Dependent variables are the outcomes that may change when the data of the independent variables (fixed) change; the classification is shown as follows:

Dependent Variables (outcomes):

(a) Occupants' overall QoL experience;
(b) Overall perceived comfort;
(c) Perceived productivity;
(d) Perceived health;
(e) General satisfaction with the workspace; and
(f) Meeting needs.

Independent Variables:

(a) Workspace features: enclosure, location, proximity to windows, presence of blinds, controllability of blinds, operable windows, views, task lighting, and colour of illumination.

(b) IEQ factors: occupants' assessment of each of the (instrumental, latent, and symbolic) IEQ factors that are classified into Ambient, Designed, and Behavioral Environments, such as IAQ, Thermal Comfort, Lighting, Acoustics, Layout, Furniture, etc.

(c) Occupants' demographic information: age, gender, and educational background.

(d) Job-related information: length of time with the company, type of job/task, transportation method, commuting time.

(e) Knowledge and expectations regarding green buildings: knowing whether it is a green building or not, liking to work in a green building or not.

Indicators

According to the model described in the proposed theoretical framework in **Chapter II; Section 2.8**, individual questionnaire items serve to indicate on what basis the variables are measured. A sub-set of questions are used as indicators for each of the IEQ factors, where each IEQ factor has several indicator or predictor items that collect data for that factor. For example, IAQ is an overall assessment item and contains additional questions to assess air movement/circulation, air dryness, air freshness, and air odors as indicators of IAQ. Regarding the outcomes or the dependent variables, Perceived Satisfaction, Health, Comfort, Productivity, and Meeting Needs with the overall workspace are indicated as

(1) Satisfaction: satisfied/unsatisfied.

(2) Health: unhealthy/healthy (headache, nausea, lack of concentration, depression, lack of motivation, eye discomfort, fatigue, etc.).

(3) Comfort: comfortable/uncomfortable.

(4) Productivity (measured in perceived performance): work enabling (enhancing)/interfering.

(5) Meeting needs: satisfied/unsatisfied.

(ii) Thematic Analysis: Open-ended Questionnaire Questions

The open-ended questions in the questionnaire represent the comments that are left after the IEQ rating questions (closed-ended questions) in the questionnaire. These include those reasons beyond the assessment and the means used to feel more comfortable—or any other added notes. Those comments are complementary to the interviews, as both methods enable a deeper understanding of occupants' QoL and of the IEQ factors that interact with the occupants' experience. Furthermore, the comments help gain insights and to expand interpretations for the reasons behind the assessment, as well as offer the chance to explore missing factors in the work environment that contribute to occupants' QoL. Moreover, the questionnaire's design allowed a rating for the overall assessment, as well as a rating for each measuring indicator of an IEQ being assessed. The use of spaces for comments (open-ended questions) compensated for the possible limitation of the prescribed indicators and enabled a more comprehensive assessment. This open-ended assessment also helped to compensate for the low number of respondents to the questionnaires (48 participants), as it enriched the research with a lot of in-depth information based on occupants' own words, similar to the interviews. The open-ended questions are analyzed in different steps:

1st step: The comments are extracted in a table form representing qualities in the questions that had a space for further commenting. The table has two columns: one for the respondent number (#R) and the other for the building name and the responses to each quality or QoL outcome.

2nd step: Themes are elicited from occupants' comments (all the comments are listed in a table) under each IEQ, and given a different colour code.

3rd step: The frequency of themes is calculated to find repetition and set priorities.

4th step: The results are triangulated with other data gathering tools to better understand the occupants' experience from different dimensions.

3.2.2.2 Qualitative Analysis

Qualitative data are collected using open-ended questions in the questionnaire, interviews, and focus groups. Interpretive inquiry is used to elicit the constructs that are inferred from the analysis of occupants' narrations in the interviews and text in the open-ended questions of the questionnaires. Furthermore, the *repertory grids technique* (based on the Personal Construct Theory (PCT) (Kelly, 1955) is applied in the focus group, so occupants use the technique on their own constructs (elicited after interpretation). Hence, the data collected from all the qualitative tools used create information through constructs eliciting using themes and codes, constructs laddering, and repertory grids. The purpose of qualitative analysis is to convey meaning, structure, and order to the data. Interpretation requires acute awareness of the data, concentration, and openness to delicate connotations of social life (Marshall & Rossman, 1999).

(i) Constructs Eliciting: Themes and Codes

This is where the researcher assigns codes and themes to the emergent patterns (word repetition) and emergent constructs (attributes of the environment) that are elicited from the interviews and the open-ended questions in the questionnaire (Miles & Huberman, 1984). Emergent themes and codes, as derived from the narrative of the participants, provide the interpretations and meanings of the issues the participants recount to the researcher (Vaikla Poldma et al., 2014; Vaikla Poldma, 2015). This enables the researcher to analyze the content of the data expressed from occupants' conversations and text writings to represent meanings related to the environment.

(ii) Constructs Laddering

This step follows the codes for patterns and constructs in order to know the hierarchy or significance of each IEQ factor and its importance on occupants' perceived QoL. The words of the respondents are classified into themes, and then the number of times they appear is

counted to indicate the weight of each variable and its degree of influence. This process defines subordinate or super-ordinates constructs (Hinkel, 1965).

(iii) The Personal Construct Theory: Repertory Grids

The Personal Construct Theory (PCT) was created by the psychologist George Kelly (Kelly, 1955) and is used to see how people perceive, structure, and attribute meaning to their environment according to their own schemas (Honikman, 1976). The PCT is used in the present research to converge the researcher's understanding about occupants' perceptions of their workspaces' IEQ and the concept of a humane place, in addition to how their physical environment affects their QoL—all deriving from their own words, terms, language, and constructs. PCT is used in the focus group phase; it incorporates the constructs of the data collected from the open-ended questions in the questionnaire and interviews; together with the IEQ factors that emerged from the qualitative data or were tested in the questionnaires, to create a repertory grid. The repertory grid itself is a matrix, where the columns can represent the IEQ factors found. The rows represent the perceived QoL indicators (constructs) and the cells indicate—with a number—the position of each IEQ factor within each QoL indicator. These grids identify the preference, ranking, and magnitude of each elicited construct. Hierarchical Cluster Analysis technique is used to help with defining clusters such as instrumental, latent, and symbolic qualities, or themes of comfort, as well as rank the significance of IEQ factors. A part from the repertory grid used for some IEQ factors is shown in Figure 14.

	IAQ	Lighting quality	Daylighting	Thermal comfort	Acoustical quality	Weight	
Not healthy	4.0	3.5	4.25	3.75	2.5	33.33	Healthy
Uncomfortable	3.5	3.25	3.5	3.25	2.25	33.33	Comfortable
Not supporting task performance	3.75	3.25	3.25	3.25	2.25	33.33	Supporting task performance
Total weight: 100							

Value	Description
1	Strong agreed with left pole
2	Agree with left
3	Neutral
4	Agree with right
5	Strongly agree with right pole

Figure 14. Part from the repertory grid

Steps of the interviews' data treatment:

1st step: All interviews were transcribed into word documents that are saved confidentially, and each participant is given a code.

2nd step: Salient issues derived from the conversations were underlined and then used to create the tables of the IEQ factors and themes.

3rd step: First Analysis I: Emerging IEQ factors and themes: The tables created herewith include the analyzed data that is classified into six columns representing building code/interviewee codes. These are: Occupants' responses (underlined quotes), interpreted felt experience, Indoor Environmental Quality (IEQ) factor elicited, comfort level influenced, and the QoL descriptors (health, comfort and productivity), (see Appendix D).

BLDG/ Interviewee	Occupants' Responses	Experience	IEQ Factors	Comfort Level	QoL

4th Step: Second Analysis II: Defining IEQ factors, themes and their frequency: After occupants' experiences are interpreted and the IEQ factors have been elicited, they are grouped into themes, as shown in Table VI. These themes emerged as categories and are colour-coded. The repetition of each theme determines the frequency of its repetition, thereby indicating its significance and relative importance among other themes.

Table VI. Codes of Themes

OCCUPANTS' LIVED EXPERIENCE THEMES		COLOUR CODE
COMFORT THEMES:	Physical Comfort	Green
	Functional Comfort	Blue
	Psychological Comfort	Orange
	Social Comfort	Yellow
	Cultural Comfort	Red
QOL DESCRIPTORS THEMES	Health	Purple
	Comfort	Pink
	Productivity	Brown
IEQ FACTORS THEMES	Ambient Conditions	Light Green
	Designed Environment	Light Orange
	Behavioral Environment	Light Blue

3.3 Sample Selection

This research uses a mixed-methods sampling technique (MM sampling) that allows the combination of both qualitative and quantitative orientations, generating complementary databases and thereby providing both depth and breadth in the information (Kaeding, 2007). MM sampling uses *probability sampling* for quantitative investigation and *purposive sampling* for qualitative research. Probability sampling is used to achieve representativeness with a larger number of selected units, and thus "*leads to greater breadth of information*" (Teddlie & Tashakkori, 2009. Purposive sampling selects units according to a specific purpose, and so it "*leads to greater depth of information from a smaller number carefully selected cases"* (Teddlie & Tashakkori, 2009). According to Patton (2002), "*there are no rules for sample size in qualitative inquiry,"* as it is more useful to look at it in terms of the saturation of information (Glaser & Strauss, 1967; Corbin & Strauss, 2014), which occurs when there is a repetition in the ideas without getting any new information, and so there is no need to add more units (Teddlie & Tashakkori, 2009). Both numeric and narrative data are generated using the MM technique, and so the focus can be on both external validity and transferability. As stated by Teddlie and Tashakkori, (2009) "*Many of the research topics under examination in the human sciences are quite complex. To study these issues comprehensively, MM sampling techniques (not just purposive or probability techniques) are required"* (p.171).

The first stage of the study used a convenience sample. C*onvenience sampling* relies on an accessible and willing-to-participate sample, so the researcher surveyed occupants of different office buildings in Calgary by contacting the city's project managers as well as University of Calgary faculty members. The buildings were chosen according to their status as LEED or conventional modern office buildings with open-plan working areas and possible closed private offices for managers, as well as the company's/department's willingness to participate in this research. After selecting the buildings, the occupants were selected randomly to participate by being given the questionnaire. The participants for the interviews were selected to represent two groups: managers and employees. Focus group participants were selected using purposive sampling, where occupants who had indicated unique responses, such as

extreme satisfaction or extreme dissatisfaction in the questionnaires or interviews, were requested to participate.

3.3.1 What is Being Sampled?

Subjects: Employees working in office buildings in Calgary, Alberta, Canada

Settings: Office buildings in Calgary

The research sample size comprises three office buildings: two LEED and one conventional.

1. The Child Development Center (CDC): a LEED-NC building.
2. The Water Centre (WCB): a LEED-NC building.
3. The Tetranex Solutions Inc. Glenmore Workplace (GLW): a conventional building.

Events and Activities: Job task performance, work collaboration, social life at work.

Processes: Occupants' perceived IEQ and QoL at work

The sample of buildings and respondents in each building are presented as follows in Table VII, Table VIII, and Table IX.

Table VII. Buildings in the Research Sample

Target Population:	All LEED and Conventional modern office buildings in Canada		
Accessible:	3 office buildings (2 LEED and 1 Conventional)		
Setting:	Child Development Centre (CDC)	Glenmore Workplace (GLW)	Water Center (WCB)
CONSTRUCTION YEAR START/ COMPLETION DATE:	Mar 2005 / Oct 2007	N/A. Renovation dates: elevator systems 2000, 2007 & 2011. Metal siding replacement 2011	Opened June 4, 2008
Building Type:	LEED® Platinum Green Office Building	Conventional Office building	LEED® Gold Green Office Building
Building Location:	Calgary, Alberta, Canada	Calgary, Alberta, Canada	Calgary, Alberta, Canada
Sampled Floor:	2nd floor	1st floor	All 4 floors
Occupants:	Alberta health services employees & managers	Tetranex solutions Inc. employees & managers	City of Calgary water resources & services employees & managers
#Occupants/building:	80	25	400

Table VIII. The Distribution of Questionnaire Respondents in Each Building.

BUILDING/ GENDER	*CHILD DEVELOPMENT CENTRE (CDC) BUILDING (N=30)*			*GLENMORE WORKPLACE (GLW) (N=25)*			*WATER CENTRE (WCB) (N=30)*			***TOTAL***		
	M	**F**	**T**	**M**	**F**	**T**	**M**	**F**	**T**	**M**	**F**	**T**
RESPONDENTS	0	14	14	11	2	13	7	14	21	18	30	48

M: male F: female T: Total

Table IX. The Interviews: Number of Respondents in Each Building

BUILDING/ GENDER/ WORK POSITION	*CHILD DEVELOPMENT CENTRE (CDC)*			*GLENMORE WORKPLACE (GLW)*			*WATER CENTRE (WCB)*			***TOTAL***		
	M	**F**	**T**	**M**	**F**	**T**	**M**	**F**	**T**	**M**	**F**	**T**
EMPLOYEE	0	2	2	2	0	2	1	2	3	3	4	7
MANAGER/LEADER	0	1	1	1	0	1	0	0	0	1	1	2
*OTHER**	0	0	0	0	1	1	0	0	0	0	1	1
TOTAL	0	3	3	3	1	4	1	2	3	4	6	10

M: male F: Female T: total

*The category of *other* includes administrative assistants.

3.3.2 Recruitment of Participants

During the recruitment process, the researcher sent recruitment letters to project managers, facility managers, managers, and team leaders in different office buildings in Calgary, in addition to faculty staff, colleagues and friends. Multiple office buildings were visited as a means to recruit occupants and to gain acceptance by building occupants to participate in the study. In 2013 the researcher connected with a project manager in the City of Calgary, but due to the flood in Calgary in June 2013, the study had to be delayed because of damages to the buildings chosen for study, and the researcher continued to search for other appropriate buildings.

The study was later pursued in March–May 2014 and in November–December 2015. In the case of the WCB building the researcher had several discussions with the project manager. For the CDC the researcher contacted the manager of the 2nd floor workplace that is used as an office by Alberta Health Services for children's assessment, documentation of cases, and

treatment. Similarly, the researcher contacted the owner and manager of the GLW via a common acquaintance. Employees were then contacted by the researcher and recruited via an invitation from the managers in each building.

The questionnaire was prepared in two versions: a printed copy and a PDF. Fillable copy was used for employees who preferred to fill their answers on a computer (85 questionnaires were distributed in total and 48 returned from all buildings, as previously shown in detail in Table VIII). Occupants' job positions and duration of the interviews and focus groups (focus groups were conducted on the WCB and GLW) are indicated for each building as follows:

Participants Recruited for Interviews:

BUILDING	CDC	GLW	WCB
N of Interviews/BLDG:	3	4	3
Participant #1:			
Code:	CDC-IP1	GLW-IP1	WCB-IP1
Job:	Pediatric Occupational Therapist	Junior control electrical engineer	Instructional Designer, Learning & Employee Development, Water Resources
Duration of interview:	41 min	33 min	49 min
Participant #2:			
Code:	CDC-IP2:	GLW-IP2:	WCB-IP2:
Job:	Nurse Clinician, Team Leader and CDS Central Intake Coordinator	Manager and owner Principal, Process Controls Specialist	Project manager, water resources, City of Calgary
Duration of interview:	1hr: 14 min	52 min	52 min
Participant #3:			
Code:	CDC-IP3:	GLW-IP3:	WCB-IP3:
Job:	Psychologist FASD Clinic Child Development Services	Senior control electrical engineer	Business Change and Process Analyst The City of Calgary Water Resources
Duration of interview:	43 min	1 hr.	1 hr.

Participant #4:		
Code:	GLW-IP4:	—
Job:	Secretary	
Duration of interview:	50 min	

Participants recruited for Focus Groups:

BUILDING	**GLW**	**WCB**
Number (N) of Focus Groups:	1	1
N of participants in the Focus Groups:	4	4
Participant #1:		
Code:	GLW-FGP1	WCB-FGP1:
Job:	Principal, VP of Operations at Tetranex Solutions Inc.	Team Lead-Water Resources, Resource Planning and Policy The City of Calgary
Participant #2:		
Code:	GLW-FGP2	WCB-FGP2:
Job:	Junior Electrical Designer	Enmax Contract Services Coordinator The City of Calgary
Participant #3:		
Code:	GLW-FGP3	WCB-FGP3:
Job:	Senior Electrical Designer	Operations Administrator for the City of Calgary
Participant #4:		
Code:	GLW-FGP4	WCB-FGP4:
Job:	Control Systems Engineer	Safety Advisor UEP for Construction Services Division for the City of Calgary
Duration of Focus Group meeting:	51 min	50 min

3.4 Research Setting:

Three buildings were selected for the study: two LEED-certified office buildings (CDC and WCB) and a conventional office building (GLW). All of the buildings are located in Calgary, Canada, and they are all office buildings with modern work environments featuring open-plan layouts. The GLW and the CDC also have enclosed offices for managers. A summary of each setting is presented in Table X and Table XI.

3.4.1 Setting 1: The Child Development Centre (CDC) LEED Office Building

The Child Development Centre (CDC) was the first LEED® Platinum standard building in Alberta when it opened in October 2007. Located in Calgary, it is considered among the most heavily-instrumented buildings in North America. It has received many awards and obtained the highest score (57 points of a possible 70) for a LEED-certified building in Canada in 2007. It also received the highest score in the world for a cold-climate LEED certified building when it was built (CDC, 2015).

Figure 15. The CDC main entrance

Compared to conventional buildings, the CDC uses many sustainable strategies to reduce its energy costs (over 70%) and water use (more than 55%). Some examples of these strategies include the use of a solar photovoltaic system, solar panels that double as a window shading device, large windows to maximize daylighting, motion-activated energy efficient lights, high-performance boilers, ventilation via a raised-floor access system, low-flow plumbing fixtures, dual-flush toilets that use grey water from the central heating and cooling plant, waterless urinals, exterior zinc cladding concrete with 75% fly-ash content; high reflectivity and emissivity roofing system, and 83% of construction waste diverted from landfills (Young, 2009). The building's different spaces are shown in pictures A-R of Figure 18.

3.4.2 Setting 2: The Tetranex Solutions Inc. Glenmore Workplace (GLW) – Conventional Office Building

The Tetranex Solutions Inc. has its Glenmore Workplace on the 2nd floor of this building. This conventional building is occupied by multiple tenants from different companies, and the companies have their own suite(s). The Tetranex company has two suites (zone I and zone II).

Figure 16. GLW Building

Each suite has its own entrance doors on the first floor. Each includes an open-plan office workplace with enclosed offices along the outer walls and corridors, and a meeting room, a computer lab, a room for storage, printing and copy center areas, and a kitchenette. The suite in zone I also has a reception area with a front desk and small waiting area. No washrooms are located inside the suites (they are in the corridors of the building and are shared with other tenants). The physical work environment is shown in pictures A-R of Figure 19.

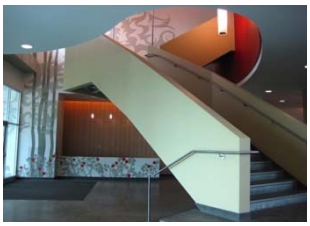
3.4.3 Setting 3: Water Centre Building (WCB) – LEED Office Building

The WCB building is a LEED® Gold office building in Calgary, Alberta. Completed in 2008, it has been given the Alberta Emerald Award for its sustainable strategies.

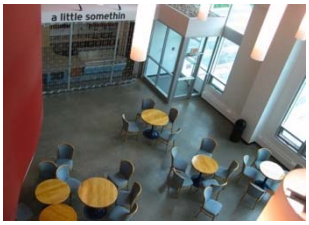
It contains office spaces on four floors, 10 large meeting or board rooms (each with seating for 16 people), 10 small meeting rooms (seating 4–8 people), copy rooms, quiet rooms adjacent to the work units, training rooms, crew-gathering areas, resource center, coffee areas and washrooms on each floor, staff lounge, gym, and cafeteria on the main floor, data service rooms, change rooms, and a service area for operations staff, such as fleet parking.

Figure 17. Water Center external view

Sustainable principles are used such as using less energy and less water, using recycled materials whenever possible, generating less waste throughout construction, and providing a healthy and dynamic working environment for employees. The different building spaces are shown in pictures A-R of Figure 20.



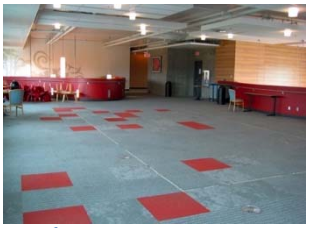
A. CDC main entrance reception and foyer



B. CDC main floor cafeteria

C. Elevators leading to the 2nd floor

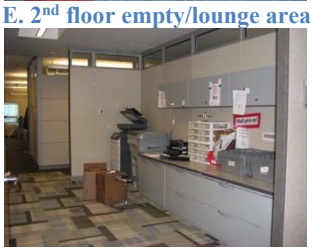
D. Public washrooms



E. 2nd floor empty/lounge area

F. Treatment rooms

G. Corridor leading to workstations



H. Storage & coat hanging wardrobe area

I. Copy and printing area

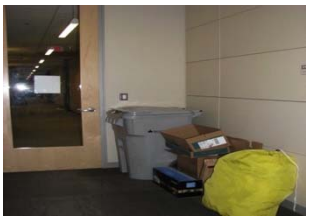
J. Meeting rooms

K. Private meeting rooms

L. Washrooms

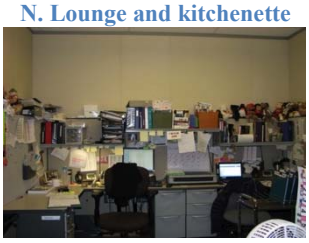
M. Private telephone rooms

N. Lounge and kitchenette

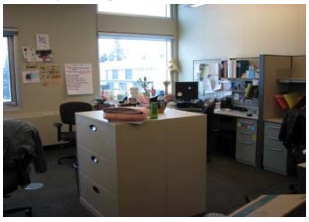


O. Recycling area in the corridor

P. Typical workstations



Q. Workstations side by side



R. Team leader workstation

Figure 18. The Child Development Centre

A. Tetranex reception

B. Corridor leading to workstations

C. Meeting room

D. Corridor with private offices leading to the open-plan workplace

E. Artwork in the corridor

F. Lounge and kitchenette

G. Computer lab

H. Copy and printing room

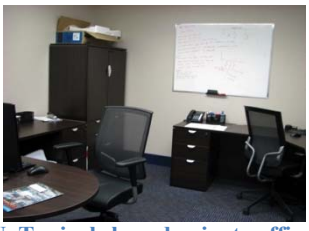
I. Another Copy and printing area

J. Flooring carpet

K. Workspace organization

L. Workspace organization

M. Typical workstations near windows

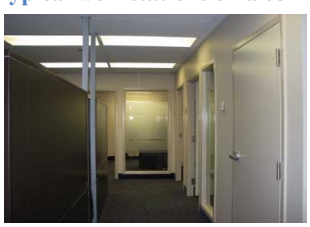


N. Typical shared private offices

O. Typical workstations on a corridor

P. Workstations side by side

Q. Typical private offices



R. Private offices

Figure 19. Tetranex Solutions Inc. Glenmore Workplace

A. Reception area

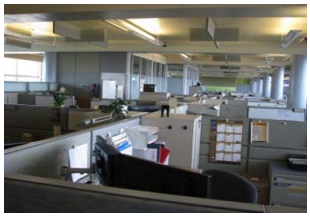
B. Main circulation corridor

C. Cafeteria in the main floor

D. Statement staircase

E. Small meeting rooms in the main floor

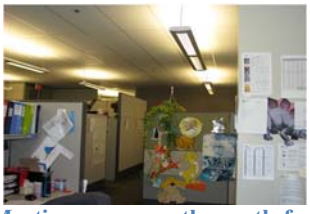
F. Entrance to workstations



G. Workspaces organization

H. Kitchenette

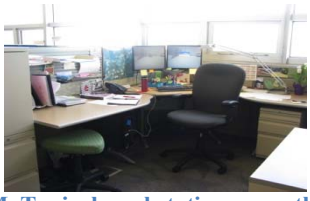
I. Copy and printing area



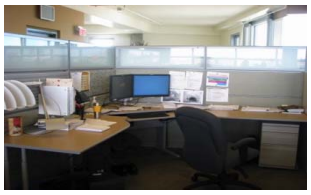
J. Meeting rooms on the south-facing corridor

K. Typical large meeting room

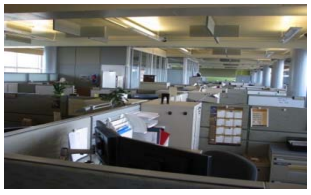
L. Washrooms



M. Typical workstations near the windows

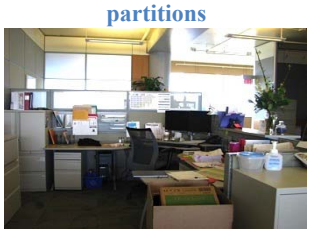


N. Typical workstations with high partitions



O. Typical workstations with low partitions

P. Storage at additions in workstations



Q. Directors' workstations

R. Directors' workstations

Figure 20. The Water Centre Building

Table X. The Research Setting Summary in the Three Buildings

BUILDINGS	CHILD DEVELOPMENT CENTRE (CDC)	GLENMORE WORKPLACE (GLW)	WATER CENTER (WC)
BUILDING TYPE:	Green office building	Conventional Office building	Green Office building
ORGANIZATION:	Alberta health services	Tetranex Inc.Solutions	City of Calgary water resources and services
CERTIFICATIONS & AWARDS:	•**LEED® Platinum** •Calgary Award for Environmental Achievement; 2008 Summit Award from APEGGA.	None	• **LEED® Gold** • Alberta Emerald Award
BUILDING LOCATION:	Calgary, Alberta, Canada	Calgary, Alberta, Canada	Calgary, Alberta, Canada
ARCHITECT:	Kasian Architecture Interior Design and Planning Inc.	Unknown	Sturgess Architecture
START/ COMPLETION DATE:	Mar 2005 / Oct 2007	First developed unknown, renovation dates: elevator systems 2000,2007 & 2011. Metal siding replacement 2011	Opened June 4, 2008
# OF FLOORS:	Four-story	Two-stories	Four-story
BUILDING AREA:	167,443 ft^2	28,900 ft^2	183,000 ft^2
PARKING:	Underground and outdoor parking	Underground parking garage	Outdoor parking
WORKPLACE DESIGN:	Open-plan and enclosed offices	Open-plan and enclosed offices	Open-plan
WORKSTATIONS TYPE:	High partitioned cubicles & enclosed offices	Desks with Hutches and enclosed offices	Low and high partitioned cubicles

Table XI. The Systems Used for Ambient Conditions in the Three Buildings

VENTILATION	Operable windows & Under Floor Air Distribution (UFAD) supplied by air handling units that have demand-controlled outdoor air supply and Variable Air Volume (VAV) box in each pod (six workstations grouped together)	Gas-fired Make-Up Air Units (MAU)	Operable windows & displacement ventilation using natural convection (warm air rises through under-floor sir system, and cool air is pushed down by radiant cooling slabs in the ceiling)
ILLUMINATION	Natural Daylighting and artificial lighting.	Natural Daylighting and artificial lighting.	Natural Daylighting and artificial lighting.
THERMAL COMFORT (heating & cooling)	Heating by perimeter radiators supplied by gas-fired boilers, and chiller with water tower for cooling	Heating by perimeter radiators supplied by gas–fired boilers Cooling using roof top mounted A/C units complete with Variable Air Volume (VAV) controllers and heating coils	Under-floor heating & radiant ceiling slab cooling. Evaporative cooling and heat recovery are provided in air-handling units.
NOISE CONTROL	White noise	N/A	Acoustic panels (sound masking)

3.5 Pilot Study

The pilot study was conducted in the fall of 2013. The researcher distributed 11 questionnaires and conducted two face-to-face interviews. Questionnaires were distributed either by hand or online. The pilot study took place in a small conventional office, where the researcher was able to make a walk-through tour, record observations about the work environment and the employees' behaviors, conduct the two interviews, and distribute five questionnaires. The rest of the questionnaires were sent via e-mail to employees working in other office buildings. Those participants were asked to fill out an extra page in the questionnaire that requires data about their workspaces' features. The two different strategies used in the distribution of the questionnaires helped the researcher to test the different possibilities available for the actual survey. The pilot study also helped the researcher to refine,

modify, exclude, and/or add some questions in the questionnaires and interviews for the actual study.

3.6 Validity Issues

In a mixed-methods approach, the validity is built on the appropriateness, thoroughness and effectiveness of the methods applied (Creswell, 2013). In this type of study, it is trustworthiness that is achieved, rather than validity per se.

In the qualitative inquiry the study uses multiple sources of data collection: observations, walk-through tours, photographs, interviews, and focus groups; it then triangulates them to allow the bias in one method to be compensated for by another. The triangulation of multiple methods in data collection and analysis strengthens the reliability and internal validity (Merriam, 1998). In addition, the hierarchy of the sequence used from one qualitative method to another has an influence; starting with observations and then proceeding to unstructured interviews, semi-structured interviews, and ending with the focus groups helps to modify and focus the research questions for better findings. Prolonged repeated visits and observations of the site, as well as accurately repeating the same methods and procedures in reporting for the three buildings, increases the internal validity and the sample population for a better understanding of the phenomena. To ensure the internal validity of the interviews, the analysis is supported by quotes from the participants' narrations. Rich, thick, detailed descriptions are used in the analysis, giving a solid framework in a way that allows repetition, transferability and comparisons by other studies to further increase the external validity (Merriam, 1998).

In the quantitative inquiry, internal validity is assured by making the questions direct and simple. The questionnaire was modified from previous valid questionnaires. Random techniques were used in the sampling of the questionnaire's respondents. In the interviews, both negative and positive responses from the occupants were sought to avoid bias. The sample number had the possibility of expansion up to saturation, where there is a repetition of the same results and no new information is being added. Finally, triangulation between qualitative and quantitative results was used to ensure better interpretations of the findings.

3.7 Ethical Considerations

The main focus and purpose of this research is to develop humane criteria for assessing indoor environments by proposing a more occupant-oriented sustainable and humane framework for the IEQ criteria of green building assessment. Human comfort and improved QoL through better physical environments is therefore an ultimate goal of this study; consequently, ethical issues concerning the study participants' human rights were given a high priority during the study's data collection methods.

The research study and plan was reviewed by the University of Montreal Institutional Review Board (IRB), and prior to the recruitment of participants, the researcher obtained the ethic certification via Comité plurifacultaire d'éthique de la recherche (CPÉR) at Université de Montréal. This certification provides the participants with the necessary means to give their informed consent and assesses the potential physical, psychological, economic, social, or legal risk of harm (Sieber, 1998). A copy of the *certificat d'éthique* is presented in Appendix E. Moreover, the researcher developed an *informed consent form* to be signed by the participants before beginning their participation in the study (Creswell, 2002). A copy from the consent form is in Appendix F.

Before conducting any questionnaires or interviews with the occupants, the purpose of the study was stated clearly, making sure to present its impact and possible benefit to them, as well as the procedures (if any), and the time anticipated to be spent in participation. The participants were assured about their right in participating voluntarily, as well as their right to leave at any time (to make sure they would feel comfortable enough) and their right to ask any questions (Creswell, 2013). To avoid any employees feeling afraid of complaining about their work environments and to eliminate the risk of becoming known by the stakeholders, the confidentiality and privacy of their personal information was taken very seriously. They were also assured that the research would not deal with whether they liked their tasks or not. In addition, the results were investigated and discussed exclusively by the researcher and with research supervisors, without any chance of revealing the respondents' identities to their employers. Even so, any refusals to participate, whether in the interviews or the questionnaires, were respected as a means to increase the validity of the results.

Permission from individuals of authority to access the sites, conduct interviews, and focus groups with participants—and take the required photographs, notes, and observations—were arranged prior to studying each building. The researcher was also cognizant of the impact and disturbance that might occur during the observations and her prolonged stay at the workspace. Permission from the occupants was also sought before taking any photos, in order to make sure that no one appears (identifiably) in the pictures. The pictures taken did not zoom in on any personal pictures present in the workstations, so they stay unrecognizable.

To protect the identity of the participants, the researcher dissociated their names in the questionnaires and interviews (Creswell, 2013). This research also respects ethical considerations in the language used in the written materials.

4 CHAPTER IV: RESULTS AND FINDINGS

This chapter presents the results and findings of the study. This includes the collection and analysis of the observations, interviews, questionnaires, and focus groups. It is organized according to the phases of inquiry, as previously mentioned in **CHAPTER III Section 3.1.1.1**. Objectives, methods used, and phases of inquiry are shown in Table XII.

Table XII. Objectives, Methods, and Phases of Inquiry

OBJECTIVES	Method	Phase
OBJECTIVE I: Documenting occupants' overall perceived QoL experience in LEED-certified and conventional office buildings.	Observations Interviews Focus groups	Phase I Phase II Phase III
OBJECTIVE II: Explaining occupants' overall perceived QoL experience in LEED-certified and conventional office buildings.	Questionnaire: Descriptive analysis	Phase II
OBJECTIVE III: Determining IEQ factors interacting with occupants' QoL in LEED-certified and conventional office buildings.	Observations Interviews Focus groups	Phase I Phase II Phase III
OBJECTIVE IV: Identifying IEQ factors' significances on occupants' QoL in LEED-certified and conventional office buildings.	Questionnaire: Inferential analysis	Phase II
OBJECTIVE V: Defining constructs of a humane work environment.	Interviews	Phase II

4.1 Observations from the Walk-Through Tours

Observations were done to document occupants' QoL experience and the IEQ factors interacting with their experience (OBJECTIVE I and III). They were done as **Phase I** in the study to guide the questions for the interviews in **Phase II**. During site visits to the three buildings, the researcher documented observations in field notes and photos. The photos were analyzed using annotated diagram method (Zeisel, 1984). This method marks or comments the observation documented on the picture. The researcher described and documented IEQ factors in the building features and occupants' behaviors based on the criteria shown in Table XIII, Table XIV, and Table XV. The results of the observations were thereafter triangulated with the rest of the data gathering tools (interviews, questionnaires, and focus groups) to confirm their interpretations.

The findings from observations include the general observations, comparative evaluations, probe questions, and suggestions. Observations of building features and occupants' behaviors are presented for each building according to three categories of IEQ factors: Ambient Conditions, Designed Environment, and Behavioral Environment. The IEQ factors in the Designed Environment are presented in the order of their location in the building, as experienced during the walk-through tours. For example, it begins with the main entrance, followed by the reception and waiting area, then follows the circulation to the work environment. The building features include the Ambient Conditions and the Designed Environment. The occupants' behaviors include coping and adaptation (adding, removing, adjusting, and customizing) toward the environment (Ambient Conditions and Designed Environment), and pro-sustainable behaviors.

Table XIII. Observations' Criteria for Ambient Conditions

Building Features: Ambient Conditions	
Ambient Conditions	**What to observe**
(1) Lighting: Artificial and Daylighting	Amount of illumination; fixtures or windows (types, condition, dimensions, distribution, location); colour; glare; shade; reflections.
(2) IAQ	Ventilation systems or fixtures (type, condition, location) & odors
(3) Sound & Noise Control	Strategies and treatment elements, heard noises.
(4) Thermal Comfort	Systems (type, condition, location), felt temperature and/or humidity.

Table XIV. Observations' Criteria for the Designed Environment

Building Features: Designed Environment	
Designed Environment	**What to observe**
(1) Layout	Zoning (location of different zones).
(2) Main Entrance and Reception	Type, condition, colour, finishing materials, & dimensions of ceilings, walls, & floors, furniture. Organization of space, architectonic details, cleanliness, etc.
(3) Circulation Corridors	Type, condition, colour, finishing materials, & dimensions of ceilings, walls, and floors. Signs, architectonic details, cleanliness, etc.
(4) Spatial Organization	Organization of workstations in the layout.
(5) Access to Equipment	Location from workspaces.
(6) Personal Workspaces	Type, condition, colour, finishing materials, & dimensions of desks & chairs. Equipment, architectonic details, etc.
(7) Meeting Rooms	Type, condition, colour, finishing materials, & dimensions of ceilings, walls, & floors, furniture. Architectonic details, cleanliness, equipment, etc.
(8) Views	Quality of viewed scene (what is viewed).
(9) Amenities	Availability and quality of type, condition, colour, finishing material, & dimensions of ceilings, walls, & floors, furniture. Architectonic details, organization, cleanliness.
(10) Washrooms	Cleanliness, fixtures.

Table XV. Observations' Criteria for Occupants' Behaviors

Occupants' Behaviors	
Behavioral Environment	**What to observe**
(1) Coping and Adaptation Behaviors toward the Ambient Conditions	e.g., using task lighting, headphones, heaters, fans, etc.
(2) Coping and Adaptation Behaviors toward the Designed Environment	e.g., adding furniture, adding personal items, etc.
(3) Pro-sustainable Behaviors	e.g., recycling, composting, etc.

4.1.1 The CDC (*LEED-Platinum Green Office Building*)

4.1.1.1 Ambient Conditions

Observations for the Ambient Conditions (including Lighting, IAQ, Acoustical Quality and Noise Control, and Thermal Comfort) are documented for the CDC as follows.

Lighting/Illumination

Lighting is provided through both natural daylighting, which comes from peripheral operable windows, and artificial lighting, provided by different types of lamps.

Daylighting is natural light that emanates from windows. The design of the open-plan allows daylighting to penetrate to other workstations. However, due to the proximity from windows, it is observed that peripheral workstations (located on external walls) had higher levels of illumination compared to workstations deeper in the floor plan.

Figure 21. Operable windows

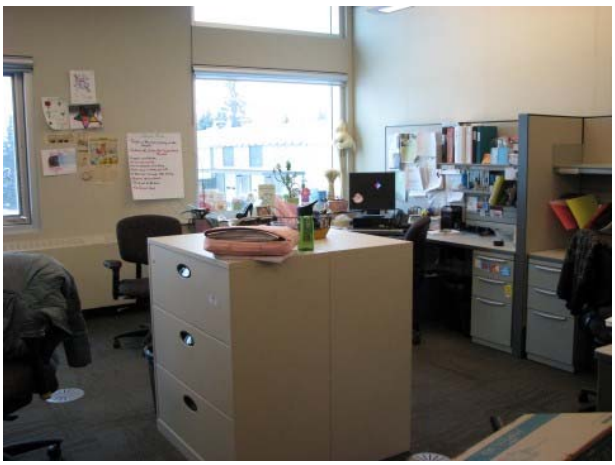


Figure 22. Illumination in workstations beside windows

Artificial lighting is provided through fluorescent lamps and recessed lights. The lighting shuts off automatically after the building working hours, and light sensors turn light off in unoccupied rooms. It is a strategy to save energy in LEED-certified buildings.

It is observed that the ambient lighting in the CDC has a yellowish colour, and the amount of illumination is not consistent everywhere (some areas are darker than others, such as the area in front of the elevators). This colour and inconsistency in the amount of illumination questions how psychologically comfortable and supportive of the ability to perform tasks (such as reading) comfortably they are for the building occupants. (Further investigations are required in other phases.) Also, some treatment and observation rooms (used to observe kids during experimental treatments) are found to have no daylighting (no windows), and the artificial lighting fixtures in some spaces are broken. This questions the frequency and response of maintenance of fixing broken bulbs. (see Figure 23, Figure 24, and Figure 25.

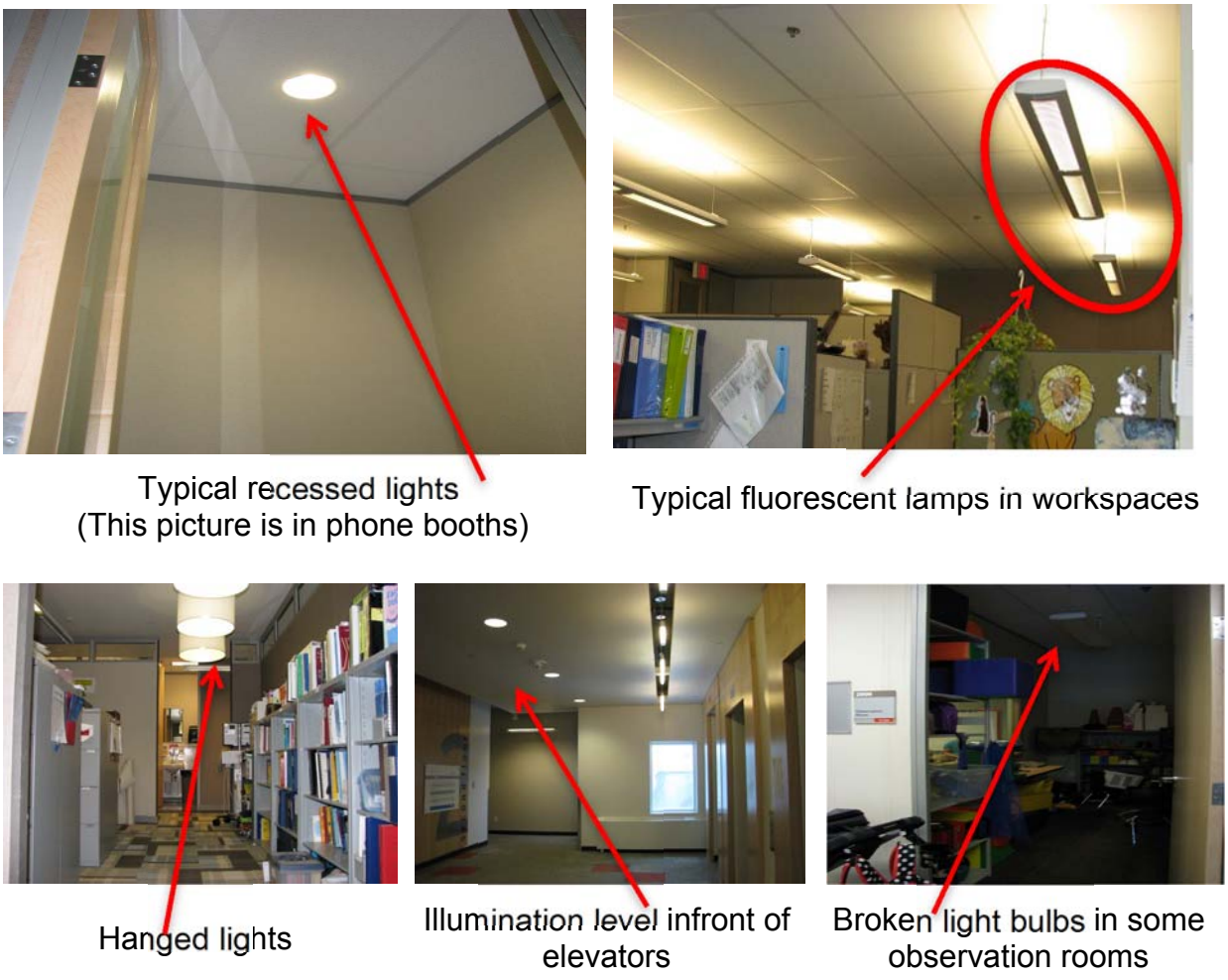


Figure 23. Different artificial lighting in the CDC

Figure 24. Observation room with very poor illumination

Figure 25. Treatment room with broken light bulb

Indoor Air Quality:

The CDC benefits from the availability of natural ventilation, which can be customized and provided via operable windows, and from the mechanical fresh-air ventilation system, which introduces air via an under-floor ventilation system and comes out of air vents. It is observed that the air vents are located on the floors and that they produce cold air. It is also observed that in some workstations they interfere with the location of chairs and desks. Ventilation systems are found to shut off automatically after typical building use hours. However, the researcher wonders (are further investigated in other phases) whether this strategy to save energy impacts the quality of air in the morning, when employees arrive the next day. Generally, the researcher hasn't smelled any significant odors in the workplace.

***Sound/Noise Control**:*

The CDC uses white noise to mask noise. White noise is a technique where a device is used to generate random background noise (like the sound of trees, HVAC, waterfalls, etc.). It masks the unwanted sounds occurring in the office. However, noise from colleagues has still been heard during the researchers' site visits.

Thermal Comfort:

To maximize solar gains in winter, the building is longest along its east-west axis to benefit from the north and south solar exposure, reduce glare, reduce heat gain on the east and west

sides; therefore, less cooling is required (less external heat gain). The building also has fin tube radiators located at walls and motion sensors to regulate temperatures. The air-handling units also have heat recovery wheels. Those wheels transfer heat from the return air to the supply air to optimize the efficiency of the heating and cooling coil. It is observed (on the days of the researcher's visits) that the temperature inside the open-plan workplace is felt as generally colder than in the enclosed offices, and workstations near windows are felt colder. This suggests that the HVAC system might be malfunctioning and also emphasizes the importance of giving occupants control over the thermostats.

4.1.1.2 Designed Environment

In the Designed Environment, the researcher will start with a simple description of the layout and different zones found in the CDC; thereafter, she will present the design elements and IEQ factors in the different spaces, according to their location in the buildings and the criteria previously mentioned in **Section 4.1** of this chapter.

Layout: Workplaces on the CDC's second floor have two zones: zone I has an open-plan workplace and zone II has enclosed private offices and treatment rooms. The different zones will be presented on the floor plan (see Figure 26). To reach the second floor workspaces you can either take the elevator or the stairs, which can be reached from the main floor (just beside the main entrance). Besides the staircase in the second floor there is an empty space—a lounge that includes one table with a few kid-size chairs. On the second floor there is a corridor to the left that leads to the public washrooms and the private offices. On the right-hand side there is a door leading to a reception and appointment waiting area for kids and their families. The reception area is separated by another door from the office zone that has the open-plan workspaces where clinicians do their office work. This door opens into a corridor where the workstations are to the right and meeting rooms to the left. There is a common storage place with drawers and a wardrobe for hanging coats at the entrance of the workspace's area. The zone also has a kitchenette with microwaves and fridges. There is only one single (unisex) washroom in the open-plan workplace zone.

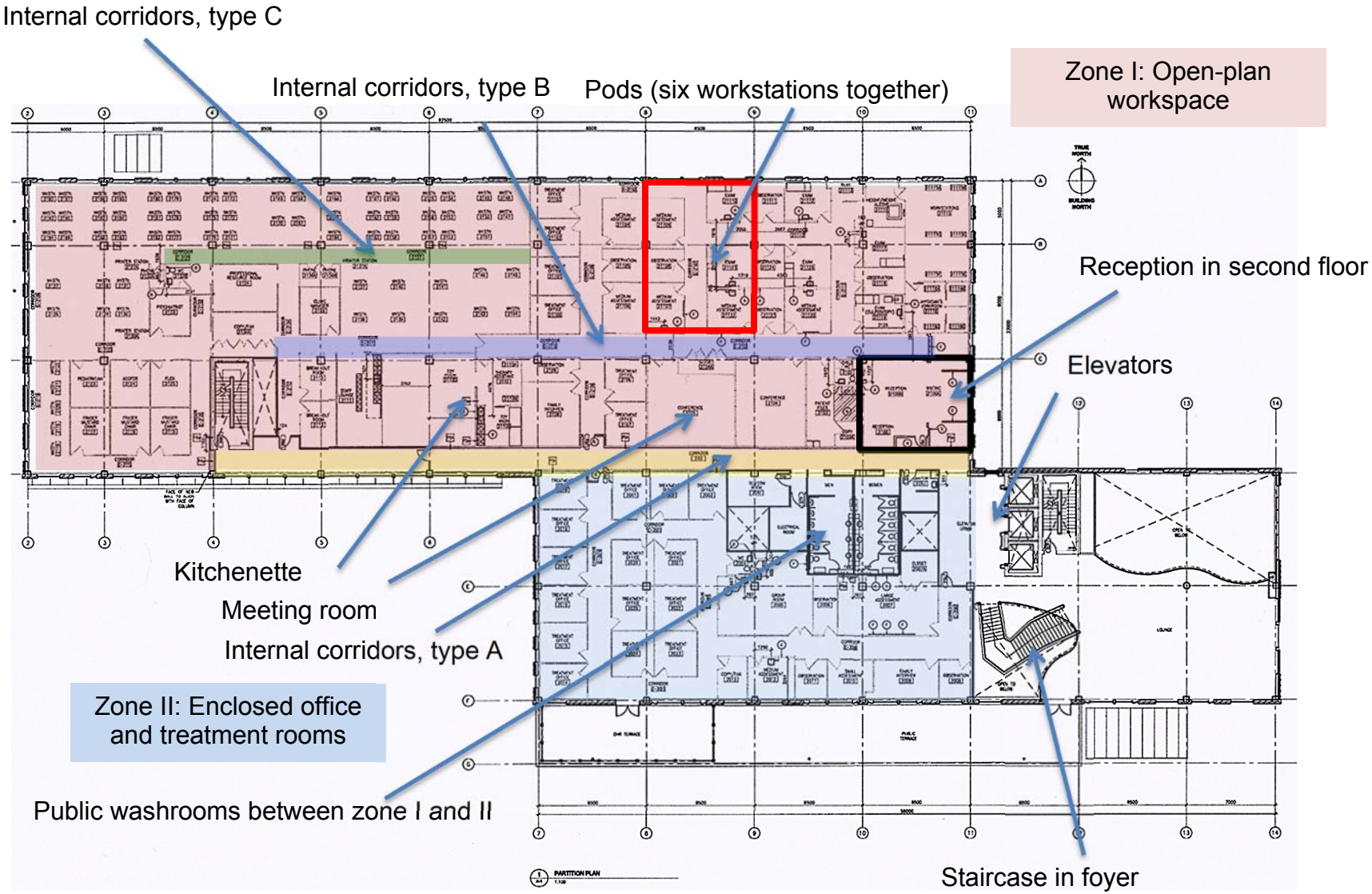


Figure 26. The CDC floor plan

Main Entrance and reception area:

The entrance façade of the building has a remarkable hand that symbolizes kids, as shown in Figure 27.

In the reception area (from the main entrance) inside the building, there is a staircase (in the foyer) with bright red and orange colours, as shown in Figure 28 and a front desk reception with some decorative red and grey floral patterns. However, the front desk has not been used; there is no receptionist or security guard.

Figure 27. Kid's hand print on external wall in the CDC

This is supposed to be a kid-friendly facility, yet it is noticed that there are no safety handrails on the sides of the stairs. The researcher finds it can be easily climbed by kids in case of insufficient or lack of supervision. The colours of the walls, ceilings, and floors are all grey because they are composed of unfinished concrete slabs (a strategy used in green buildings to reduce the use of materials) and grey tiles, as shown in Figure 29.

Apart from the main entrance of the building and the front desk, there is a glass door in the second floor with a small reception and waiting area, leading to the open-plan workplace zone. The waiting area has few seats (less than 10) and some toys for younger kids.

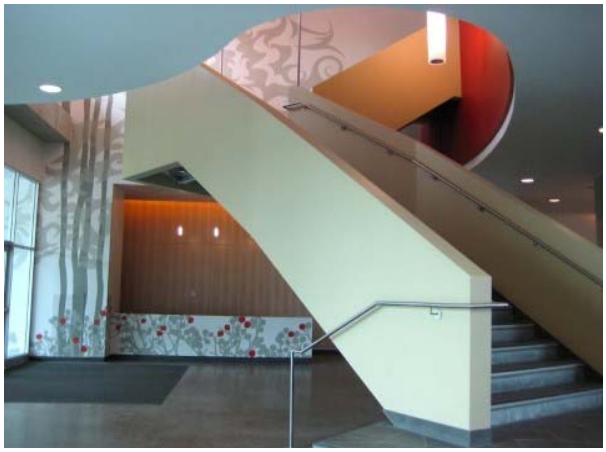


Figure 28. Foyer staircase in the CDC

Figure 29. Concrete slabs beside the stair case in the CDC

Circulation:

Circulation corridors are important design elements that may interact with occupants' wayfinding ability, and overall ability to circulate within the workspace. The proportions of corridors may have a psychological influence (feeling too narrow, too dark, crowded). Several observations are documented in the corridors used for circulation. Three categories of corridors are found: **(1) corridor type A** represents the longer corridor separating the open-plan workplace from the enclosed offices and treatment rooms, **(2) corridor type B** represents a shorter corridor that goes from the entrance of each zone leading to the workplace, and **(3) corridors type C** are the group of internal corridors between workstations or rooms in each zone.

The colours of walls range from beige (type A) to brown (types B and C). For wayfinding a map is found located in corridor A with instructions in case of fire; also, some signs for exits are found, and the carpet patterns are different from the ones used in the workspaces, as shown in Figure 30, Figure 31, and Figure 32.

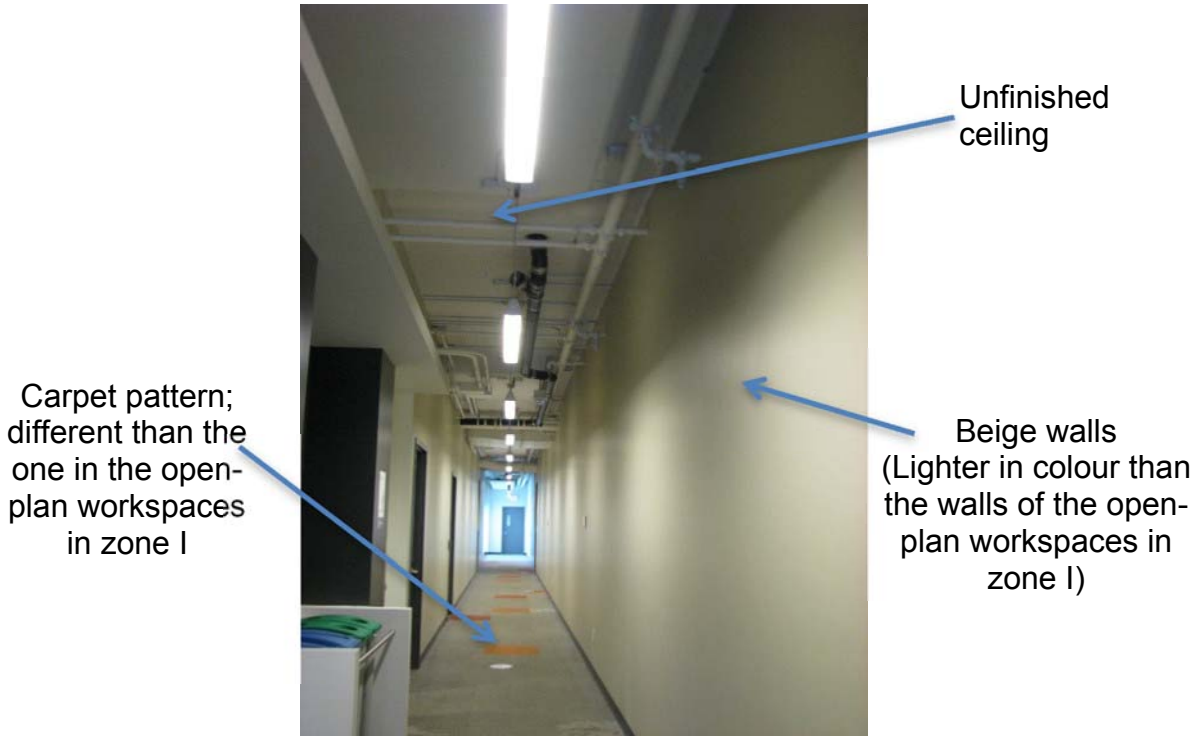


Figure 30. Corridor type A, separating enclosed offices from the open-plan workspaces in the CDC

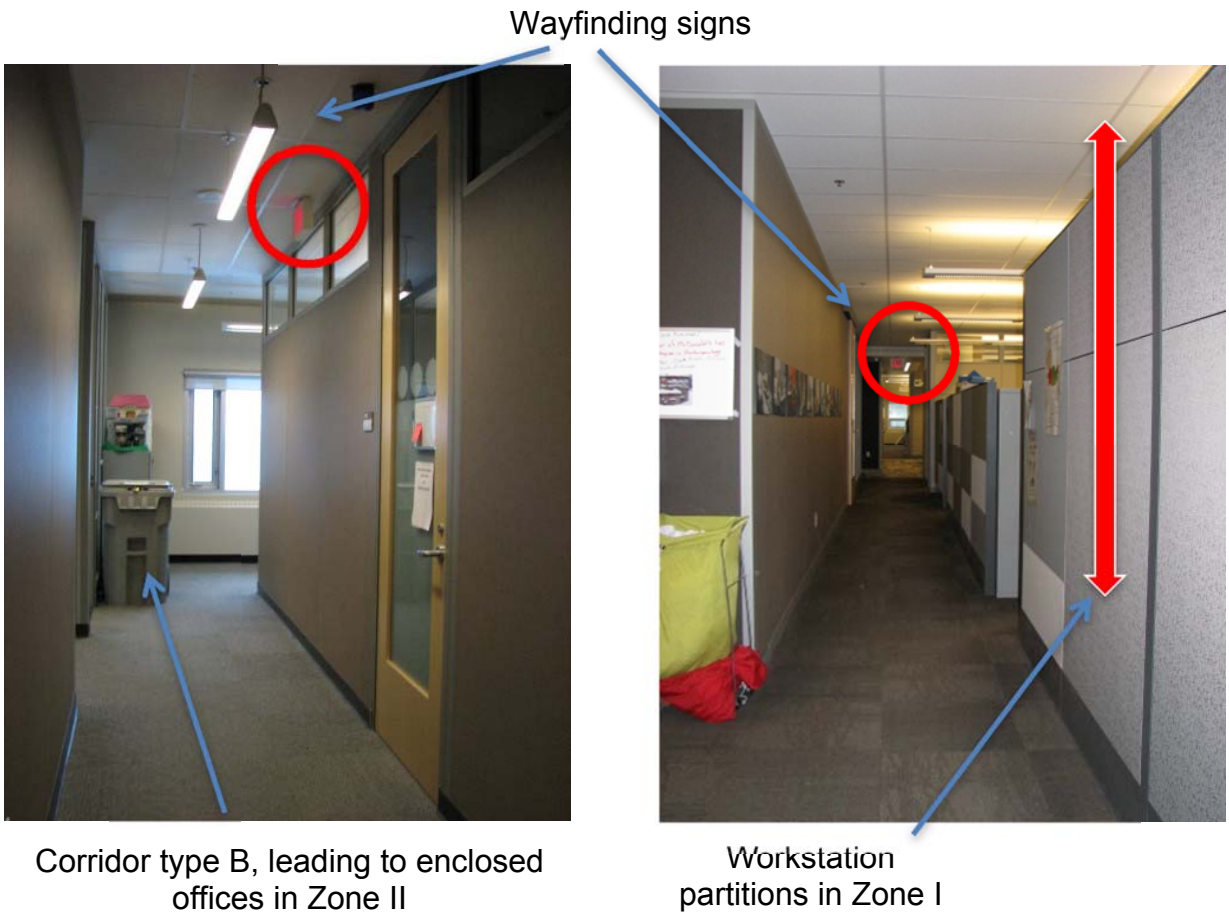


Figure 31. Type B corridors leading to zone I and II in the CDC

Figure 32. Type C corridors between workstations in zone I in the CDC

Spatial Organization:

Pods are workstations placed in groups of six or less, and they are organized on a modular pattern with corridors in between, as shown in Figure 33.

Figure 33. Modular pattern of workstations in the CDC

***Access to Equipment (printers and copy machines)*:**

Printers and copy centers are placed in corridors and entrances, as shown in Figure 34 and Figure 35 of the open-plan workplace. Their location is not midway in the floor plan, so they are closer to some workstations and not others. This may cause higher noise and crowding, but better accessibility for occupants of closer workstations.

Figure 34. CDC entrance of the open-plan workplace

Figure 35. CDC printers and copy centers in corridor

Personal Workspaces:

Workspaces in the CDC include personal workstations in the open-plan zone, enclosed offices, and other rooms for more clinical tasks.

Employees' workstations

Employees work in an open-plan layout in workstations with high partitions— 1.5m, 1.7m, and 2.1m (53", 67", and 83") tall—and are located side-by-side and grouped as pods. Personal workstations include a desk, chair, a shelf to store work-related documents, and a desktop computer. It is observed that the sizes of storage cabinets varied from one workstation to another; some have high ones and some have just the drawer pedestal ones. It is suggested that the location of the workstation in the layout affected the size available for furniture, the type of workstation (shared or individual), and the status of the employee (seniority). This variance in storage availability also made several workstations very crowded and unorganized with work-related or personal items. This questions whether the size of workstations is inadequate in fulfilling occupants' work needs (see

Figure 36 and Figure 37). It is also found that carpets are installed throughout the workspace. This is essential for absorbing noise (especially while walking); however, they need frequent cleaning to prevent problems in the IAQ.

Figure 36. Smaller storage cabinets in shared workstations in the CDC

Figure 37. Storage boxes on the floor in the CDC

Directors' workstations

It is found that team leaders, managers, and some senior employees work in either privileged spots, such as corners, beside windows, and have bigger-sized desks, or work in enclosed offices. It is suggested that status impacts workstation size and location.

Figure 38. A comparison between the size of a team leader's workstation to the left and a typical workstation of an employee to the right in the CDC

Other workspaces

Assessment rooms are furnished with bright colours to be kid-friendly. The rooms provide physical and functional support by having some kids' furniture, and the materials on the floors can be easily wiped for better hygiene; small sinks with soap are available for hand cleaning to maintain hygiene and cleanliness (see Figure 39 and Figure 40).

Figure 39. Treatment room with coloured furnishings in the CDC

Figure 40. Sink and soap for hygiene in assessment rooms in the CDC

Meeting Rooms: There are two types of meeting rooms: rooms for teleconferences or presentations, as shown in Figure 41, and rooms for private talks. However, the doors of the private rooms are not visually private, as the glass walls are not fully opaque, as shown in Figure 42. This compromises confidentiality, an issue that impacts Functional and Psychological Comforts.

Figure 41. Conference rooms with screens in the CDC

Figure 42. Semi-opaque glass used in meeting rooms in the CDC

Views:

Trees (most of them are evergreen) are seen from the windows, but there is no landscape or other scenes of nature close by. There is a car-loading zone adjacent to the building (see Figure 43). Being on a main street and near a car-loading zone may cause external noise.

Figure 43. Views in the CDC

Amenities:

There are three areas available for eating and social gathering: the kitchenette, the cafeteria, and the lounge.

Kitchenette: It can accommodate eight persons. It has not been occupied by anyone throughout all the researcher's visits at different times (see Figure 44). It is possible that the number of seats available are few compared to the number of occupants in the building (the second floor has 85 employees), and this may have discouraged them from using the kitchenette.

Figure 44. The kitchenette in the CDC

Cafeteria: It has 10 tables and is located in the ground floor of the building; however, a bird's eye view is possible from the lounge in the second floor. It has looked dirty and litter has been thrown on top of it from above (some tissues and other garbage). (Figure 45 and Figure 46). It is observed that there are no garbage bins that can be easily found by the building visitors.

Lounge: It is found empty, with no facilities at all and few pieces of furniture that suit the size of kids. It also had a broken window, which compromises safety and indicates a lack of frequent maintenance (see Figure 47 and Figure 48).

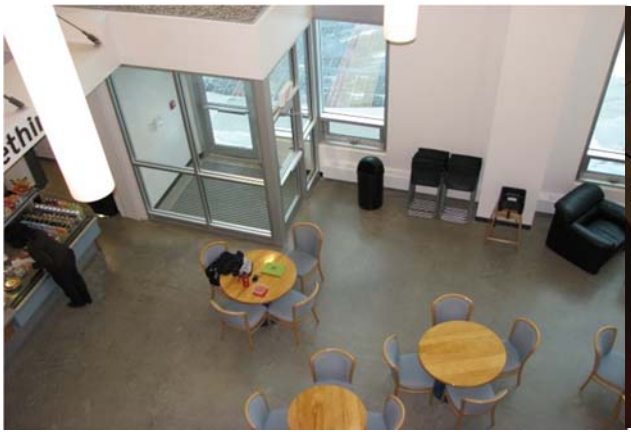


Figure 45. The ground floor cafeteria in the CDC

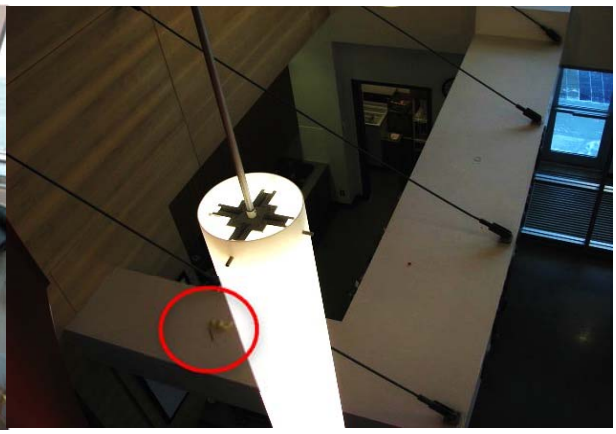


Figure 46. Garbage thrown on the top of the CDC cafeteria

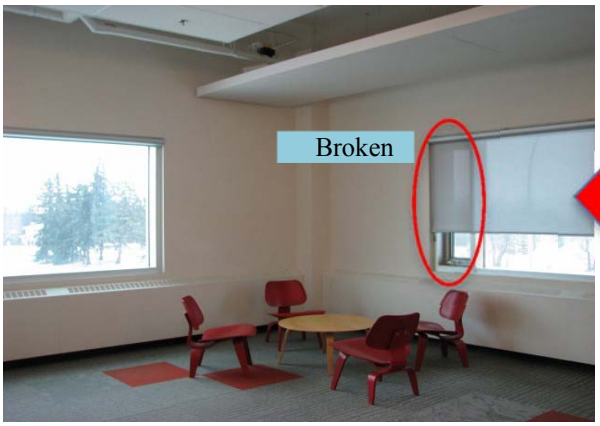


Figure 47. The lounge furniture in the CDC

Figure 48. CDC lounge area

Washrooms:

There are public washrooms in the corridor separating the open-plan workplace from the enclosed offices. There is one washroom within the open-plan workplace area. Cleaning issues are noticed in both types of washrooms (see Figure 49). Washrooms in the corridor outside the working area are very dirty, with some broken fixtures too, as shown in Figure 50. This suggests that there is low maintenance and cleaning quality is poor.

Figure 49. Washroom in work zone I in the CDC

Figure 50. Public washrooms in the circulation corridor in the CDC

4.1.1.3 Behavioral Environment

This includes only the behaviors performed by the occupants to cope or use the environment. Such behaviors in the CDC included adaptations to Ambient Conditions and the Designed Environment.

Adaptation to Ambient Conditions

Some coping and adaptation behaviors are noticed, such as the use of some throw blankets by occupants to provide more warmth, headphones to cope with noise levels, and books covering the air vents (to prevent cold air from blowing). These observations suggest that occupants are uncomfortable with the indoor thermal and acoustical conditions.

Adaptation to the Designed Environment

Most of the workstations are found very crowded with papers, boxes, folders, and personal items, such as coats and jackets (see Figure 51). Though there are available wardrobes for hangings coats, the occupants do not use them for personal items. Some workstations also have extra chairs for visitors; however, the chairs are placed outside the workstation (see Figure 52). Lots of personalization items are observed in most of the workstations and on partitions, such as artificial plants, pictures, and toys (see Figure 53). These behaviors are in response to uncomfortable temperature, insufficient storage, inadequate workstation size, inaccessibility to the coat-hanging wardrobe, and the need for self-expression and territoriality.

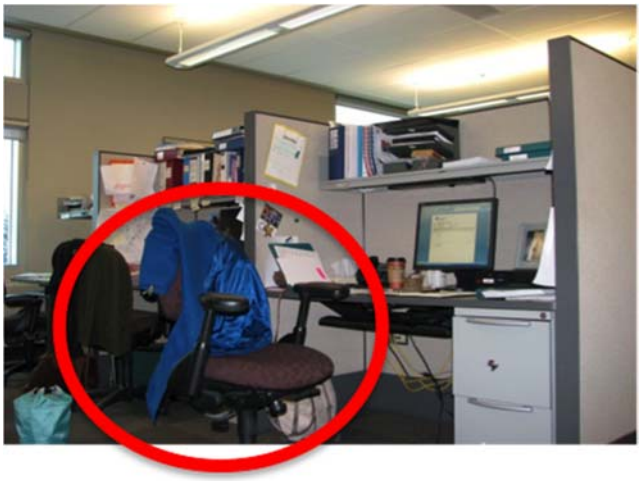


Figure 51. Coats hanged on chairs in the CDC

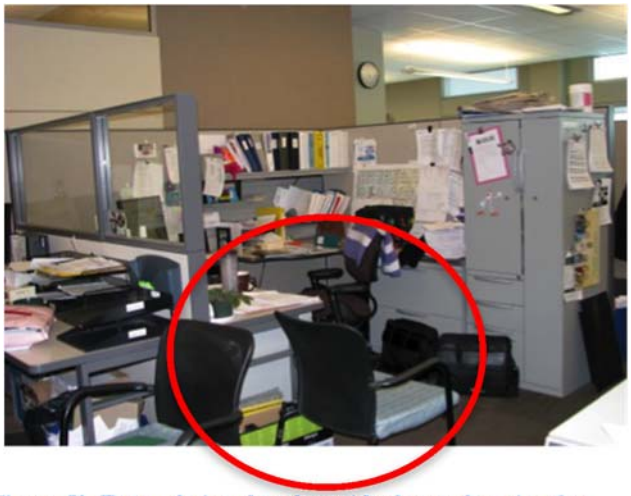


Figure 52. Extra chairs placed outside the workstation for visitors in the CDC

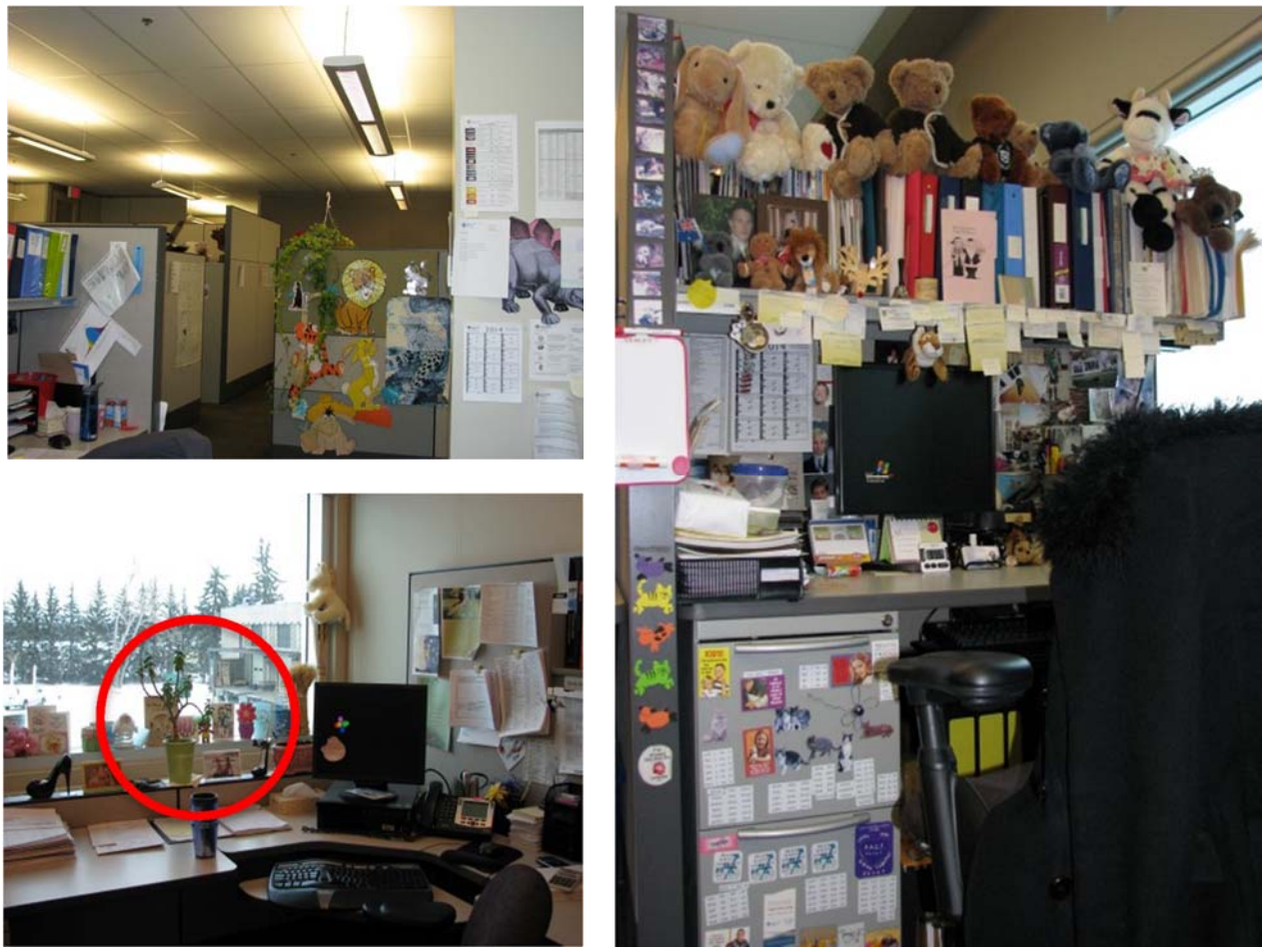


Figure 53. Personalization using toys, pictures, plants, and pictures as shown in different workstations in the CDC

Pro-Sustainable Behaviors:

Observations related to occupants' sustainable experience in the CDC include the use of low-volume flush in the toilets, waterless no- flush urinals in men's washrooms, and recycling. However, there are no places designed for recycling—they collect it from the corridor beside the entrance of the workplace (see Figure 54). This makes the corridor look narrower.

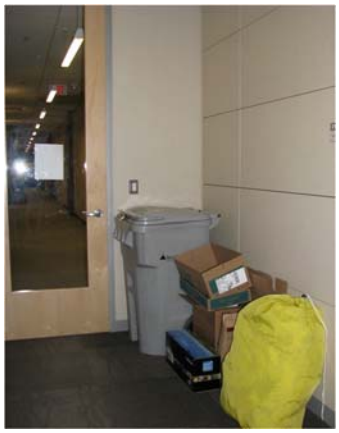


Figure 54 Recycling in the corridor of the CDC.

4.1.2 The Tetranex Solutions Inc. - Glenmore Workplace (*Conventional Office Building*)

4.1.2.1 Ambient Conditions

Observations for the Ambient Conditions (including Lighting, IAQ, Acoustical Quality and Noise Control, and Thermal Comfort) are documented for the GLW as follows.

Lighting/Illumination: Both natural daylighting and artificial ambient lighting are found.

Daylighting: It penetrates through peripheral windows (see Figure 55). The windows also have manual blinds that occupants can control. However, workstations beside windows are found to have reflections, while shadows and glare are evident on desk surfaces and computer screens. This may cause some physical (visual) discomfort and hinder the ability to get work done (Functional Comfort) (see Figure 56). Though the design of the open-plan without partitions (for the workstations) is meant to allow the daylighting to illuminate other workstations deeper in the plan, these workstations had less amount of daylighting due to the overhead cabinets (workstations may hide some daylighting from each other) and the furtherer distance from windows.

Figure 55. Peripheral windows in the GLW

Figure 56. Shades and reflections from daylighting and blinds in the GLW

Artificial lighting: It is provided by fluorescent lamps through the workspaces, and recessed lights are also provided at some areas (see Figure 57). The recessed lighting improves the aesthetical look and adds to the overall illumination of the space. The corridors do not have recessed lights, and the amount of illumination in them are found less than in the work environments.

Figure 57. Fluorescent lighting and recessed lights in the GLW

Indoor Air Quality

The windows are inoperable; hence, ventilation is provided mechanically (HVAC). No odors are smelled. Yet, the IAQ has required further information from the occupants (in interviews and questionnaires) to assess how this quality impact on their health or Physical Comfort.

Sound/Noise Control

No systems of noise control are used. However, the office has seemed very quiet most of the time, except when the HVAC fans have started working to regulate the temperature. Possible reasons for this include the fewer number of employees (25 employees, as compared to the CDC or the WCB), the fact that the building being located on a secondary road, and that there has been several empty workstations.

Thermal Comfort

The ambient temperature varied from one place to another; for example, it seemed warmer in enclosed offices and near windows. This is suggested to be due to having an older HVAC system and the lack of occupants' control over it.

4.1.2.2 Designed Environment

Layout: Tetranex Solutions Inc. is located in the first floor of the building and has two suites (see Figure 58 and Figure 59). It can be reached either by elevator or stairs. The entrance of the company has a reception with a few seats in the waiting area and no windows. Next are the kitchenette and medium-sized (6–8 persons) meeting room. Several private offices (of managers or team leaders) are located on both sides of the corridor leading to the open-plan workplace, where most employees work.

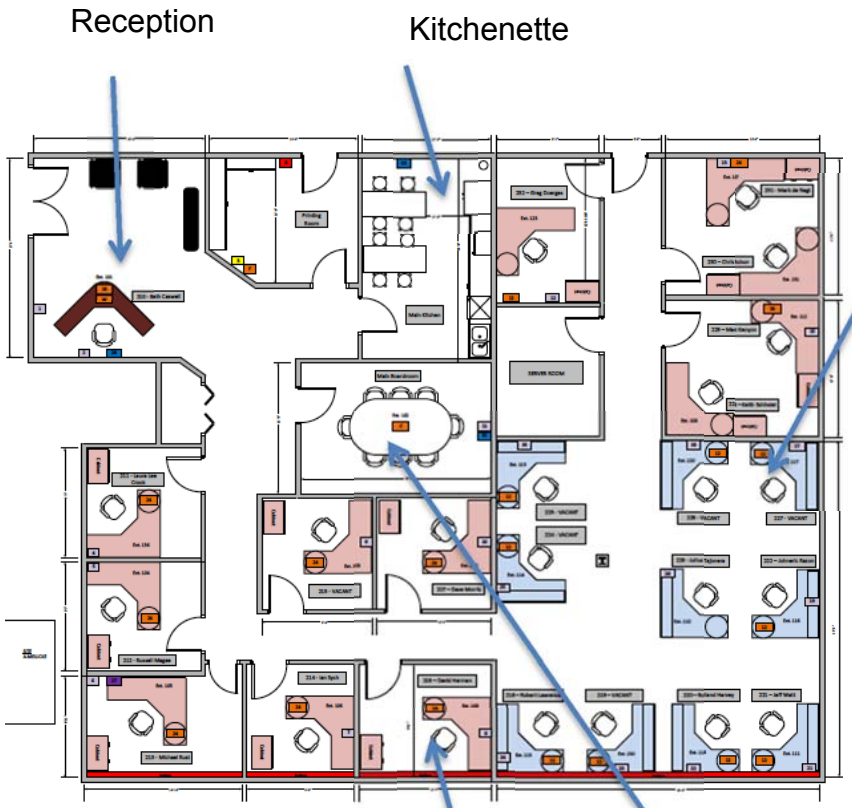


Figure 58. Floor plan of the first suite in the GLW (to the left)

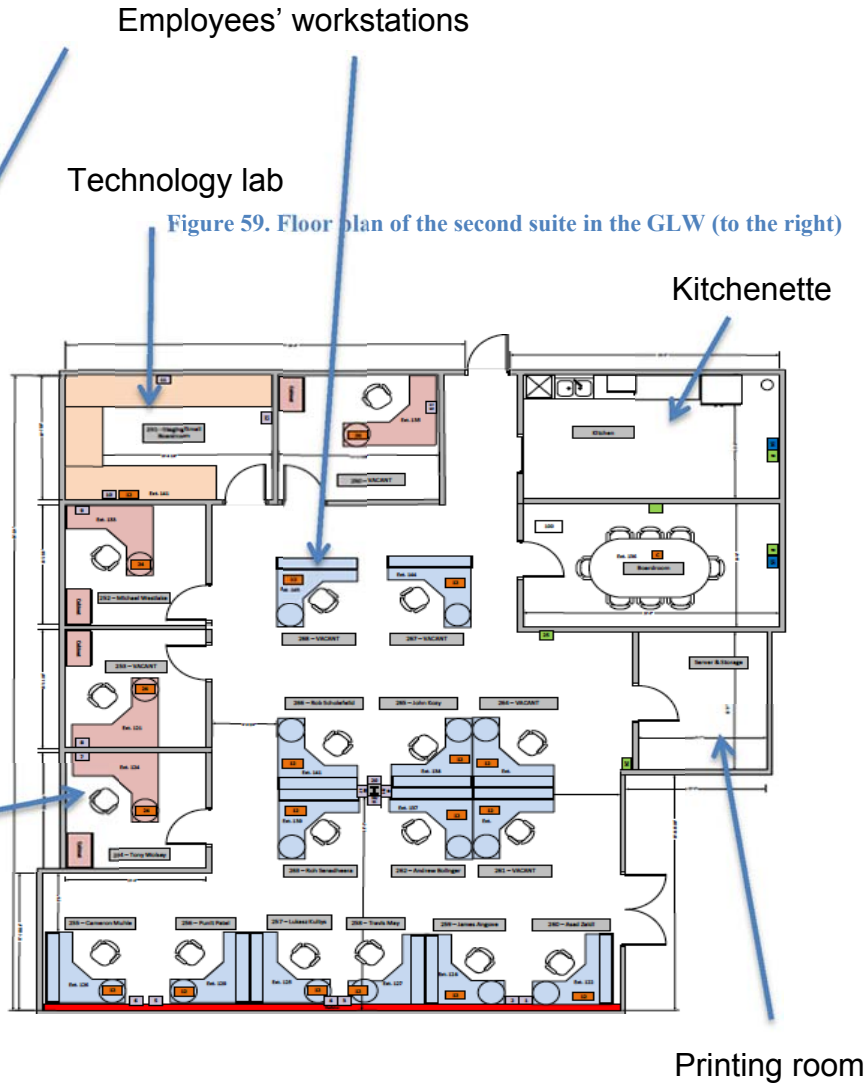


Figure 59. Floor plan of the second suite in the GLW (to the right)

Main Entrance and Reception area:

A reception with a front desk precedes the main work area. This may give a sense of security to visitors and privacy to the occupants (because the receptionist controls who can enter). A kitchenette and a meeting room are next to the reception area. The big piece of art in the reception area has a gear-like image, the colours of walls and furniture match the logo of the company, with the cool temperature of colours give a relaxing impression to the environment. The suspended and recessed lighting are used for aesthetic considerations (see Figure 60 and Figure 61).

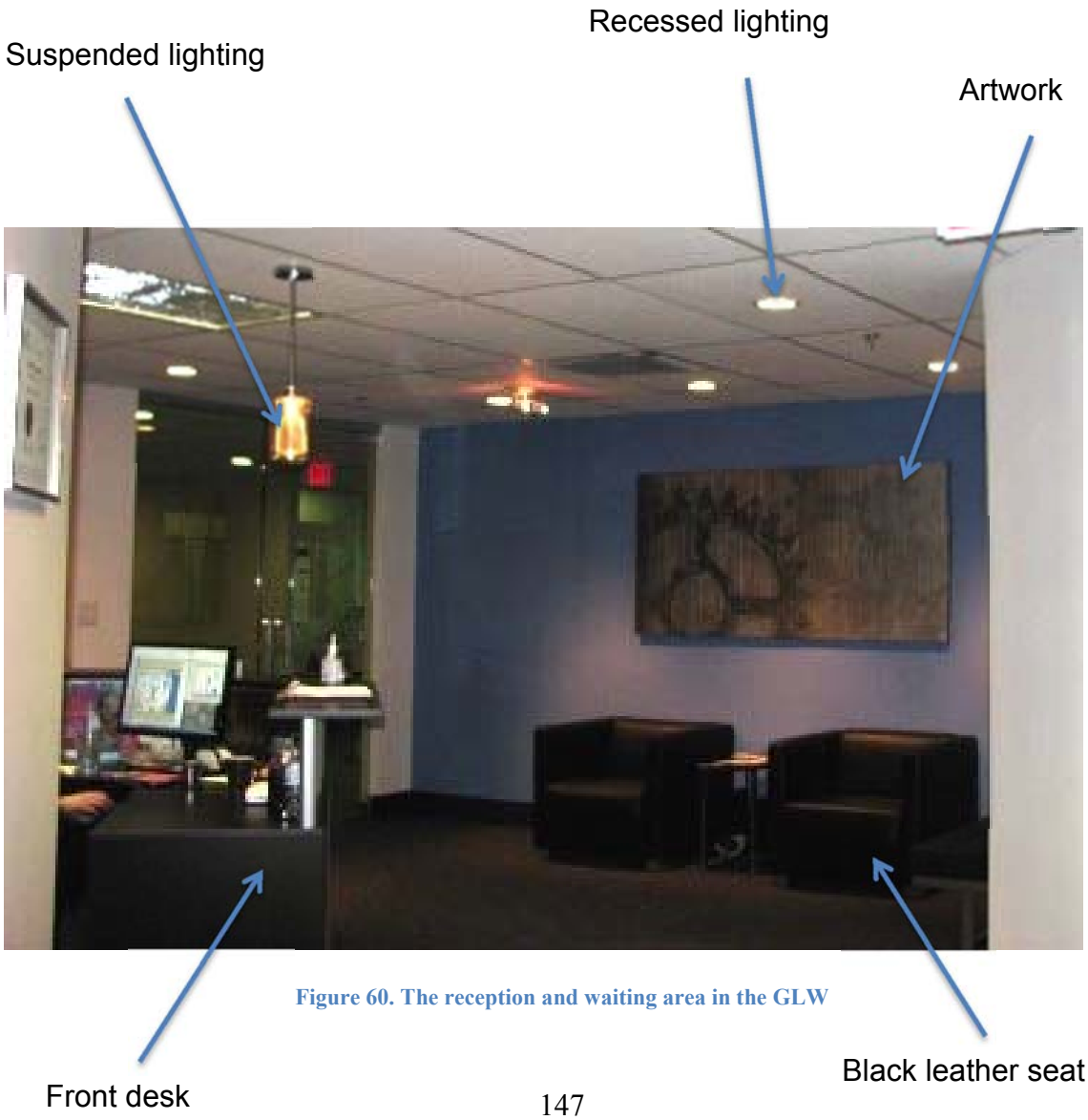


Figure 60. The reception and waiting area in the GLW

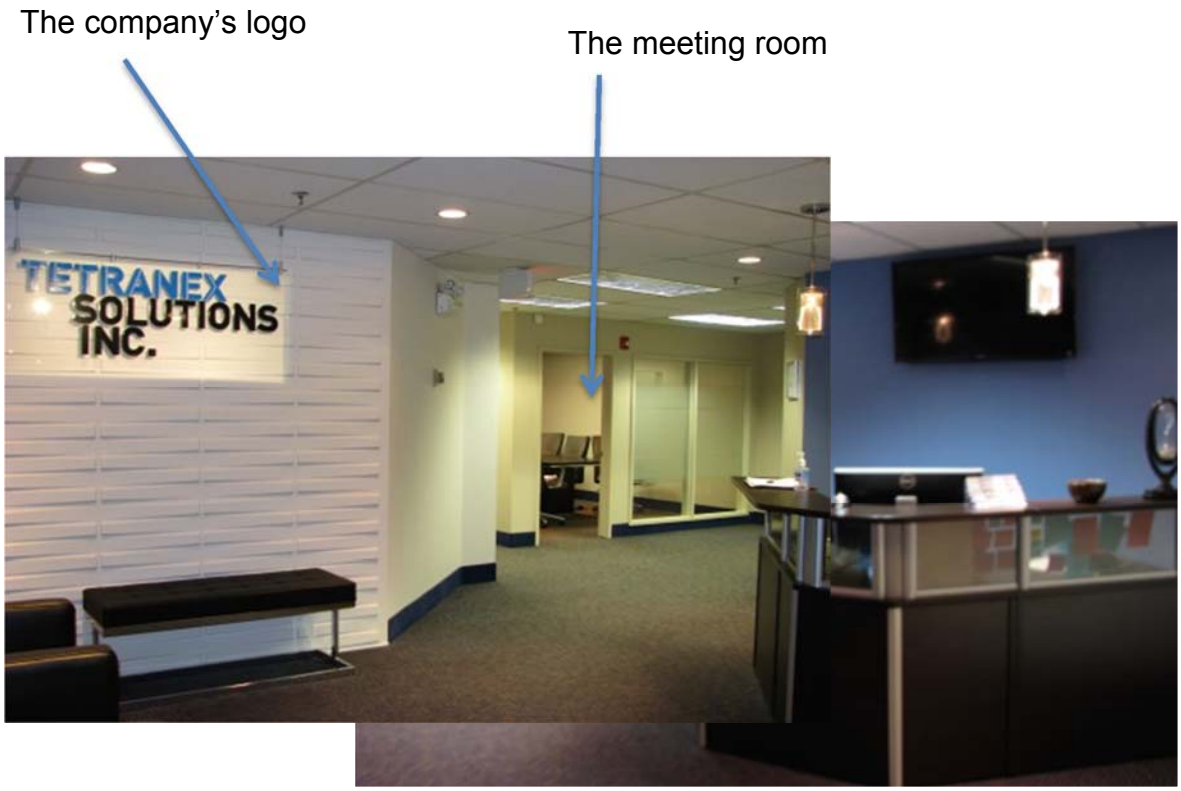


Figure 61. Reception and waiting area in the GLW

Circulation:

The corridor leading to the open-plan workplace where employees work has a lower level of illumination and looked dimmer than the reception area. On each side of the corridor there are enclosed offices for managers and leaders. Aesthetical interest is shown in the office corridor by adding a few picture frames that hold abstract paintings (Figure 62).

Figure 62. The corridor leading to the open-plan workplace in the GLW

Spatial Organization:

The workstations in the open-plan are organized in a modular fashion, and the spaces between workstations are adequate for comfortable circulation. Several workstations have been found empty. It is suggested that the wider (than the CDC) spaces between workstations, combined with the light colours of the walls and the low occupation density, give a spacious feeling to the workplace. Carpets are used on the floors of the workspaces. This could be useful for absorbing noises (especially while walking); however, they need frequent cleaning to prevent problems with the IAQ. Exit signs facilitate wayfinding directions. Furthermore, the blue colour, which is used on some walls to give some accent, is relaxing and aesthetically pleasing.

Observations are annotated on the pictures as shown in Figure 63.

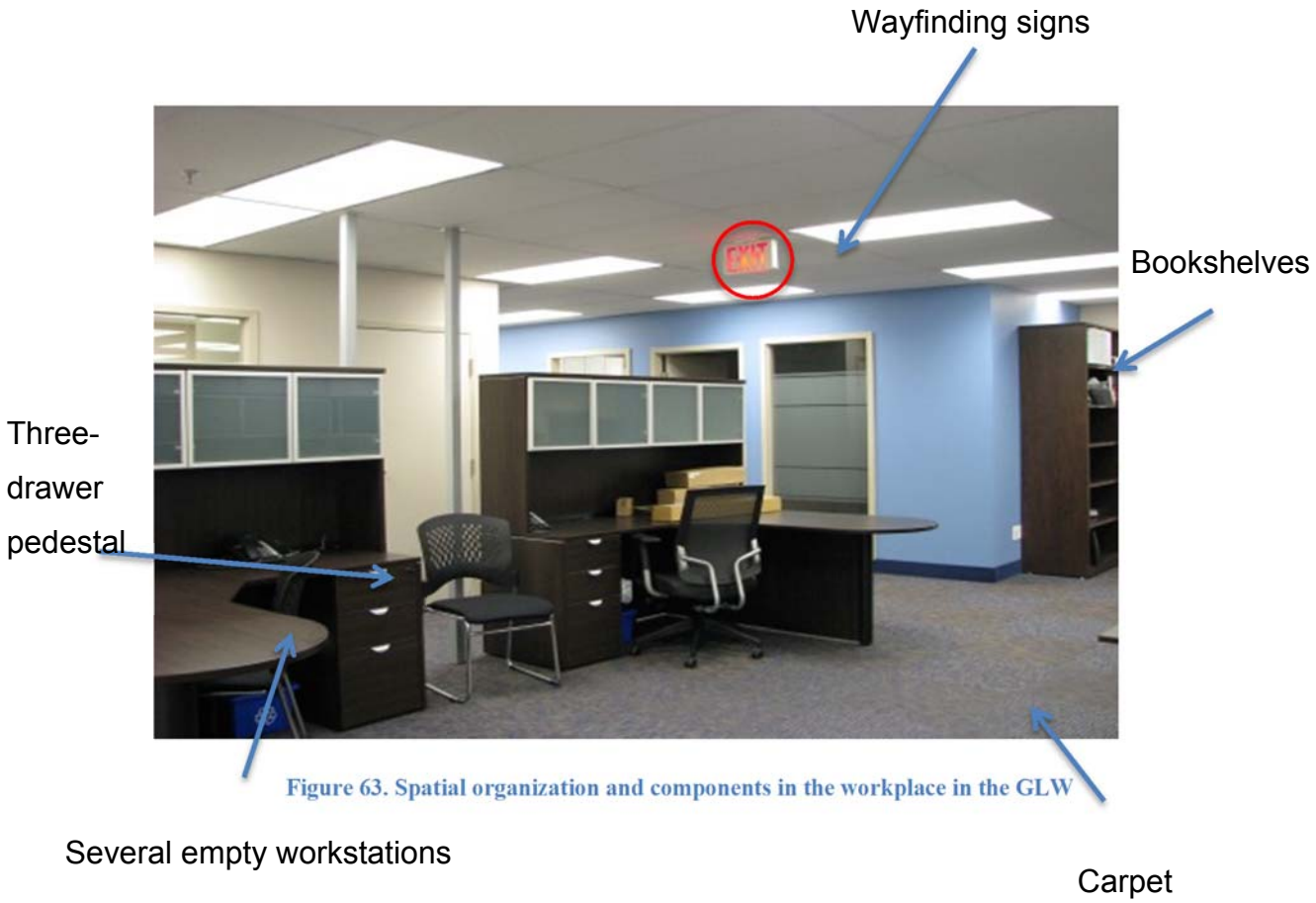


Figure 63. Spatial organization and components in the workplace in the GLW

Access to Equipment (printers and copy machines):

Printers and copy centers in zone I and zone II of the Gelnmore workplace are located differenty, as shown in Figure 64 and Figure 65. In the open-plan working area (zone I), the printers are located within the open space, which may cause some noise and crowding around them, thus disturbing employees whose workstations are nearby. In zone II, they are located in a separate room. This provides better noise control and less health risk from the (VOCs, SVOCs, siloxane, ozone, UFP, etc.)[7] emissions that impact the IAQ.

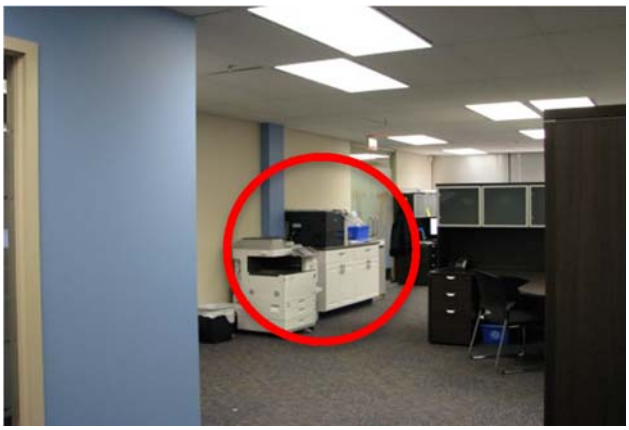


Figure 64. Printers in zone I within the open area workplace in the GLW

Figure 65. Printers in zone II in a separate room in the GLW

Personal Workspaces:

Workspaces in the GLW consist of workstations in open-plan and enclosed offices. All engineering employees work in the open-plan area, while managers and team leaders are in enclosed offices.

Employees' workstations

Most employees work in an open-plan layout in workstations with a desk, overhead cabinet, and chair; there are no partitions other than the back of the overhead cabinets that are connected to the desk surface. The back of the chairs is mesh, so further investigations (interviews) are required to know occupants' QoL experience with choice of the material used.

[7] VOC: volatile organic compounds; SVOCs: semi-volatile organic compounds; UFP: ultra fine particles.

The same furniture is used everywhere, even in enclosed offices, where the only difference is that the desks in those offices have no overhead cabinets. The equality in terms of furniture reflects the culture in the workplace. Each workstation is composed of an L-shaped desk, a chair with mesh back, computer with one or two screens, phone, recycle bin, overhead cabinets (for workstations in the open-plan area only), and hooks for hanging coats (only when the overhead cabinets are available). Every group of workstations has bookshelves close to them. This gives extra storage space when needed and avoids clutter. Some long tables are available for use when drawing and drafting work is needed. Some white boards are also available for writing notes, but not for each workstation in the open-plan area, where they are used for group communication; on the other hand, each enclosed office has one. The use of white boards may decrease the use of papers and hence promote sustainable behavior. It is also noticed that several of the workstations are empty.

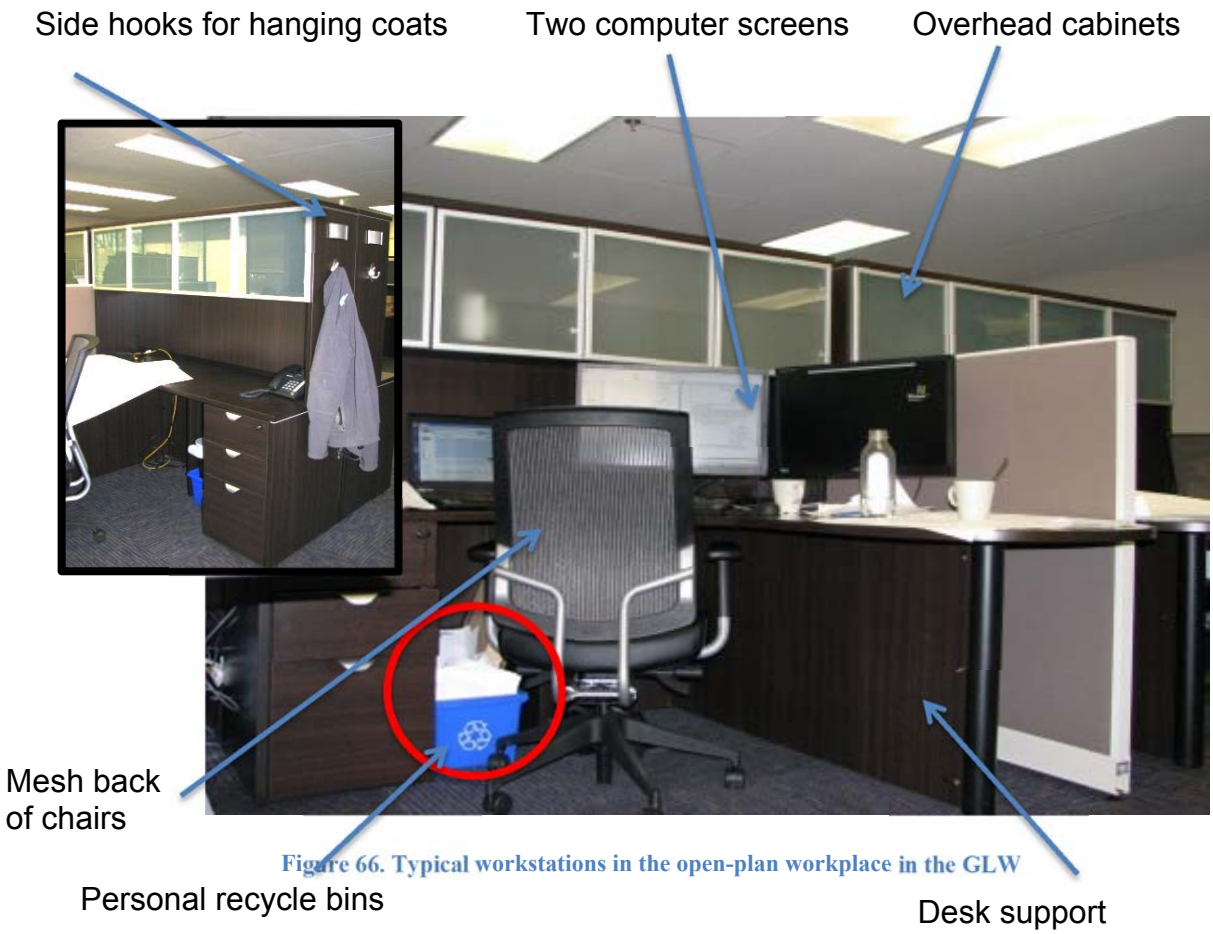


Figure 66. Typical workstations in the open-plan workplace in the GLW

Directors' workstations

Enclosed offices seem very crowded with many items, such as papers and bulletins. This crowding of documents suggests that there is a lack of overhead cabinets for storage. Coats are slung over chairs (no hooks) and walls are used for bulletins. The small bulletin board size seems to be inadequate. Doors are made of translucent glass that allow some privacy (see Figure 67).

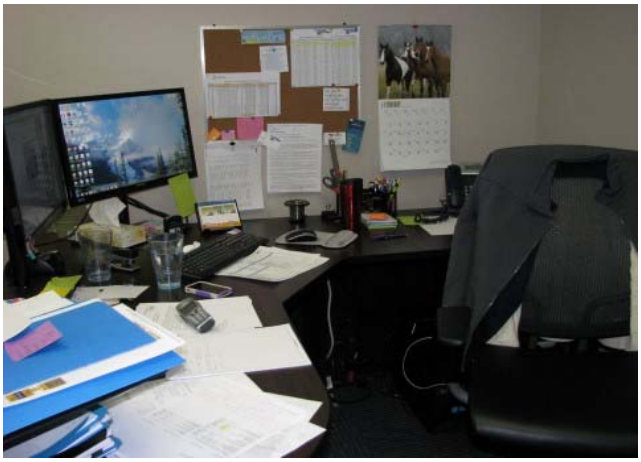


Figure 67. Different examples of clutter in enclosed offices in the GLW

Meeting Rooms:

There is only one meeting room, with a meeting table that accommodates 6–8 persons. The atmosphere and illumination (fluorescent and recessed lights) in the meeting room appear to be adequate. The blue colour of the accent wall produces a calming effect and is a comfortable, contrasting background to the screen (see Figure 68).

Figure 68. The meeting room in the GLW

Views:

The view is of a parking lot, streets, cars, and few evergreen trees and grass (see Figure 69). The trees provide some connectivity with nature, but the traffic may cause some external noises. However, because the windows are inoperable, the external noises have not been heard inside the workplace.

Figure 69. Views from the GLW

Amenities:

There is one kitchenette (no other amenities) in each zone, equipped with a microwave, fridge, dishwashing machine, and coffee machine. It also has a TV screen (see Figure 70). This makes it work as a social gathering place too.

Figure 70. Kitchenette in the GLW

Washrooms:

There are no washrooms found available in the GLW of Tetranex Solutions Inc at the time of the study. Employees have used to go to the public washrooms available in the building and shared by different tenants. This may cause work disturbance and inconvenience to the occupants; also, using public washrooms shared with other tenants may keep the washrooms busy for longer times.

4.1.2.3 **Behavioral Environment**

Adaptation to Ambient Conditions

It is found that enclosed offices usually use task lighting as compared to the open workspace (though task lighting is allowed). This suggests that the peripheral windows provide better illumination to workstations in the open-plan than to those in the enclosed offices. It is also observed that some employees (located at corridors or near the entrance of the open-plan area) clearly get distracted (startled) when someone passes by their workstation. This may suggest that the office is usually too quiet, and that they are uncomfortable with their workstation location.

Adaptation to Designed Environment

Some coping and adaptation behaviors are found, such as personalization, means used to obtain privacy, and adding furniture to increase the working space. These begaviors suggest occupants; seek for Psychological and Functional Comforts. Only a few occupants, who are found in enclosed offices or in workstations beside windows, have a few personalized items; this suggests that occupants with higher degrees of privacy show a higher tendency to engage in personalization behaviors. The addition of a board between two workstations suggests occupants need more privacy. The addition of extra tables to increase the working area suggests that the occupants in some workstations require additional size to perform their tasks, but also shows the ability to customize the space for personal needs. This may vary depending on their job description and requirements. See Figure 71 and Figure 72 for different observations of occupants' behaviors in workstations.

Figure 71. Functional (adequate space) and psychological (privacy) coping and adaptation behaviors in the GLW

Figure 72. Psychological (personalization) coping and adaptation behaviors in the GLW

Pro-Sustainable Behaviors:

The office promotes a healthy lifestyle by providing free healthy snacks (for everyone) available in the kitchenette. Another pro-environmental measure is evident by the presence of small recycle bins under each workstation, as previously shown in Figure 66.

4.1.3 The Water Centre (*LEED-Gold Green Office Building)*

4.1.3.1 Ambient Conditions

Observations on Lighting, IAQ, Acoustical Quality and Noise Control, and Thermal Comfort in the WCB are documented as follows.

Lighting/Illumination

Natural daylight is combined with different types of fluorescent and LED lamps.

Daylighting: Over 95% of the office building interior is lit by daylight. The building is designed long and narrow, with an east-to-west orientation to ensure it is taking maximum advantage of sunlight patterns year-round.

Figure 73. Northern windows int the WCB

Most of the office areas are located on the north side of the building, as shown in Figure 73, and benefit from the diffused northern light. Window sizes, building's narrow long footprint, and glazing allow maximum daylight deep into the building. White ceilings and light-coloured work surfaces are used to enhance the overall light levels.

Natural light also penetrates from the tri-coloured glass curtain wall in the south side, shown in Figure 74. Meeting rooms have glass to allow daylight to penetrate through them into the workstations beyond.

Figure 74. Tri-colour southern curtain wall in the WCB

Artificial lighting: There is a flexible system with motion and daylighting sensors, task lighting, and a combination of T8 fluorescents, T5 high-output fluorescents, fluorescent compacts and light-emitting diode (LED) lamps are used to achieve the targeted illumination level, (Figure 75).

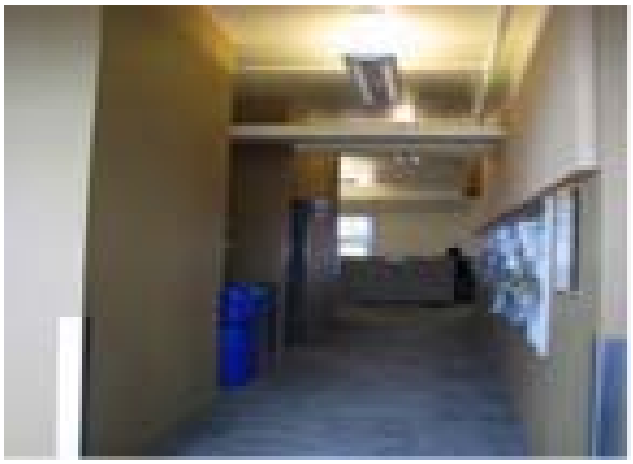


Figure 75. WCB low-voltage flourescent lighting

There is a low-voltage lighting control system that has motion and daylight sensors, a photo electric cell, and override switches for zone-switching of lighting during normal office hours, after-hours and daylight sensing in perimeter office areas and the atrium. At night, illumination is generated using an indirect lighting system that generates the adequate amount of lighting for most tasks. Furniture task lighting is available for use when needed, which gives personal control to the occupants.

Indoor Air Quality

Natural ventilation is provided through either operable windows or the building ventilation system. Most of the north side windows can be manually opened. Air diffusers, as shown in Figure 76, are placed on the floors, where adjustable fresh warm air comes from them. Radiant cooling slabs force cool air down while warm air enters from the floor and exits from the ceiling, allowing the displacement of air for a better, fresher air quality. They are also adjustable to allow personal control of flow and direction.

Figure 76. Warm air diffusers and operable windows in the WCB

Sound/Noise Control

Acoustical panels in the ceiling, as shown in Figure 77, are used to control noise, and higher walls/partitions are used for workstations that require higher sound privacy, such as the ones located at the circulation spine or at the entrance of the department.

Figure 77. Acoustical panels in the WCB

Thermal Comfort (heating & cooling systems)

The WCB is designed in a thin shape that has southern exposure to help the building get warm from the sun in the winter. The roof overhang is used to reduce heat gain in the summer. A tri-colour glass curtain wall is used to balance natural daylighting and heat gain from the south-facing façade. The building has mechanically-controlled windows on the north and south sides that can be opened in case of excessive heat. Northern operable windows are provided for employees for personal control.

Employee workstations are located along the north side of the building to avoid direct sunlight and excessive heat. Each workstation has a fully operable floor diffuser with a flow of warm air that can be personally customized. Radiant cooling is used from the ceiling slab in combination with the floor ventilation (warm air flow).

4.1.3.2 Designed Environment

Layout: The WCB has open-office plans on four floors, which are connected by a grand, exposed staircase in the atrium on the south-facing façade. The open design and vertical connectivity allows natural light to penetrate from the curtain wall's façade and enter into the workspaces areas (see the floor plans in Figure 78 and Figure 79). The workplace area is

provided with collaborative workspaces, customizable workstations, and adjustable in-floor air diffusers. Solid walls are used for pin-ups and acoustical treatment.

Meeting rooms, boardrooms, and quiet rooms are located on the south corridor, which opens on the atrium and floor-to-ceiling curtain wall of the south façade. Their north and south walls have glass to enable the penetration of light coming from the façade through the workstations beyond. The largest meeting rooms and boardrooms are provided with smart boards and teleconferencing capabilities.

Photocopying machines are put in separate rooms from the open workspace areas, except in the directors' workstations, and each floor contains washrooms and coffee rooms to enrich occupants' experience with accessible amenities.

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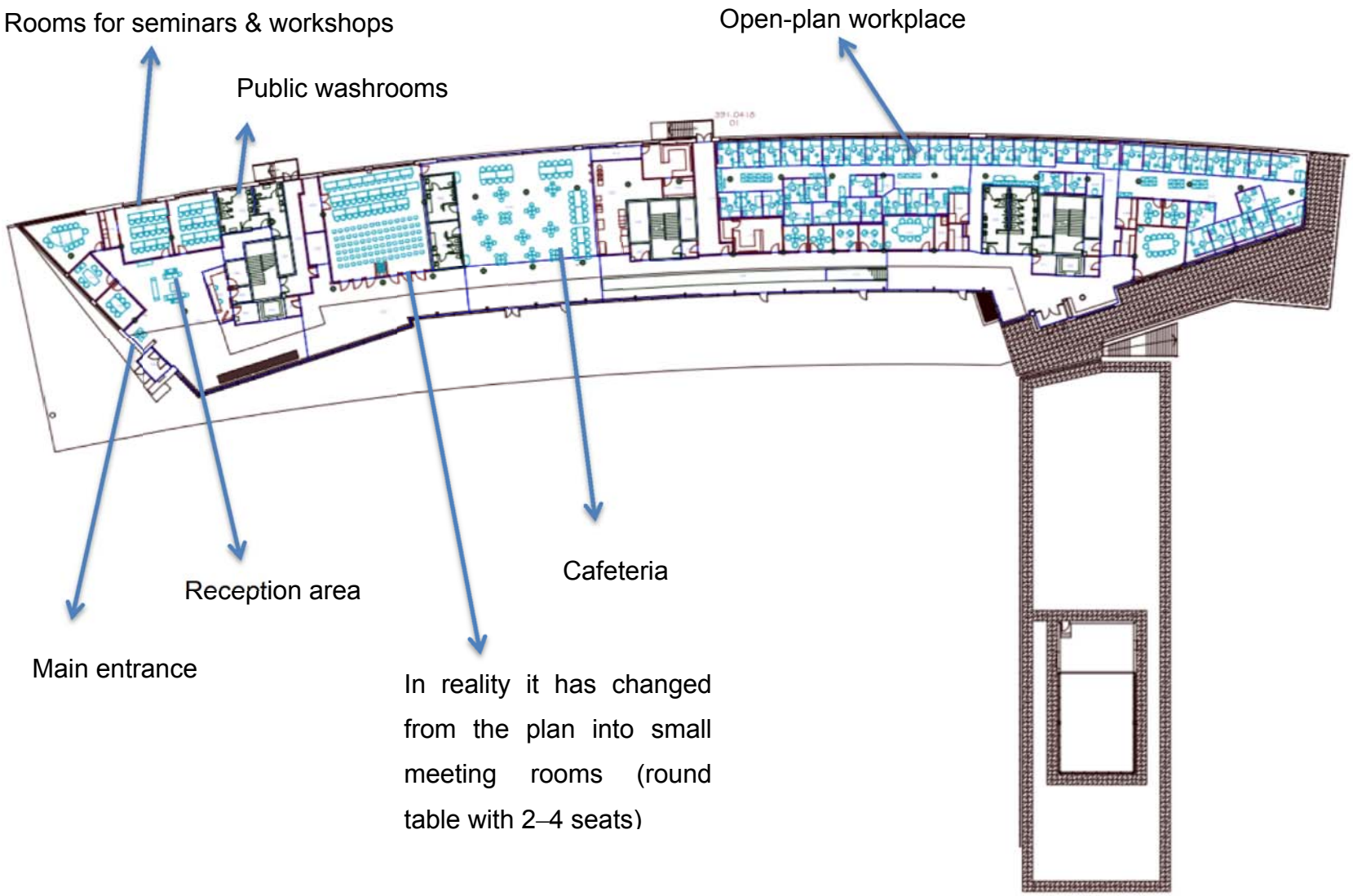
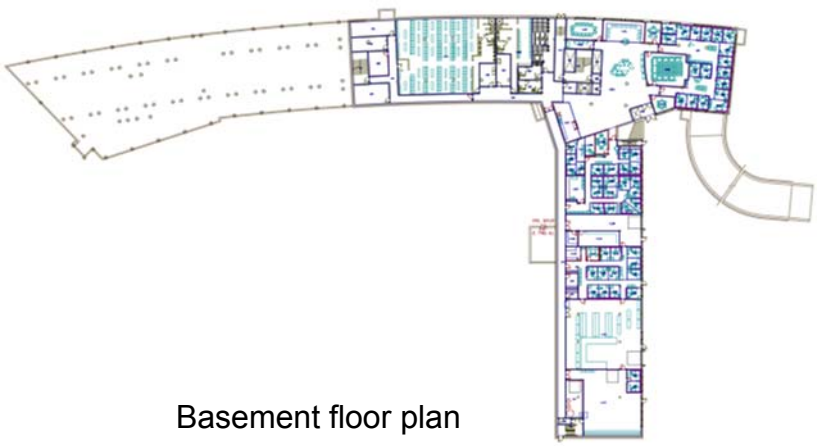
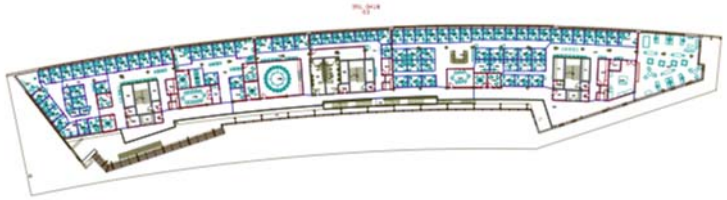


Figure 78. Floor plan of the WCB



Basement floor plan



Third floor plan

Second floor plan

Fourth floor plan

Figure 79. The floor plans of the WCB.

Main Entrance and Reception area:

The attendant at the reception area monitors who enters the building, and all visitors must sign their names as well as person visited and hour of visit. A glass door also separates the public zone from the workplace. This may increase the occupants' sense of safety and security. The public zone includes the reception and waiting area, public washrooms, and presentation rooms for seminars and educational purposes. The workplace zone includes a large cafeteria in the main floor, then open-plan workplaces and meeting rooms on four floors. Other facilities include a gym hall, lounge, small kitchenettes, and washrooms.

Figure 80. Reception area and corridor leading to a cafeteria, meeting rooms, and workspaces to the right of the picture in the WCB

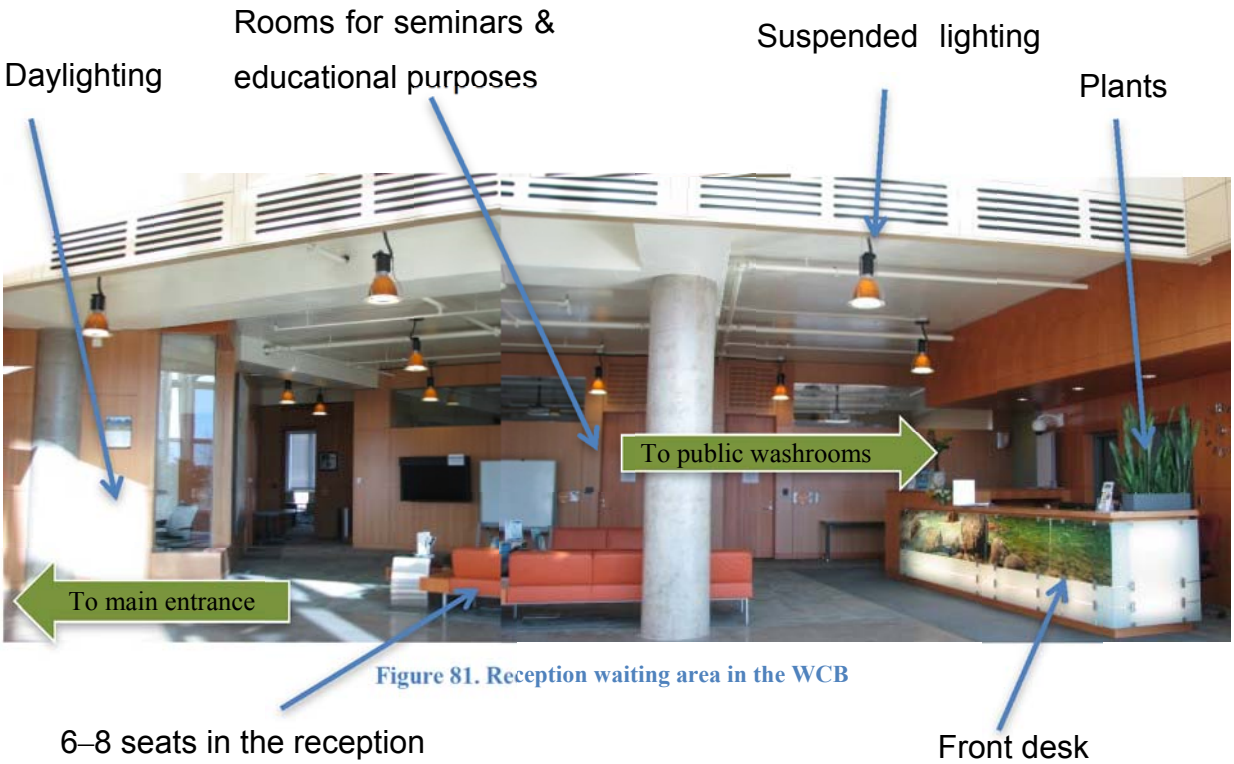


Figure 81. Reception waiting area in the WCB

Circulation:

To the right side of the reception area (Figure 80 and Figure 81) there is a long corridor leading to the workplaces zone (Figure 82). It has a cafeteria and small meeting rooms for group meetings/discussions or for individuals to work in privacy (Figure 83 and Figure 84). It also has the *statement* staircase that connects all the four floors together. Due to the curtain wall façade and penetration of daylight, the corridor is very bright and sunny, giving lots of positive energy and aesthetic charm to the building. To help in wayfinding, different zones have different colours and maps are added, as shown in Figure 85.

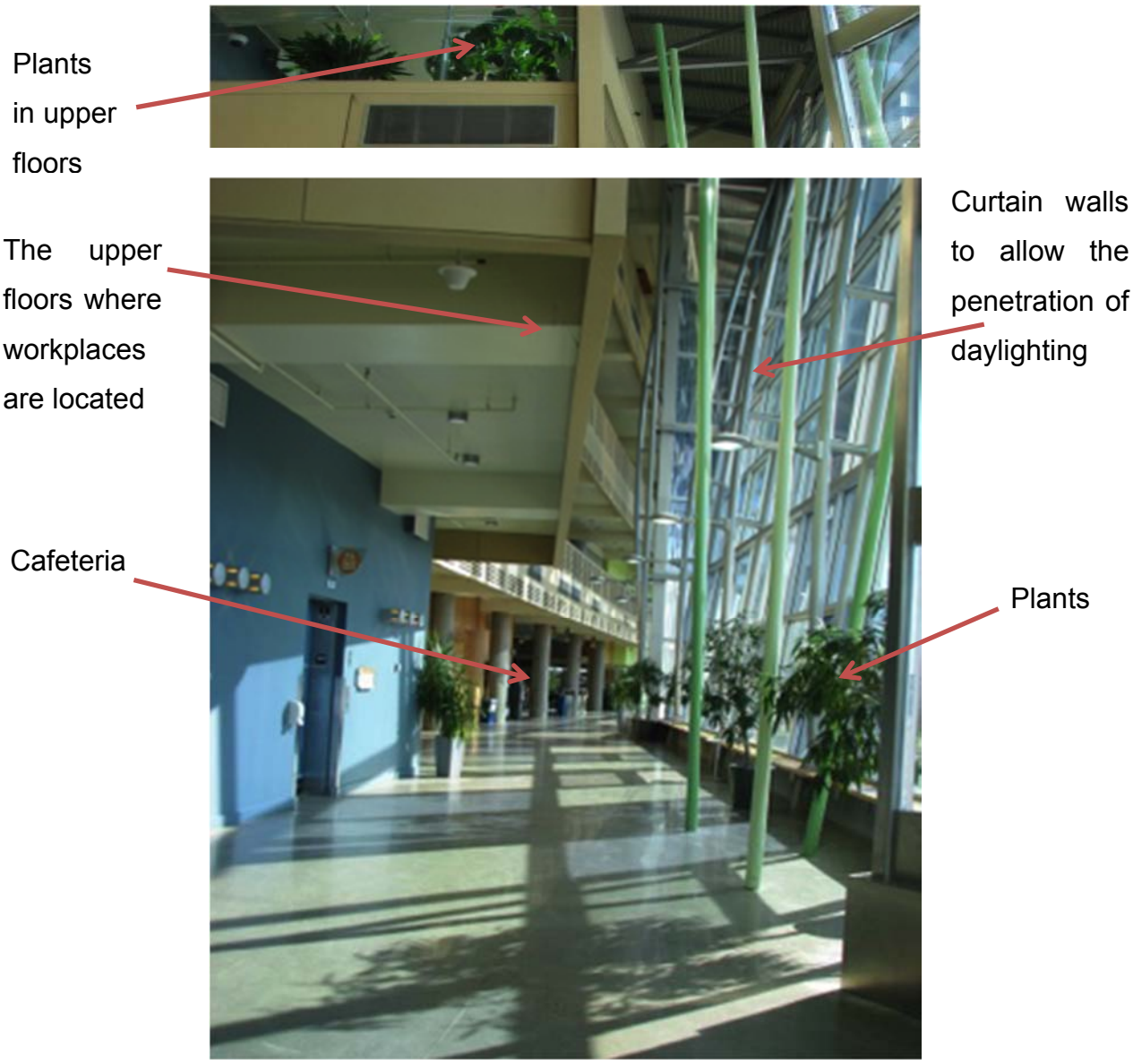


Figure 82. The main circulation corridor leading to workplaces in the WCB.

Figure 83. Cafeteria located in the main floor in WCB

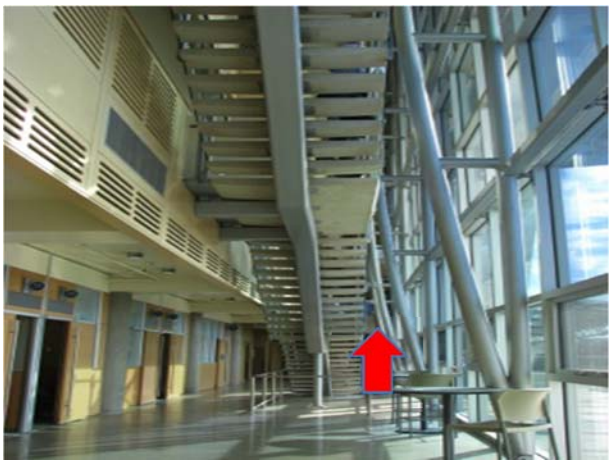


Figure 84. The staircase with meeting rooms to the left in WCB

Figure 85. Wayfinding signs in corridors in WCB

The second type of circulation are the south-facing corridors repeated in the four floors; all levels include have meeting rooms, and the workplace is located behind the south-facing corridor, as shown in Figure 86.

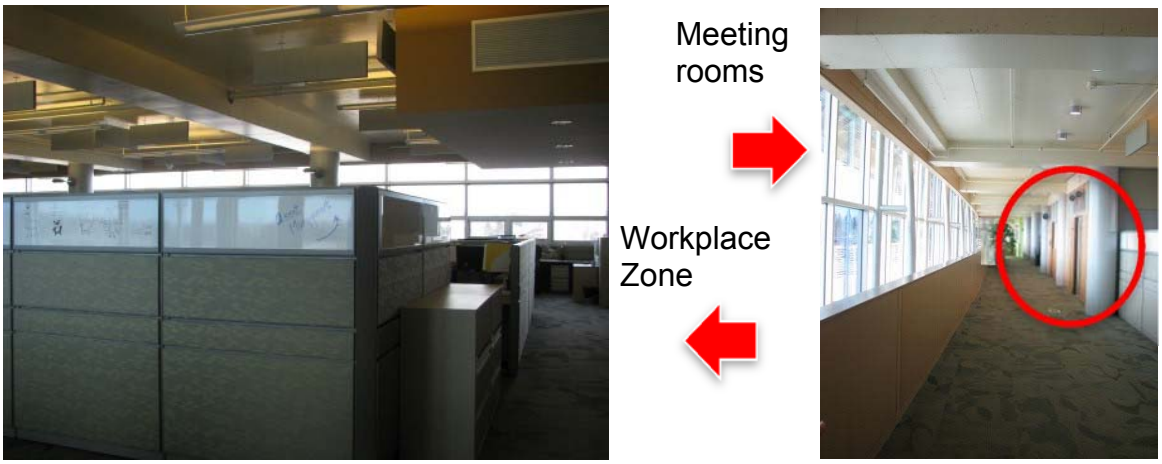


Figure 86. South-facing corridors in all four floors in WCB

Spatial Organization:

It has modular pattern for the distibution of cubicles, as shown in Figure 87. Directors' workstations are located on the inner corridor of the building, facing the southern façade, while the rest of employees are located on the northern façade to avoid the harsh southern sunlight and heat.

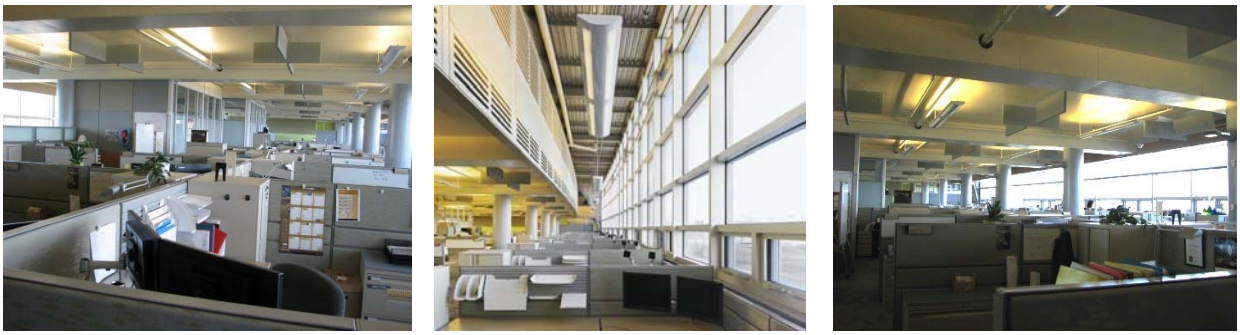


Figure 87. Spatial organizations in the WCB

Access to Equipment (printers and copy machines):

Printers are put in a separate room, with the exception of the directors' workstations, who have a printer and copy machine beside their desks, as shown in Figure 88 and Figure 89.

Separating printers by placing them in different rooms avoids occupants' contact with VOCs and other harmful emmissions, and decreases the noise and traffic (of occupants).

Figure 88. Printers for employees in WCB

Figure 89. Printers at directors' workstations in WCB

Personal Workspaces:

Employees' workstations

Employees work in an open-plan layout, where workstations are cubicles with either low or high partitions, with an upper translucent glass section. Workstations have different sizes: 2.4m x 3m and 2.4m x 3.7 m (95" x 118" and 95" x 145" respectively). Desk sizes vary according to function and not status, so larger desks are reserved for engineers drafting and operational staff using large-scale drawing sheets. Each workstation is provided with a desktop, file caddy, two-drawer lateral file, computer task light, and phone. Additional items may include coat lockers, mobile screens, task boards, tables, and other optional accessories, such as shelves or open file storage. Low workstations walls/partitions that meet windowsill height (1.3m/53") are used to allow views and natural light. High partitions with upper glass (1.7 m or 2.1 m/67" or 83") are used for visual or acoustical privacy at some locations, such as the entrance to the department or in workstations located along the circulation spine. The upper translucent glass is used to allow the penetration of light to the workstations beyond and also used for writing bulletins.

Carpets are used on the floors of the workspaces. This could be useful for absorbing noises (especially while walking); however, they need frequent cleaning so they don't cause problems in the IAQ. Chairs' backs are made of fabric. Further investigation (interviews) will be required to investigate occupants' QoL experience with mesh and fabric chairs used in the GLW and the WCB respectively (Figure 90 and Figure 91).

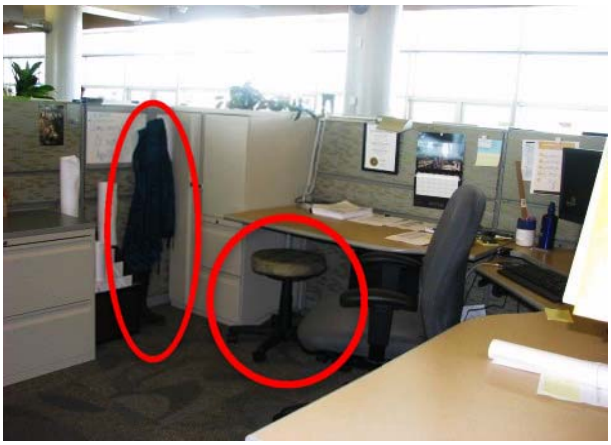


Figure 90. Cubicles with low partitions in the WCB

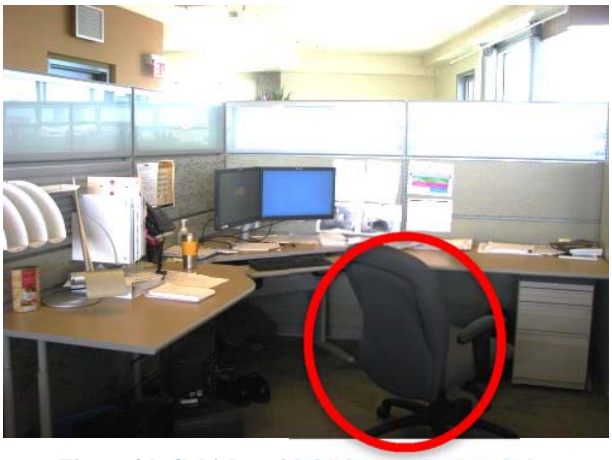


Figure 91. Cubicles with high partitions and glass top in the WCB

Directors' workstations

All workstations have the same type of furniture, and both employees and directors/managers/team leaders all work in cubicles; there are no enclosed offices. This conveys a culture of equality and non-hierarchical strategies. However, the researcher noticed that directors' workstation are positioned in more favoured locations in the open-plan office area; they are away from the crowded organization of workstations, placed near meeting rooms at the entrance of the office area, and have a few waiting seats beside them, as well as their own printers and copy centers.

Figure 92. Directors' workstations in the WCB

Meeting Rooms:

The meeting rooms accommodate 12 persons. They have screens for presentations and translucent glass walls. Some natural pictures are also added on the walls to add some aesthetics. The walls are half-transluscent and half-transparent glass to provide both privacy and daylighting.

Figure 93. Meeting rooms in the WCB

Views:

Figure 94 shows openness, landscape, pathways, and parking. These natural views add to the occupants' sense of connectivity with nature and may enhance their psychological well-being.

(The pictures are taken in the winter hence the designed landscape did not show well)

Figure 94. Views in the WCB

Amenities:

There are several amenities in the WCB, such as the kitchentte, the cafeteria, lounge, and a gym hall.

*Kitchenette***:** Each floor has a small kitchenette beside the washrooms. Kitchenettes are provided with a fridge, sink, garbage and recycling bins, as shown in Figure 95.

Figure 95. The Kitchenette in the WCB (the same on each floor)

Cafeteria:

The cafeteria, shown in Figure 96, is located in the main floor and has views of both northern and southern façades, allowing the penetration of daylighting.

Figure 96. Cafeteria in the WCB

It has colourful furniture, artificial lights, and noise control pins in the ceiling. Food options could also be purchased.

Lounge

In upper floors, the lounge, as shown in Figure 97, is spacious, with a TV, tables, chairs, and couches, as well as operable windows for views. All of these amenities are used to reduce occupants' stress and enhance their well-being.

Figure 97. Lounge in the WCB with lots of space, natural views, and large TV screen

Gym Hall:

As shown in Figure 98, there is a big space for the gym to promote a healthier lifestyle to the employees and emphasize social and economical sustainability.

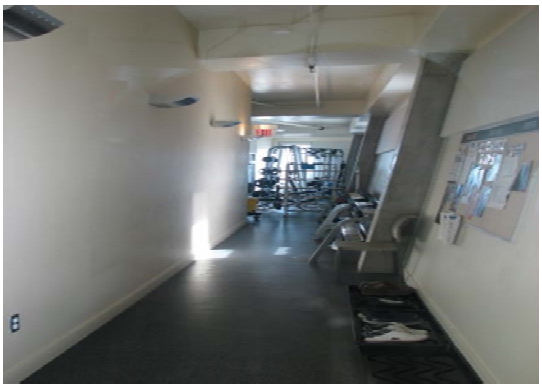


Figure 98. Gym hall in the WCB

Washrooms:

There are washrooms on each floor for both women and men. The washrooms are very clean and have a labyrinth (vestibule entry/no door), as shown in Figure 99, to the left side; this kind of entrance is suggested because it can provide privacy, reduce contamination of surfaces by contact, and increase safety in case of emergencies (screams can be heard).

Figure 99. Washrooms are the same in each floor in the WCB

4.1.3.3 Behavioral Environment

Few personalization items, such as the addition of more plants and pictures, are found in the WCB, as shown in Figure 100.

Figure 100. Plants added in workstations in the WCB

Pro- Sustainable Behaviors:

In the WCB sustainability is experienced by the occupants through many factors, such as the connectivity with nature presented in indoor plants, outdoor landscape, daylighting, and also in promoting a healthier lifestyle by using the gym hall. Furthermore, examples of sustainability are shown in the two-level flushes in the toilets and in the recyling and composting bins.

Figure 101. Recycle and composting bins in the corridor of the WCB

Recycling:

Big recycle and composting bins are put in a specific place at the entrance of the workplace, as shown in Figure 101, as well as in the kitchenette, as previously shown in Figure 95.

4.2 The Questionnaire Results

The survey was part of the quantitative strand in this study, and included a qualitative component embedded within it. Results were used to explain the relationship between IEQ factors and occupants' perceived QoL (Objectives II and IV). The questionnaire was used to understand how the occupants in LEED-certified and conventional office buildings perceive the IEQ factors and their QoL in their work environments and the significance of each factor to occupants' QoL. The results of open-ended questions (qualitative method embedded in the quantitative questionnaires) used in the questionnaires to clarify occupants' assessments are also presented.

Thirty questionnaires were distributed in the Child Development Centre (CDC) building, 25 questionnaires in the Glenmore Workplace (GLW), and 30 in the Water Centre building (WCB). The received responses are 14 questionnaires for the CDC, 13 questionnaires for the GLW, and 21 questionnaires for the WCB. This makes a response rate 46.7%, 52%, and 70% respectively as shown in Table XVI. The results are presented in terms of descriptive analysis (mean values and statistical analysis) and inferential analysis (correlational analysis).

Table XVI. Questionnaires Distribution

Building	N of occupants	N of questionnaires distributed	N of respondents	Response rate %
CDC	85	30	14	46.7%
GLW	25	25	13	52%
WCB	400	30	21	70%

4.2.1 Descriptive Analysis of the Questionnaires: Mean Values and Open-ended Questions

4.2.1.1 Ambient Conditions

Results of the mean values of Ambient Conditions are presented in bar charts in Figure 102 and Figure 103, which compared the differences between the CDC, GLW and the WCB in

summer and winter. Mean value scores above 3 indicate comfort, and below 3 indicate discomfort.

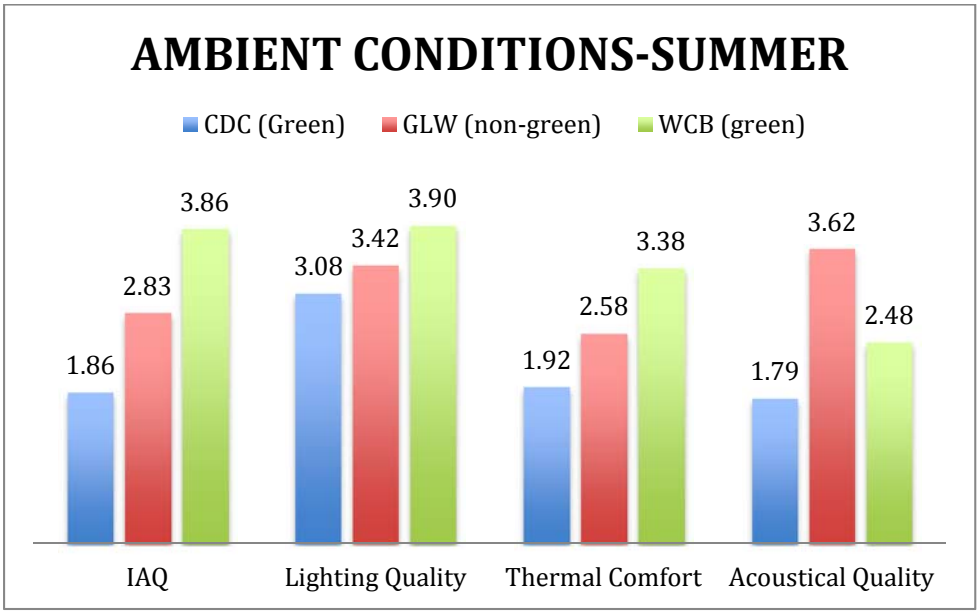


Figure 102. Ambient Conditions in the summer

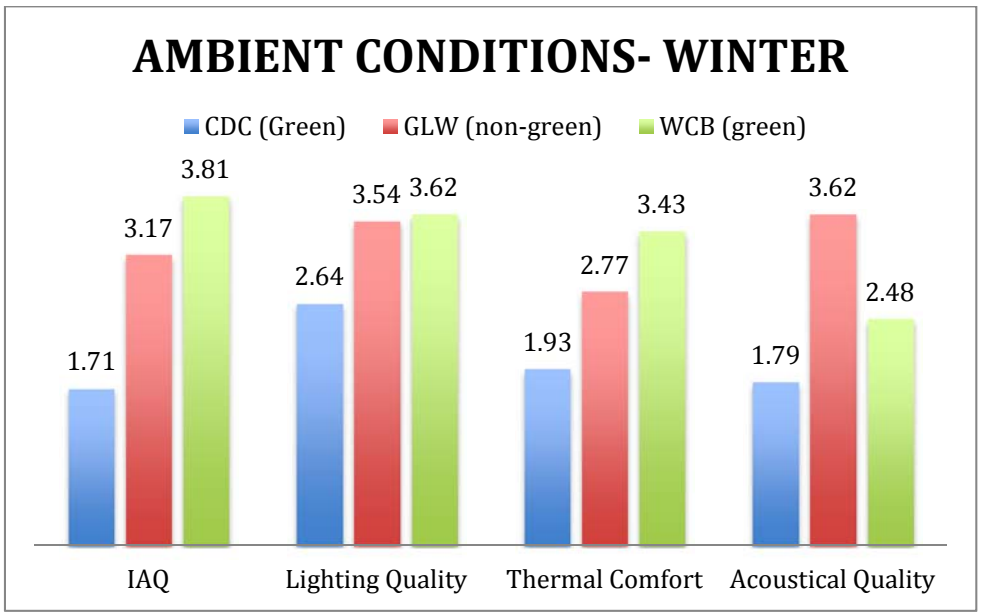


Figure 103. Ambient Conditions in the winter

(i) Child Development Centre-LEED-Platinum Green Office Building (CDC)

CDC Descriptive Analysis (Mean Values) of Ambient Conditions: During summer, Lighting Quality has shown the highest mean value (3.08) for the assessment of comfort in the CDC, followed by Thermal Comfort (1.92), IAQ (1.86), and Acoustical Quality and Noise Control (1.79) respectively. In the winter, Lighting Quality is also found to have the highest score of mean value (2.64) followed, by Thermal Comfort (1.93) and Acoustical Quality and Noise Control (1.79), but IAQ is found to have the lowest mean value (1.71). The Lighting Quality and IAQ are perceived to be slightly more comfortable in summer than winter, while Thermal Comfort and Acoustical Quality and Noise Control are almost the same. All the Ambient Conditions in the CDC, except for Lighting Quality in summer, are below 3, indicating that they are perceived uncomfortable.

CDC Open-ended Questions' Results of Ambient Conditions: Several complaints are found in occupants' comments in the questionnaire's open-ended questions regarding the IAQ, Thermal Comfort, Lighting Quality, and Acoustical Quality and Noise Control in both winter and summer. For IAQ 13 (93%) comments described it as being stagnant, dry, stuffy, and unpleasantly odorous. Occupants complained that the kitchenette or the washroom near their workstation location cause some unfavorable odors. Other complaints related to IAQ included "*everyone is always sick"* and mentioned the presence of chronic nasal infections and eye irritations.

For the Thermal Comfort factor, 11 (78%) comments about the temperature show that it is perceived as too cold in the open-plan (especially near windows) and too hot in enclosed offices, as well as inconsistent temperatures through all spaces. Cold air vents are perceived among the indicators of Thermal Comfort because occupants thought they increase their sense of cold temperature, and the cold air is perceived as uncomfortable to all occupants in the open-plan, it also increases their sense with dryness and odors. The location of those vents on the floor also interferes with workstations' furniture in several workstations. Some occupants mentioned that they use phone books to cover their air vents.

For Lighting Quality, 13 (93%) participants have commented. Discomfort with lighting included the amount of lighting being insufficient in the winter, daylighting glare, flicker,

colour of artificial fluorescent lighting (being uncomfortable and harsh on eyes), lack of control, infrequent maintenance of broken fixtures or burnt bulbs. Natural daylighting from the large windows is perceived as nice, but causes glare on computer screens located on workstations near windows; natural daylighting provides insufficient amount of illumination in the winter. Hence, desk task lighting is required in the winter.

For Acoustical Quality & Noise Control, all 14 (100%) responses received commented on the space being "*way too noisy.*" Reasons for noise, as explained by participants, are due to the lack of walls (open-plan), poor traffic, sound travels, inside sounds that dominate external noise, kid assessments that are performed in hallways (not in a specific room), and noise from colleagues and visitors. In addition, other sources include air, background noise, walking, phones, and white noise that cause everyone to speak louder (it is piped in a level that brings it to the forefront, never to the background). Noise is better in enclosed offices than in the open-plan, but it still comes from the hallway. The means occupants used to feel comfortable with the Ambient Conditions in the CDC included the use of personal fans, warm wraps, the use of headsets to talk on phone, desk task lighting, headphones, and ear plugs.

(ii) Glenmore Workplace-Conventional Office Building (GLW)

GLW Descriptive Analysis (Mean Values) of Ambient Conditions: During summer, Acoustical Quality and Noise Control has shown the highest mean value (3.62) for the assessment of comfort, followed by Lighting Quality (3.42), IAQ (2.83), and Thermal Comfort (2.58) respectively. A similar order of scores is found in winter; however, the scores are higher in all Ambient Conditions other than Acoustics, which is found to have the same score. Acoustical Quality and Noise Control had mean value of (3.54), followed by Lighting Quality (3.54), IAQ (3.17), and Thermal Comfort (2.77), in winter. Acoustical Quality and Noise Control and Lighting Quality are above 3, hence perceived comfortable in both summer and winter, while IAQ is perceived as uncomfortable in summer (below 3) and comfortable in winter (above 3), and Thermal Comfort is below 3, being perceived as uncomfortable in both summer and winter.

GLW Open-ended Questions' Results of Ambient Conditions: Comments regarding the Ambient Conditions in the GLW include 11 (85%) comments about the HVAC system being old and unreliable, causing some complaints about temperature control, lack of personal control, several breaking through the year, and noise. It is perceived to cause uncomfortable room temperature: it is hot in summer and cold in winter and causes temperature shifts.

Eleven (85%) responses are received about Lighting Quality, where the most significant complaint is about fluorescent lighting, in terms of being harsh on the eyes due to the uncomfortable colour or flicker or giving insufficient amount of lighting. People away from windows showed more need of natural daylighting and perceived the amount of illumination as less sufficient; they also used task lighting to increase the amount of illumination. However, they didn't have complaints from glare and reflections due to natural light and perceived the amount of lighting as consistent all year round. Daylighting is found to be preferred because of its natural colour and connectivity with nature; however, it is found to cause more problems with glare and reflections on the computer screens, as well as more heat gain. Hence, user-controllable blinds are considered important for adjusting daylighting amount. Occupants beside windows appreciated the availability of blinds to control natural light amount and glare. The perception of sufficient amount of illumination versus the need for task lighting varied according to workstation location and proximity to windows.

For Acoustical Quality and Noise Control comments, the occupants perceive the work environment as quiet and somehow acoustically comfortable. Few complaints were found; only a few people in the open-plan complained about printers, colleagues, or noises coming out of the HVAC (it's mainly a problem only when it turns on and off)—nothing is continuously noisy. The methods occupants employed to feel comfortable with the Ambient Conditions in the GLW building included the use of personal fans, personal heaters, headphones, and desk task lighting.

(iii) Water Centre- LEED-Gold Green Office Building (WCB)

WCB Descriptive Analysis (Mean Values) of Ambient Conditions: During summer, Lighting Quality (3.90) has shown the highest mean value for the assessment of comfort in the WCB, followed by IAQ (3.86), Thermal Comfort (3.38), and Acoustical Quality and Noise

Control (2.48). In the winter, however, the highest score is found for IAQ (3.81), followed Lighting Quality (3.62), Thermal Comfort (3.43), and Acoustical Quality and Noise Control (2.48). All the results for the Ambient Conditions, except for Acoustical Quality and Noise Control, have mean value scores above 3, indicating comfort in both summer and winter; Acoustical Quality and Noise Control is perceived as uncomfortable in both summer and winter.

WCB Open-ended Questions' Results of Ambient Conditions: Comments in the open-ended questions explained and raised several issues regarding the Ambient Conditions in the WCB**.** Occupants' complaints about the IAQ in the WCB included it being dry, stale, dusty, and having an insufficient amount of fresh air, as the window openings are small and all located on the northern side only, and some people are discouraged to open windows to avoid external noise. Other complaints included from the cafeteria (in the main floor) passing odors throughout the building.

For Lighting Quality, occupants' comments described that the building depends enormously on natural light. This created issues such as the inconsistent amounts of illumination. When using daylight, it can get dark early in the morning and very bright later in the day. Several occupants commented that they use desk task lighting to adjust the amount of lighting when needed. Other issues included incredible glare, especially in winter mornings, but in summer too. The sun shines on computer screens, causing eyestrain when staring at the computer screen all day. Furthermore, lighting is described as not conducive to individual needs because the combination of fluorescent lighting with computer screens is explained as causing eye fatigue extremely quickly.

For Thermal Comfort, occupants expressed how the building can sometimes get too cold or too hot, and that there is no personal control over heat. However, the building is responsive and does a good job in regulating the temperature, but because it is a big building it could take up to a day. Also, workstations near the glass walls are more temperature-sensitive than others. Several occupants described that they wear layers to adjust themselves with the temperatures.

Regarding the Acoustical Quality and Noise Control, most of the respondents commented on the building being too noisy and that this was distracting; some considered it as the worst aspect of this building. Explanations for this include the design of the building—it has open, continuous floors—and the location of the open cafeteria on the main floor causes lots of noise. Sound travels easily due to the openness, low partitions in the cubicles, hard floors, and concrete ceilings. Other sources of noise include the gym, employees talking, and cell-phones. Several occupants rely on earplugs and headphones to be able to concentrate on work. Some suggested changing the culture of the workplace to allow working in quiet areas, having closed offices, or installing more features that retain the open environment but absorb sound. Others mentioned that the white noise caused by mechanical systems is actually favored due to its sound-masking effect.

4.2.1.2 Designed Environment

The mean values of Designed Environment components are shown in Figure 104, a comparison between the CDC, GLW and WCB in summer and winter. Mean value scores above 3 indicate comfort and below 3 indicate discomfort.

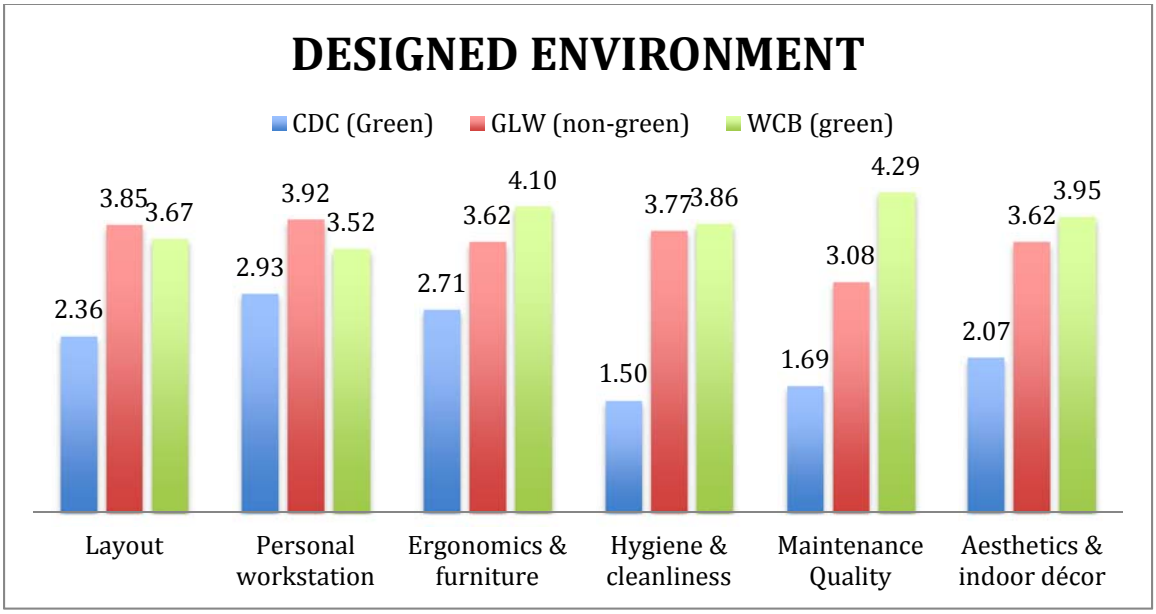


Figure 104. The mean values of the Designed Environment

(i) CDC-LEED-Platinum Office building

CDC Descriptive Analysis (Mean Values) of the Designed Environment: Results of the CDC show the highest mean value score is given to the Personal Workspace/Workstation Quality (2.93), followed by Ergonomics and Furniture (2.71), Office Layout (2.36), Aesthetics and Indoor Décor (2.07), Maintenance Quality (1.69), and Hygiene and Cleanliness (1.50). All the mean values for the IEQ factors in the Designed Environment of the CDC are below 3, indicating discomfort.

CDC Open-ended Questions' Results of the Designed Environment: Eleven (78%) negative comments are received for Layout and Spatial Organization. Responses included discomfort with the open-plan facilitating noise, daylighting causing glare, lack of privacy, crowding, and location of workstations beside the door of the washroom. They also mentioned inadequate facilities and services in the Building Amenities factor. For example, a very small kitchenette that has no windows, location of printers, and copy machines that cause crowding and noise due to chatting, and small with poor plumbing washrooms with no hot water. Other issues raised were insufficient places for social gathering, communication and collaborative work; meeting in privacy; and insufficient storage for everyone. To add to this long list, treatment spaces are far from desks and supplies are randomly placed everywhere.

Eleven (78%) responses are received for Personal Workspace Quality. The most repeated comment about personal workstations in the open-plan concerned lack of storage space, because it results in uncomfortable clutter, while in enclosed offices the amount of storage is perceived as very sufficient. Workstations proximate to the lunchroom suffered from increased traffic and noise. Technology and equipment (computer cables) not installed properly are not only layout issues, but safety issues: a falling incident causing wrist breakage has been reported. The size of workstation and the desk space are too small to allow for collaboration with fellow colleagues, and there is an uncomfortable distance between colleagues' workspaces. Some respondents suggest that personalization is one way to tolerate the discomfort with the personal workspace.

Several complaints are found in terms of Ergonomics and Furniture, such as uncomfortable chairs, chair inflexibility to suit different needs and tasks, and the near impossibility of

adjustments (not allowed except for occupants with serious health reasons). Also having shared workspaces implied that occupants had to deal with new chair and keyboard height settings every time they use a workspace.

For Hygiene and Cleanliness, several complaints are noted about washrooms being unclean, filthy, frequently out of stock from soap and tissue paper, and the lack of hot water ("*Ice cold water to wash hands")*. The washrooms have no regular cleaning or restocking, no ability to call a caretaker when needed, and water supply is limited. Other hygiene and cleanliness complaints included infrequent cleaning of the treatment rooms and work environment, unclean carpets, in addition to the shared spaces being a contributor to more health risks through the spread of more infections.

Regarding Connectivity with Nature, occupants wished to have indoor plants and the ability to use the outdoor balcony. Occupants' complaints about the Maintenance Quality included the slow response to fixing problems such as broken fixtures. Eleven responses about Image and Indoor Décor in the CDC reveal that the participants find the environment boring, bland, dull, dark, dirty, utilitarian, and that it has an unsuitable image, inappropriate materials, and irrelevant artwork for its vocation as a childcare center.. The means occupants took to feel comfortable with the Designed Environment in the CDC included the use of back or neck cushions.

(ii) Glenmore Workplace-Conventional Office Building

GLW Descriptive Analysis (Mean Values) of the Designed Environment: Results of the GLW indicate very close scores for the mean value of the factors in the Designed Environment. Factors and their mean values, in order from highest to lowest, are Personal Workspace (3.92), Office Layout (3.85), Hygiene and Cleanliness (3.77), both Ergonomics and Furniture and Aesthetics and Indoor Décor (3.62), followed by Maintenance Quality (3.08). According to the mean value scores, all are above 3; hence, it is found that all the factors measured in the designed are perceived as comfortable.

GLW Open-ended Questions' Results of the Designed Environment: All occupants working in enclosed offices gave positive comments and perceived the work environment as conducive to work collaboration, meeting in privacy, and access to resources; they were satisfied with the

excellent and comfortable kitchen, sufficient amount of space on desk, comfortable desk size, enough storage, and nice comfortable furniture. Occupants working in the open-plan had several complaints, some varying according to the workstation location. Occupants on corridors complained of distractions and the lack of privacy and wished to have partitions between workstations. Occupants working in proximity to windows had positive comments due to natural lighting. Occupants close to the kitchenette complained of some noise disturbances occurring from the TV and colleagues playing music. Other complaints from occupants, in the open-plan, included small desk size to fit the work and two monitor screens, uncomfortable desk ergonomics (with a board underneath that whacks the knees and overhead cabinets that may bang heads), uncomfortable chairs with mesh and no solid backs, and an uncomfortable degree of enclosure (too open). Few occupants in the open-plan had extra tables and cabinets beside their workstations, and they had positive comments regarding the sufficiency of space and storage.

Occupants' experience with Hygiene and Cleanliness was positive, except for the building washrooms. Because there are no washrooms in the work environment, they have to use the public washrooms, which have foul odors, plugged toilets, and backed-up sewage problems. Occupants commented on Maintenance Quality as comfortable, in a timely manner and with good frequency. Concerning Connectivity with Nature, occupants commented that the views are not special and that there is not enough daylighting for everyone or for growing plants. Ten responses are received for the image and indoor décor, and they varied from neutral, pleasant, clean and simple in colour and décor (with nothing needed to be changed) to uncomfortable, distracting carpets, and the need for more indoor plants, warm colours, modern materials like glass and steel, and some relevant artwork. Occupants' methods to feel comfort with the Designed Environment include the use of back or neck cushions at the GLW.

(iii) Water Centre- LEED-Gold Green Office Building (WCB)

WCB Descriptive Analysis (Mean Values) of the Designed Environment: Results of the WCB indicate that the highest mean value score is given to Maintenance Quality (4.29), followed by Ergonomics and Furniture (4.10), Aesthetics and Décor (3.95), Hygiene and Cleanliness (3.86), Layout (3.67), and Personal Workspace (3.52). All mean value scores are

above 3. Hence, all the IEQ factors measured in the Designed Environment are perceived as comfortable.

WCB Open-ended Questions' Results of the Designed Environment For the Layout and Spatial Organization factors, the work environment in the WCB has an open-plan layout with no enclosed offices. Issues that concerned occupants included uncomfortable distances between cubicles (perceived as "*too close*"), insufficient places for meeting in privacy where the "*bay rooms*," designed to be quiet, private rooms for small meetings, are found to be hard to book with the large number of employees; on top of that, they are not very private, as the walls are not sound proof, and private conversations are very easily heard—they are small and have no windows, so are not "*inspiring.*"

The open-plan layout has insufficient places for communication and collaborative work, the access to resources and printers varies according to your cubicle location—so close to some and far from others—because "*printers are few and far between.*" So the layout is thought of as being functional, yet the openness and continuation between different floors and cafeteria in the main floor is described as very noisy, and there is no privacy at all. Several occupants suggested providing more quiet rooms for privacy, having rooms for relaxation and taking breaks, accepting the idea of different work styles and moving people to work in quieter places in the building. One of the occupants also commented that *"The largest fundamental mistake made in the design of this building is the absence of an easy and open access between the lower and main floor. This physical separation has contributed to a perceived separation between work groups, creating an upstairs/downstairs mentality."*

Comments on Personal Workspaces Quality indicate a good amount of desk space, reasonable amount of storage for files and personal items, but maybe more locker and cabinet space to secure/conceal items is needed, as well as more wall space for hanging items like maps. Discomfort with low partitions in cubicles due to the lack of privacy was noted.

Comments on Ergonomics and Furniture show that desks and chairs are adjustable and fit to a stand-up mode. However, this mode of working is uncomfortable for privacy issues, as occupants would be able to stare more into each other's cubicles (low partitions). It is described that *"ergonomics and furniture are taken very seriously*" and, though some

occupants were still uncomfortable after all the possible adjustments, the WCB performs an ergonomic assessment and responds to occupants' requirements. The main reason for discomfort is the positioning of occupants' backs facing the entrance of the cubicle; that is found to be very uncomfortable to most of the respondents due to privacy issues, and it cannot be fixed due to the short cords of computers. Several occupants also commented that they use back or neck cushions, foot rests, and wrist supports for the mouse to feel more comfortable.

Overall, the comments about Hygiene and Cleanliness show that public spaces in the building look clean and good; however, personal workstations' phones, furniture, keyboards, and desks don't get cleaned, and the supplies for occupants to do it by themselves are limited. Also, carpets need more frequent vacuuming, as they smell musty and dusty sometimes. Other complaints included discomfort with waterless urinals (a strategy used by the LEED to reduce water use), as they are extremely smelly. Another concern is described by one of the occupants as, "*If my neighbor sneezes I feel I get some in my workspace, as the glass partitions are not in place.*"

Maintenance Quality comments describe it as great, frequently responding to issues and easily accessible via e-mail. However, the only complaint is about the ongoing noisy drilling and grinding during work hours.

The Connectivity with Nature factor elicited mostly positive responses**.** Occupants liked the views and daylighting; however, more plants are requested in the comments of several occupants to create a greener environment.

For Aesthetics and Indoor Décor, occupants' responses described the building as such: "*modern professionalism,*" "*decor is boring and bland*" due to the lack of colour, all is beige and grey and not inspiring, "*very typical office*" that can sometimes get messy from the busy crowded workstations, has "*semi-industrial fee,*" and "*rough warehouse look,*" due to the unfinished concrete that gives an unfinished look to the building. However, the favored features in the building included the natural light and the water-themed artwork placed around the building.

4.2.1.3 **Behavioral Environment**

Results of the mean values of behavioral factors as presented in bar charts are shown Figure 105: They compare the CDC, GLW and WCB in summer and winter. Mean value scores above 3 indicate comfort and below 3 indicate discomfort.

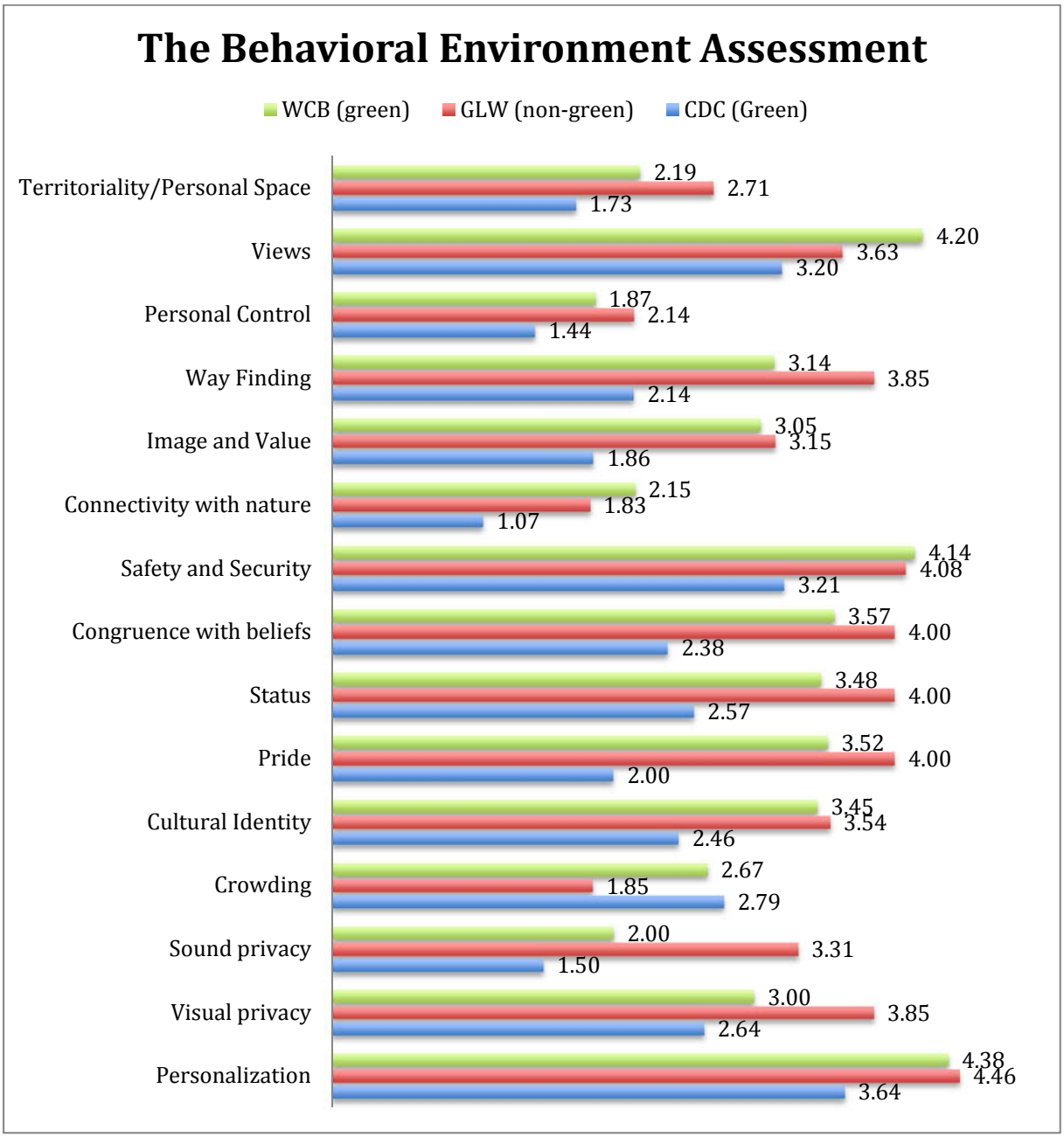


Figure 105. The mean values of the Behavioral Environment

(i) CDC-LEED-Platinum Office building

CDC Descriptive Analysis (Mean Values) of the Behavioral Environment: Results of the CDC-LEED platinum building show that the highest comfort score is given to Personalization (3.64), followed by Safety and Security (3.21), Views (3.20), Crowding (2.79), Visual Privacy (2.64), Status (2.57), Cultural Identity (2.46), Congruency with Beliefs (2.38), Wayfinding (2.14), Pride (2.00), Image and Value (1.86), Territoriality (1.73), Sound Privacy (1.50), Personal Control (1.44), while Connectivity with Nature (1.07) is perceived to have the lowest comfort level. IEQ factors with mean values above 3; perceived as comfortable are Personalization, Safety and Security, and Views. Visual Privacy, Sound Privacy, Crowding, Cultural Identity, Pride, Status, Congruence with Beliefs, Connectivity with Nature, Image and Value, Wayfinding, Personal Control, and Territoriality all have mean values below 3; hence, they are perceived as uncomfortable by the occupants in the CDC.

CDC Open-ended Questions' Results of the Behavioral Environment: Comments related to the Behavioral Environment in the CDC included the lack of Privacy in the open-plan layout, the desire for Personalization to tolerate the work environment, Safety and Security as jeopardized by Hygiene and Cleanliness (29%), Maintenance Quality (25%), Layout (13%) and need for more social gathering places in it, IAQ (9%), Ergonomics and Furniture (8%), Personal Workspace (8%), Lighting Quality (4%), Thermal Comfort (indoor temperature) (4%) in the order of the frequency of repetition.

(ii) Glenmore Workplace-Conventional Office Building

GLW Descriptive Analysis (Mean Values) of the Behavioral Environment: Results of the GLW show that the highest comfort score is also given to Personalization (4.46), and also followed by Safety and Security (4.08), then Pride, Status, and Congruence with Beliefs (4.00), Visual Privacy and Wayfinding (3.85), Views (3.63), Cultural Identity (3.54), Sound Privacy (3.31), Image and Value (3.15), Territoriality (2.71), Personal Control (2.14), Crowding (1.85), and the least score is also given to Connectivity with Nature (1.83). IEQ factors with mean values above 3 (perceived as comfortable) are Personalization, Visual Privacy, Sound Privacy,

Cultural Identity, Pride, Status, Congruence with Beliefs, Safety and Security, Image and Value, Wayfinding, and Views. While IEQ factors with mean values below 3 (perceived as uncomfortable) by the occupants in the GLW are Crowding, Connectivity with Nature, Personal Control and Territoriality.

GLW Open-ended Questions' Results of the Behavioral Environment: Comments related to the Behavioral Environment of the GLW included the need for Privacy for workstations located on corridors, and Safety and Security as jeopardized by Hygiene and Cleanliness (33%), Maintenance Quality (33%), IAQ (17%), and Furniture (17%) in order of the frequency of repetition.

(i) Water Centre- LEED-Gold Green Office Building (WCB)

WCB Descriptive Analysis (Mean Values) of the Behavioral Environment: Similar to the CDC and GL workplace, Personalization (4.38) is also found to have the highest mean value score, followed by Views (4.20), Safety and Security (4.14), Congruence with Beliefs(3.57), Pride (3.52), Status (3.48), Cultural Identity (3.45), Wayfinding (3.14), Image and Value (3.05), Visual Privacy (3.00), Crowding (2.67), Territoriality/Personal Space (2.19), Connectivity with Nature (2.15), Sound Privacy (2.00), and Personal Control (1.87). IEQ factors with mean values above 3 (perceived as comfortable) are Personalization, Views, Safety and Security, Congruence with Beliefs, Pride, Status, Cultural Identity, Wayfinding, Image and Value. While Visual Privacy is neutral, the IEQ factors with mean values below 3 (perceived as uncomfortable) by the occupants in the WCB are Crowding, Territoriality, Connectivity with Nature, Sound Privacy, and Personal Control.

WCB Open-ended Questions' Results of the Behavioral Environment: Comments related to the Behavioral Environment in the WCB included liking Personalization (the ability to personalize), the discomfort with the lack of Privacy, and that the Thermal Comfort (temperature), IAQ, Layout, Furniture, Cleanliness, and Maintenance all contribute to the Safety and Security feeling.

Descriptive Analysis of Overall QoL Among the three buildings

Results of the mean values for overall QoL assessment, presented in bar charts, are shown Figure 106. The results show GLW as having the highest mean value (3.69), followed by the WCB (3.6), and then the CDC (2.48). Mean values under 3 indicate discomfort.

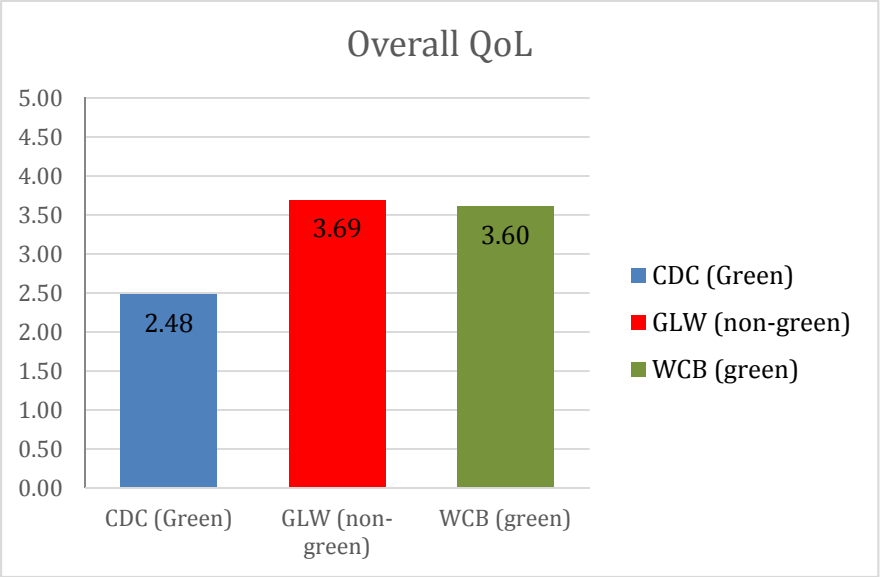


Figure 106. Bar charts for QoL descriptive assessment

4.2.2 Inferential Analysis of the Questionnaires: Correlational Analysis

4.2.2.1 Overall IEQ Factors vs. the Overall Occupants' QoL Experience in Green and Conventional Office Buildings.

This section presents the results of the Pearson 2-tailed Correlations that were done using the SPSS version 21. Correlations test the association between IEQ factors and occupants' perceived QoL. A one asterisk (*) is used to indicate the correlation significance at 0.05 level (2-tailed), and a two asterisks (**) indicate correlation significance at 0.01 level (2-tailed), which means a higher strength of correlation. Furthermore, the + or – sign indicates the direction of correlation—whether positively correlated or negatively correlated. The presentation of results is classified into results of the conventional office building and results

of green office buildings, where each building type has IEQ factors categorized into Ambient Conditions (summer and winter), Designed Environment, and Behavioral Environment.

(i) Significant IEQ Factors to Occupants' QoL Experience in Conventional Office Buildings

Significant IEQ Factors in the Ambient Conditions: In the summer and winter, IAQ is found significant and positively correlated only with the overall QoL. Lighting Quality in the summer is found significant and positively correlated with Meeting Needs and Overall QoL. In winter, Lighting Quality is found significant with Overall Satisfaction, Meeting Needs, and Overall QoL. Thermal Comfort in summer and winter is found significant and positively correlated only with Meeting needs and Overall QoL. Acoustical Quality and Noise Control in summer and winter is found significant and positively correlated with Overall Satisfaction, Meeting Needs, and Overall QoL. Correlation coefficients and significances are shown in Table XVII and Table XVIII.

Table XVII. Significant IEQ Factors in the Ambient Conditions for the Conventional Office Building in Summer

Ambient Summer		Overall Satisfaction	Meeting Needs	Overall QoL
Indoor Air Quality	Pearson Correlation	-.130	-.041	.344*
	Sig. (2-tailed)	.451	.812	.040
Lighting Quality	Pearson Correlation	.293	.538**	.778**
	Sig. (2-tailed)	.082	.001	.000
Thermal Comfort	Pearson Correlation	.043	.421*	.746**
	Sig. (2-tailed)	.804	.011	.000
Acoustical Quality and Noise Control	Pearson Correlation	.699**	.601**	.455**
	Sig. (2-tailed)	.000	.000	.004

Table XVIII. Significant IEQ Factors in the Ambient Conditions for the Conventional Office Building in Winter

Ambient Winter		Overall Satisfaction	Meeting Needs	Overall QoL
Indoor Air Quality	Pearson Correlation	-.059	.146	.388*
	Sig. (2-tailed)	.734	.394	.019
Lighting Quality	Pearson Correlation	.474**	.658**	.839**
	Sig. (2-tailed)	.002	.000	.000
Thermal Comfort	Pearson Correlation	.215	.584**	.758**
	Sig. (2-tailed)	.189	.000	.000
Acoustical Quality and Noise Control	Pearson Correlation	.699**	.601**	.455**
	Sig. (2-tailed)	.000	.000	.004

Significant IEQ Factors in the Designed Environment: Layout, Personal Workspace /Workstation, Ergonomics and Furniture, Hygiene and Cleanliness, and Aesthetics and Indoor Décor qualities are found significant and positively correlated with Overall Satisfaction, Meeting Needs, and Overall QoL. However, Maintenance Quality is found significant and positively correlated only with overall QoL. Correlation coefficients and significances are shown in Table XIX.

Table XIX. Significant IEQ Factors in the Designed Environment for the Conventional Office Building

Designed		Overall satisfaction	Meeting Needs	Overall QoL
Office Layout	Pearson Correlation	.858**	.757**	.632**
	Sig. (2-tailed)	.000	.000	.000
Personal Workspace Quality	Pearson Correlation	.750**	.835**	.612**
	Sig. (2-tailed)	.000	.000	.000
Ergonomics & Furniture	Pearson Correlation	.624**	.572**	.648**
	Sig. (2-tailed)	.000	.000	.000
Hygiene and Cleanliness Quality	Pearson Correlation	.401*	.584**	.622**
	Sig. (2-tailed)	.011	.000	.000
Maintenance Quality	Pearson Correlation	.136	.278	.768**
	Sig. (2-tailed)	.408	.086	.000
Aesthetics and Indoor Décor	Pearson Correlation	.754**	.553**	.500**
	Sig. (2-tailed)	.000	.000	.001

Significant IEQ Factors in the Behavioral Environment: Personalization, Visual privacy, Cultural Identity, Pride, Congruency with Beliefs, Image and Value, Personal Control, and Territoriality are found significant and positively correlated with Overall Satisfaction, Meeting Needs and Overall QoL. Crowding is negatively correlated and significant with Overall Satisfaction, Meeting Needs, and Overall QoL. Sound Privacy, Safety and Security, and Views are found significant and positively correlated only with Overall Satisfaction and Overall QoL. Connectivity with Nature is found significant and positively correlated only with Overall Satisfaction and Meeting Needs. Wayfinding is found significant and positively correlated only with Overall QoL. Correlation coefficients and significances are shown in Table XX.

Table XX. Significant IEQ Factors in the Behavioral Environment for the Conventional Office Building

Behavioural		Overall satisfaction	Meeting Needs	Overall QoL
Personalization	Pearson Correlation	.699**	.412**	.745**
	Sig. (2-tailed)	.000	.009	.000
Visual Privacy	Pearson Correlation	.808**	.594**	.914**
	Sig. (2-tailed)	.000	.000	.000
Sound Privacy	Pearson Correlation	.569**	.270	.714**
	Sig. (2-tailed)	.000	.096	.000
Crowding	Pearson Correlation	-.448**	-.379*	-.467**
	Sig. (2-tailed)	.004	.017	.003
Cultural Identity	Pearson Correlation	.573**	.384*	.566**
	Sig. (2-tailed)	.000	.016	.000
Pride	Pearson Correlation	.650**	.408**	.740**
	Sig. (2-tailed)	.000	.010	.000
Status	Pearson Correlation	.126	.158	.082
	Sig. (2-tailed)	.445	.336	.620
Congruence with Beliefs	Pearson Correlation	.697**	.500**	.841**
	Sig. (2-tailed)	.000	.001	.000
Safety and Security	Pearson Correlation	.338*	.000	.499**
	Sig. (2-tailed)	.036	1.000	.001
Connectivity with Nature	Pearson Correlation	.420*	.630**	.303
	Sig. (2-tailed)	.011	.000	.072
Image and Value	Pearson Correlation	.752**	.585**	.617**
	Sig. (2-tailed)	.000	.000	.000
Wayfinding	Pearson Correlation	.179	.146	.443**
	Sig. (2-tailed)	.275	.374	.005
Personal Control	Pearson Correlation	.511**	.526**	.530**
	Sig. (2-tailed)	.001	.001	.001
Views	Pearson Correlation	.606**	.253	.590**
	Sig. (2-tailed)	.002	.234	.002
Territoriality/Personal Space	Pearson Correlation	.746**	.637**	.761**
	Sig. (2-tailed)	.000	.000	.000

(ii) Significant IEQ Factors to Occupants' QoL Experience in Green Office Buildings

Significant IEQ Factors in the Ambient Conditions: The Ambient Conditions (in summer and winter) IAQ, Lighting Quality, Thermal Quality, and Acoustical Quality are found significant and positively correlated with Overall Satisfaction, Meeting Needs, and Overall QoL. Correlation coefficients and significances are shown in Table XXI and Table XXII.

Table XXI. Significant IEQ Factors in the Ambient Conditions for the Green Office Buildings in Summer

Ambient Summer		Overall Satisfaction	Meeting Needs	Overall QoL
Indoor Air Quality	Pearson Correlation	.583**	.662**	.543**
	Sig. (2-tailed)	.000	.000	.001
Lighting Quality	Pearson Correlation	.486**	.433*	.472**
	Sig. (2-tailed)	.004	.011	.005
Thermal Comfort	Pearson Correlation	.460**	.561**	.517**
	Sig. (2-tailed)	.006	.001	.002
Acoustical Quality and Noise Control	Pearson Correlation	.561**	.508**	.561**
	Sig. (2-tailed)	.000	.002	.000

Table XXII. Significant IEQ factors in the Ambient Conditions for the Green Office Buildings in Winter

Ambient Winter		Overall Satisfaction	Meeting Needs	Overall QoL
Indoor Air Quality	Pearson Correlation	.602**	.717**	.577**
	Sig. (2-tailed)	.000	.000	.000
Lighting Quality	Pearson Correlation	.383*	.407*	.420*
	Sig. (2-tailed)	.023	.015	.012
Thermal Comfort	Pearson Correlation	.546**	.579**	.508**
	Sig. (2-tailed)	.001	.000	.002
Acoustical Quality and Noise Control	Pearson Correlation	.561**	.508**	.561**
	Sig. (2-tailed)	.000	.002	.000

Significant IEQ Factors in the Designed Environment: Layout, Personal Workspace, Hygiene and Cleanliness, Maintenance, Aesthetics and Indoor Décor qualities are found significant and positively correlated with Overall Satisfaction, Meeting Needs, and Overall QoL. Ergonomics and Furniture is found significant and positively correlated only with Meeting Needs and Overall QoL. Correlation coefficients and significances are shown in Table XXIII.

Table XXIII. Significant IEQ Factors in the Designed Environment for the Green Office Buildings

Designed		Overall Satisfaction	Meeting Needs	Overall QoL
Office Layout	Pearson Correlation	.641**	.591**	.566**
	Sig. (2-tailed)	.000	.000	.000
Personal Workspace Quality	Pearson Correlation	.353*	.473**	.418*
	Sig. (2-tailed)	.037	.004	.013
Ergonomics & Furniture	Pearson Correlation	.284	.441**	.439**
	Sig. (2-tailed)	.098	.008	.008
Hygiene and Cleanliness	Pearson Correlation	.610**	.678**	.644**
	Sig. (2-tailed)	.000	.000	.000
Maintenance Quality	Pearson Correlation	.691**	.692**	.677**
	Sig. (2-tailed)	.000	.000	.000
Aesthetics and Indoor Décor	Pearson Correlation	.719**	.649**	.658**
	Sig. (2-tailed)	.000	.000	.000

Significant IEQ Factors in the Behavioral Environment: Visual Privacy, Sound Privacy, Pride, Congruency with Beliefs, Connectivity with Nature, Image and Value, and Territoriality are found significant and positively correlated with Overall Satisfaction, Meeting Needs, and Overall QoL. Personal Control and Views are found significant and positively correlated only with Meeting Needs and Overall QoL. Personalization and Crowding are found significant only with Meeting Needs, but Crowding is negatively correlated. Cultural Identity is found significant and positively correlated only with QoL. For correlation coefficients and significances see Table XXIV.

Table XXIV. Significant IEQ Factors in the Behavioral Environment for the Green Office Buildings

		Overall satisfaction	Meeting Needs	Overall QoL
Personalization	Pearson Correlation	.252	.380*	.321
	Sig. (2-tailed)	.144	.024	.060
Visual Privacy	Pearson Correlation	.540**	.474**	.592**
	Sig. (2-tailed)	.001	.004	.000
Sound Privacy	Pearson Correlation	.514**	.496**	.588**
	Sig. (2-tailed)	.002	.002	.000
Crowding	Pearson Correlation	-.271	-.338*	-.321
	Sig. (2-tailed)	.115	.047	.060
Cultural Identity	Pearson Correlation	.302	.256	.388*
	Sig. (2-tailed)	.088	.151	.026
Pride	Pearson Correlation	.769**	.705**	.793**
	Sig. (2-tailed)	.000	.000	.000
Status	Pearson Correlation	.312	.253	.175
	Sig. (2-tailed)	.068	.142	.314
Congruence with Beliefs	Pearson Correlation	.483**	.505**	.557**
	Sig. (2-tailed)	.004	.002	.001
Safety and Security	Pearson Correlation	.332	.290	.240
	Sig. (2-tailed)	.052	.091	.164
Connectivity with Nature	Pearson Correlation	.505**	.537**	.479**
	Sig. (2-tailed)	.002	.001	.004
Image and Value	Pearson Correlation	.579**	.561**	.629**
	Sig. (2-tailed)	.000	.000	.000
Wayfinding	Pearson Correlation	.107	.100	.253
	Sig. (2-tailed)	.541	.568	.142
Personal Control	Pearson Correlation	.214	.422*	.486**
	Sig. (2-tailed)	.216	.012	.003
Views	Pearson Correlation	.360	.411*	.441*
	Sig. (2-tailed)	.051	.024	.015
Territoriality/Personal Space	Pearson Correlation	.629**	.579**	.682**
	Sig. (2-tailed)	.000	.000	.000

(iii) A Comparison of Significant IEQ Factors Affecting Occupants' QoL Experience in Green and Conventional Office Buildings

Significant IEQ factors to occupants' QoL are compared between green and conventional office buildings in both summer and winter and shown in Table XXV. Twenty IEQ factors are found significantly correlated with occupants' QoL in green buildings, compared to 23 significant IEQ factors in the conventional office building.

It is found that in green buildings, Pride and Territoriality, IEQ factors from the Behavioral Environment, are the most significant factors in correlation with occupants' perceived QoL. They are followed by Maintenance quality, Aesthetics and décor, and Hygiene and cleanliness, which belong to the Designed Environment. For the Ambient Conditions in the summer, the most significant IEQ factor is Acoustical Quality and Noise Control, followed by IAQ, Thermal Comfort, and Lighting Quality. In winter it is IAQ, followed by Acoustical Quality and Noise Control, Thermal Comfort, and Lighting Quality that are the least significant factors among the 20 IEQ factors in green buildings.

For the conventional office building, Visual Privacy and Congruency with Beliefs (also from the Behavioral Environment) are the most significant IEQ factors determining occupants' perceived QoL. Those are followed next by Lighting Quality from the Ambient Condition (in both summer and winter), then Maintenance Quality from the Designed Environment.

If we compare the top five significant IEQ factors in both green and conventional office buildings, it is found that among the top five factors for green buildings, two of them are from the Behavioral Environment, three from the Designed Environment, and none from the Ambient Conditions. However, in the conventional office building, three factors belong to the Behavioral Environment, one factor to the Designed Environment, and one factor to the Ambient Conditions. These results emphasize the importance of IEQ factors in the Behavioral Environment to occupants' perceived QoL in office buildings, whether green or conventional.

The comparison between summer and winter is only relevant to the Ambient Conditions. While no difference has been found in the Ambient Conditions of the conventional office building between summer and winter, green buildings showed a little variation. The Lighting Quality is perceived as slightly better in the summer than the winter in green buildings. This

suggests that there is more consistent and brighter (giving more sufficient amount of illumination) daylighting in the summer. Considering that daylighting is a common feature in green buildings, it may affect the illumination levels in different seasons. Furthermore, the comparisons between IEQ factors in green and conventional buildings have shown that Acoustical Quality and Noise Control was more significant in green buildings than in the conventional one. This is due to more occupants' concern with noise control from the design features and strategies that allow the penetration of daylighting, ventilation, heating and cooling (to save energy), such as more open spaces and continuity between floors (as in the WCB) in green buildings.

Lighting Quality showed more significance in the conventional building than the green ones. This is suggested to be due to more dependence on artificial lighting, which provides more consistent illumination than daylighting strategies. Aesthetics and Indoor Décor was found to be more significant in green buildings than the conventional one. This might be due to the fact that green buildings are relatively newer, thereby using more modern and updated materials, such as glass, metal, and curtain walls.

Pride is found to be more significant in green buildings than the conventional building. This is suggested to be due to the symbolic factor of being green, indicating occupants' appreciation of more responsibility towards the environment and saving the planet, such as in the WCB, where people felt proud of being part of that, and a high level of Pride was significant with the high perceived QoL. Negative effects on Pride, as in the CDC, result in people feeling disappointed with the performance of the building; their low Pride is significant with the low perceived QoL in the building. Results also show that occupants in green and conventional buildings have similar needs, hence the IEQ factors significant with their QoL were similar, albeit the order of significance differed due to different building conditions and features.

Table XXV. Ranking of IEQ Factors Significant with Occupants' QoL in Green and Conventional Office Buildings in Summer and Winter

Most Significant

Green QoL-summer	Conventional QoL-summer	Green QoL-winter	Conventional QoL-winter
Pride	Visual Privacy	Pride	Visual Privacy
Territoriality	Congruency with Beliefs	Territoriality	Congruency with Beliefs
Maintenance Quality	Lighting Quality	Maintenance Quality	Lighting Quality
Aesthetics & décor	Maintenance Quality	Aesthetics & Décor	Maintenance Quality
Hygiene & Cleanliness	Territoriality/Personal Space	Hygiene & Cleanliness	Territoriality/Personal Space
Image & Value	Thermal Comfort	Image & Value	Thermal Comfort
Visual Privacy	Personalization	Visual Privacy	Personalization
Sound Privacy	Pride	Sound Privacy	Pride
Layout	Sound Privacy	IAQ	Sound Privacy
Acoustical Quality& Noise Control	Ergonomics & Furniture	Layout	Ergonomics & Furniture
Congruency with Beliefs	Layout	Acoustical Quality & Noise Control	Layout
IAQ	Hygiene and Cleanliness Quality	Congruency with Beliefs	Hygiene & Cleanliness Quality
Thermal Comfort	Image & Value	Thermal Comfort	Image and Value
Personal Control	Personal Workspace /Workstation Quality	Personal Control	Personal Workspace /Workstation Quality
Connectivity with Nature	Views	Connectivity with Nature	Views
Lighting Quality	Cultural Identity	Views	Cultural Identity
Views	Personal Control	Ergonomics and Furniture	Personal Control
Ergonomics & Furniture	Aesthetics and Indoor Décor	Lighting Quality	Aesthetics and Indoor Décor
Personal Workspace	Safety and Security	Personal Workspace	Safety and Security
Cultural Identity	Crowding	Cultural Identity	Crowding
	Acoustical Quality & Noise Control		Acoustical Quality & Noise Control
	Wayfinding		Wayfinding
	IAQ		IAQ

4.3 Findings from the Interviews

Understanding the occupants' lived experience is essential to create a holistic understanding of the work environment. The interviews are found to be very useful to build this understanding and interpret occupants' lived experience based on their own words. Thereby, the interviews helped the researcher to identify the IEQ factors that were not mentioned in the questionnaire, thus confirming issues and answering the research questions: *What is occupants' QoL experience in LEED-certified and conventional office buildings and what IEQ factors interact with occupants?, and What does a humane work environment mean to occupants and what factors constitute it?*

Findings from the interviews are presented in the order of research objectives of the qualitative strand: (1) (OBJECTIVE I) **Documenting** occupants' overall QoL in LEED-certified and conventional office buildings, (2) (OBJECTIVE III) **Determining** IEQ factors interacting with occupants' QoL in LEED-certified and conventional office buildings, and (3) (OBJECTIVE V) **Defining** constructs of a humane work environment.

4.3.1 OBJECTIVE I: Documenting Occupants' Overall QoL in LEED and Conventional Office Buildings

To understand occupants' QoL experience with their work environments, interviewees were asked to describe their overall experience with the building. Descriptions included their daily routine of actions, and overall impressions about the building and their life interactions inside it. Questions also included the description of feelings, related to the space when first arriving at the work environment, as well as when leaving the space. This enabled the researcher to picture the peak of emotions. This is because people first impressions about the space usually capture the pleasant or unpleasant prediction of occupants' daily experience (based on what is already in their minds from previous knowledge and experiences with the situations in the work environment). It could also indicate the coping actions the occupants use when they first arrive to be able to use the space comfortably. Similarly, when leaving the space, occupants could describe to the researcher whether the employees are finally looking forward to get rid of environmental stressors in their work environment or if there is nothing

really bothering them that much. Further questions discussed occupants' perceptions of qualities in their environment that interact with their work experience in getting the job done, emotions and feelings, health and safety, or body comfort. Responsive follow-up questions were used when needed, as well as any questions related to the observations previously conducted.

4.3.1.1 Occupants' Overall QoL Experience Descriptions

While the CDC has the highest level of LEED certification (Platinum level), several occupants' complaints are found associated with the work environment. Following are a few excerpts presenting occupants' descriptions of their overall experience with the building. As stated by **CDC-IP1**, *"I am lucky that I get to go out to other locations just to see other children at preschool or at home. I am not spending all my time here. If I was I would probably feel different."* **CDC-IP2** said, *"This is a challenging workspace."* **CDC-IP3** said, *"This is a spectacularly awful building to work in."* **CDC-IP1** pointed out several attributes of the building: *"Hmm, busy, noisy, cold, drab . . . Umm dirty . . . it's cramped, it's dingy. It is not a pleasant workspace, so people do what they need to do to make it as positive as possible*."

To the contrary, in the conventional office building (the GLW of Tetranex Solutions Inc.), the occupants had a more positive experience and perceived the work environment, as stated by **GLW-IP1**, as "*quiet. It's not very stressful . . . It's open, friendly— just a lot of space."* **GLW-IP2**'s impressions were negative**:** *"Exposed, open, no privacy . . . it can be noisy . . . it can also be too quiet."* **GLW-IP3** said, *"On general basis it's comfortable and open and friendly."*

A similar positive experience is also found in the WCB, although its LEED certification is of a lower level (Gold) than the CDC (Platinum); however, occupants' described it like **WCB-IP3**: *"This building is great. How they designed the building is amazing."*

4.3.1.2 Occupants' General Satisfaction and Dissatisfaction

In the CDC factors affecting occupants' Overall Satisfaction are found to be underground Parking, Daylighting, and Privacy and Personal Control of enclosed private offices (privacy, feeling of respect and control, and, thus, increases in morale and professional recognition). In

terms of Parking, one of the interviewees referred to as **CDC-IP1** said, *"I have underground parking; I am sorry that is all I can say . . . this is a spectacularly awful building to work in."* For Daylighting, another participant, **CDC-IP2**, stated, *"I would probably have to say the natural light; that is probably my biggest thing that I need to feel happy."* **CDC-1P3**, an interviewee who worked in an *enclosed office* said,

> *"So I like having the private workspace; and I think that in terms of feeling that you are treated as a professional, and your work has been treated respectfully and that you can control your work and who is in your office, etc. I think this is hugely positive for morale and your professional recognition of what you do."*

Dissatisfaction is indicated in the several complaints found to be associated with the lack or poor IEQ factors, such as Thermal Comfort; feeling too cold in the open-plan office environment and feeling too hot in the enclosed offices is the most significant complaint, followed by the lack of temperature control, which **CDC-IP1** elaborates upon*:* "*The heating has been my biggest challenge because they can't seem to be set."*

Other reasons for dissatisfaction were Hygiene and Cleanliness, Noise, Crowding, Personal Workspace (lack of enough storage), Layout (lack of enough rooms for treatment), Building Amenities (inadequate kitchenette and eating area), Congruency with Beliefs (the culture of shared spaces) factors, as well as complaints about motion-sensor lights and thermostats (also are indicators of lack of Personal Control). **CDC-IP1** describes the inadequacy of the motion sensors:

> *"If you are having a meeting in a room and people are actually listening to what you are talking about, the light will go off because they are motion-sensored. So you can be sitting receiving a tele-health presentation or having someone talking and because people are sitting like this, the light goes off . . . and the other thing is the temp is motion- activated, so if you are in a place and you leave it, it falls to 15 ºC. That is pretty cold."*

In the GLW factors affecting occupants' general satisfaction are found to be IAQ, Hygiene and Cleanliness (in water quality), Congruency with Beliefs (in equity), Personal Control and Status indicated by ownership (giving a feeling of control and belongingness), Amenities (food, TV, etc.), Social Interaction (via social gathering places as the kitchen), and Daylighting. Social Interaction and Building Amenities (lounge, kitchen area, food, etc.)

factors had the highest frequency of significance, as mentioned by three out of four interviewees (75%).

Dissatisfactory experiences included complaints about furniture quality (effect on health and absenteeism), lack of recreational facilities (such as showers), workplace dimensions (the need for a higher ceiling), the lack of brighter-colored ceiling, the rough finishing material of ceiling), not having enough meeting (conference) rooms, no sound privacy, lack of break rooms for private phone calls, workstation locations on corridors or at the entrance of the workplace, lack of privacy, open-plan, absence of daylighting, and the use of fluorescent lighting. One of the interviewees mentioned that some qualities are missing from this current work environment, but were so much appreciated in his/her experience with previous workplaces, such as aesthetics: modern style, light colors, white airy materials, glass, windows, and daylighting. *"It was bright. It was sunny,"* said **GLW-IP2**. He/she reminisced about other features missing from the current workspace but were cherished in the previous workspace: big U-shaped desks, lots of storage, lots of room, lots of shelves, low partitions between workstations, no overhead bins (that you can hit your head on), privacy, flexibility and adjustability, different configurations for computer locations and placement, a closet for personal items in each workstation, and the ability for self expression: partitions were made of materials that could be used as boards for writing notes with dry erase markers. The kitchen had a nice coffee machine, fridges, microwaves, etc.; the three different kitchen areas had enough space and were never congested. The brand-new building was ergonomically-designed (well-done fit and finish).

In the WCB factors affecting occupants' General Satisfaction are found to be Ergonomics and Furniture, Personal Control Quality (indicated in the control and adjustability of the workstation furniture), Daylighting, Views (via windows), and Aesthetics and Indoor Décor (from the vertical continuity and openness coming from the glass staircase and the visual connectivity between floors), Connectivity with Nature (via outdoor landscape), Image and Value (indicated in building design), and Layout Quality. No dissatisfactions have been reported, other than one complaint about the difficulty in booking rooms and the noise coming from the open space, affecting the ability to focus on work. However, both complaints weren't mentioned by the occupants as negatively affecting their General Satisfaction, as people in the

WCB seemed generally satisfied with the building due to many positive attributes and factors masking the negative ones.

4.3.2 OBJECTIVE III: Determining IEQ Factors Interacting with Occupants' QoL in LEED and Conventional Office Buildings

The researcher found several IEQ factors interacting with occupants' QoL experience and their indicators, based on occupants' own words.

In the CDC, Aesthetics and Indoor Décor can play an important role in lifting the spirits and giving a bright anti-depressing feeling to occupants. Spatial Organization (that doesn't cause crowding), Layout that has adequate and sufficient place for social gathering (promotes Social Interaction), and good Hygiene and Cleanliness are also found important. Personalization, a type of self-expression that reflects identity and determine Territoriality, can make the workspace tolerable to the occupants and give them a sense of belonging. Congruency with Beliefs represented in organizational culture that can affect the feeling of belongingness; actually, personalization was a method of adaptation the occupants used to cope with problems with organizational culture. Personal Workspace (Workspace size, has sufficient storage and adequate desk space) is a positive experience when the size is adequate—it creates more comfort, and when it is larger than others it is found to increase the Pride factor for this employee. Views that establish Connectivity with Nature and have operable windows, which increase occupants feeling of the Personal Control factor, are also favored. Operable windows classify as an IAQ factor too, by allowing the penetration of fresh air for better air ventilation and circulation. Thermal Comfort with consistent temperatures and comfortable, quick-heat regulation are preferred). Noise control and Sound Privacy, Lighting Quality (amount of illumination), as well as Maintenance Quality that make sure systems work and are fixed in a timely manner are also among the IEQ factors affected occupants' QoL experience in the CDC.

In the GLW, IEQ factors that interact with occupants' lived experience with their indicators (as elicited from interviewee words) are Acoustical Quality & Noise Control, Layout (that allows openness collaboration), Ergonomics and Furniture Quality (that respects equity,

physical support and adjustability), Spatial Organization (that doesn't cause crowding), Privacy (visual and sound), Thermal comfort (humidity and temperature), Aesthetical Quality and Indoor Décor (in colors that are comfortable, calming, and relevant to the company), and Lighting Quality (that has a comfortable color and is close to natural lighting).

In the WCB, IEQ factors that affect occupants' lived experience with their indicators (as elicited from interviewee words) are Layout (openness that creates social connectivity and interaction, and flexibility), Equipment and Resources (access to resources), Personal Workspace (enough storage, shelves, and adequate workstation size), Lighting Quality (amount of illumination that is not too bright and doesn't cause glare/reflections on computer screens), Thermal Comfort (comfortable temperature), Ergonomics and Furniture (customized furniture, chairs that can be changed to suit occupants' needs) , Aesthetics and Indoor Décor (plants, which also apply to the Connectivity with Nature factor), and Hygiene & Cleanliness.

Generally the IEQ in the work environment can be grouped into three categories: (1) Ambient Conditions, (2) Designed Environment, and (3) Behavioral Environment. Four IEQ factors are elicited in the Ambient Conditions category, nine in the Designed Environment, and 14 in the Behavioral Environment.

4.3.2.1 Theme 1: IEQ Factors in the Ambient Conditions Interacting with Occupants' QoL Experience

1. IAQ: The air quality of the indoor environment is indicated by occupants in terms of odors, allergens, dryness, and ventilation. Participants in the CDC complained about health risks due to the air quality, and according to one of the interviewee named **CDC-IP1**, "*Since I moved here, I've had to take Benadryl in the morning and the afternoon . . . otherwise my eyes are incredibly red and my nose constantly runs, and I cough, which I don't do at home—like, as soon as I leave this building, I don't do that."* This issue did not only affect the occupant's physical health, but also influenced his/her mental well-being. **CDC-IP3** was also worried about IAQ: *"If I am getting stuffed up, I am not gonna feeling very well. I am going to be in distress."* It is suggested that open plans cause higher transmission of infections due to the air being in an *open space* where all employees sit together and breathe the same air. It is also found that it allows the smells to be easily spread. **CDC-IP1** said, *"We have bad smells, so*

sometimes you can smell carbon dioxide. Not carbon. Sorry. Car exhaust is what I say". Furthermore, the air in the CDC is perceived as dry even in enclosed offices. **CDC-IP3**: "*I think the only thing that affects my health because I do tend to have some sinus issue is the dryness . . . And it affects my stuffiness."* In addition, a technique usually used for ventilation in green buildings is using the air vents to push natural ventilation inside the building and circulate the air for a better IAQ. However, in the CDC the occupants complained about the air vents for three reasons: first, for being cold; second, for their location relative to where their seats are; and third, for the speed of air flow coming out of them. It is perceived as bothering their Physical Comfort, as well as their ability to get the work done (Functional Comfort), as confirmed by **CDC-IP1**: "*That's not good because when you are cold then you are distracted.*"

Less concern was given to IAQ in the GLW. "*Air is just a minor thing,"* is **GLW-IP2**'s opinion regarding how their IAQ relates to QoL in the building. Only one interviewee thought, *"I sneeze more when I am at work, actually."*

Similarly, no complaints are found in the WCB regarding the IAQ, other than it is perceived as a bit dry. But generally occupants felt comfortable and appreciative, as stated by **WCB-IP1**: *"I appreciate they are supposedly using low VOC materials, and I would have noticed that if there was…I mean I am sensitive to smells—I would have noticed that and I don't notice that here."*

2. Lighting Quality (Illumination and Daylighting): Few complaints about the illumination are mentioned during the interviews in the CDC. **CDC-IP1** said, "*If it is flickering or whatever. I have certainly had an increase in my migraines since I moved to this building, and talking to somebodies; that has been reflected with them too—an increase in sick days. I have a good medication that I take. It allows me to work through the pain*." Other complaints include insufficient amount of illumination too.

To the contrary, in the GLW several complaints are found, as three out of the four interviewees perceived the fluorescent lights as uncomfortable. **GLW-IP2** said**:** "*They make my eyes hurt*"; they are considered "*horrible. It's harsh white light, it's awful, horrible to work under it.*" However, **GLW-IP3** believe that they are "*better on energy and everything, but*

they're pretty harsh on the environment . . . for reading, looking at the computer screen all day long, you know having better light for documentation would be better." **GLW-IP2** compared the fluorescent lighting with LED and said, "*What a difference . . . it seems cleaner and fresher.*" Another complaint about the Lighting Quality came from **GLW-IP3**: "*We don't have great desk lamps either. We just have small bulbs on, so everyone who wants one can get one, but they are not great*." It is also found to cause Functional, Psychological (emotional), and Physical Discomfort. **GLW-IP1:** "*I think lights do a lot . . . sometimes I've noticed some lights kind of making me a little tired, and being tired at work obviously evokes some other emotions; like, it's not great being tired when you have to get things done.*"

One of the factors affecting Illumination/Lighting Quality is the Daylighting and the absence of it so the lights in the GLW are perceived as stated by **GLW-IP2:** "*Not natural enough; like, natural lights really seem to help me a lot and these lights for some reason—I am not sure entirely why—just aren't the best for me . . . feel just a little bit more tired, like it kind of bothers my eyes a little bit, and then I find myself just wanting to kind of close my eyes—same as if I am tired.*" The lack of daylighting is perceived by another interviewee as the only factor affecting his/her psychologically: "*Definitely the sunlight, I don't get it*" (**GLW-IP4**).

In the WCB the illumination is perceived by all interviewees as good and comfortable, like **WCB-IP1:** "*Consistently good. So things like lighting and heating—that kind of stuff is consistently acceptable—that you feel good and that is not something you have to worry about*." Reasons for the comfortable quality in lighting were being consistent and not being too bright for computer screens, as well as not causing headaches.

3. Acoustical Quality and Noise Control: Occupants in the CDC complained about the lack of soundproofing materials, lack of noise control, and lack of sound privacy, causing distractions especially when talking on phones or in assessment rooms with patients that have confidential information to say. **CDC-IP1** does not find this easy to deal with: *"It is hard sometimes hearing people's conversations, you know. Sometimes you hear some stuff that is not so great . . . so there is a huge lack of privacy here."* Therefore, this further impacts occupants' ability of getting their work done comfortably. Hence, the type of work the

employees are performing is found to be highly sensitive and affected by the lack of sound privacy and ability to control noise and distractions.

In the GLW occupants were comfortable and no complaints were associated with 3. Acoustical Quality and Noise Control factor, as **GLW-IP1** says, "*Most of the client discussions are happening with the managers here in offices and then we're kind of working with the managers and actually getting things done, rather than dealing with the clients.* He/she was comfortable with this strategy and commented: *"So that kind of works really well."*

Similarly, no issues or complaints are found with Acoustical Quality and Noise Control in the interviews in the WCB.

4. Thermal Comfort: Is perceived and indicated by the occupants in terms of temperature. Thermal Comfort has the most complaints in the CDC. **CDC-IP3** states, "*Temperature is becoming a real problem."* **CDC-IP1** explains, "*That's the other thing in LEED platinum buildings. [It] is very interesting because there always seem to be a lack of— so, for example, in terms of temperature . . . it's always either too hot or it's freezing, so it seems it takes a lot of time for the temperature to regulate when the weather regulates or deregulates."* Occupants' perceived the temperature as too cold in the open space zone, where **CDC-IP1** works: "*Being cold all the time is an overriding thing."* **CDC-IP1**: "*I did not expect to be freezing here all the time."* Occupants are too hot in private enclosed offices, and according to the interviewee **CDC-IP3**, "*I don't feel well when I am really too hot, so that the heating has a negative effect on my mood.*" It is also found to affect the work performance, as mentioned by another participant, **CDC-IP2:** *"Well, you know, if I am cold, I am distracted. If I am too hot I am distracted . . . I think the climate control is one of the biggest things that would impede my ability to do my work."* Temperature inconsistencies in the CDC seem to be a major issue. The inconsistency is found on two levels. The first level being inconsistent in its regulation within the same space, as according to **CDC-IP1**: *"I have to say a lot of the time I am very cold here; the temperature regulation is really poor."* **CDC-IP1**: *The temperature regulation seems to be delayed, and it's not always comfortable."* The second level of inconsistency is between different locations in the building and different spaces. **CDC-IP1**: "*The temp is motion-activated, so if you are in a place and you leave, it falls to 15 ºC. That is pretty cold."* Another

reason seemed to be the lack of follow-up maintenance. **CDC-IP1**'s radiator doesn't even work: "*I have a radiator beside me, but when they built the building, they forgot to actually put the heating radiator mechanism in there, so it's a blank wall with a heating cover over top. So I have no source of heat where I sit."*

Thermal Comfort in the GLW was also a concern due to the HVAC system that is old and causes temperature inconsistencies as well:

> *"Yeah, air is terrible. Usually I am a pretty happy guy; the HVAC in my office (enclosed office) is terrible, so [when it comes to] heating and ventilation because it's an older building and the window area single pane glass . . . in the hot days, it's hot and the cold days it's freezing . . . so the control of the HVAC is not that great . . . because on hot days it's pretty hard to stay motivated when you're passing out.* (**GLW-IP3**)

Generally during the interviews there were no major complaints from temperature regulation in the WCB; however some occupants perceived the temperature as cold, "*especially in the summer because it's almost worse in the summer… Yaa, and you can't dress right, so I always wear a bunch of sweaters no matter what time of the year,* said **WCB-IP3**. This is found to have an impact on Psychological Comfort, as further described by **WCB-IP3**: "*Grumpy or annoying may be."*

4.3.2.2 Theme 2: IEQ Factors in the Designed Environment Interacting with Occupants' QoL Experience

5. Layout: Occupants in the CDC complained about the open space being noisy, distracting, having no privacy, and spreading infections.

In the GLW the *open space* versus the *enclosed office* influenced people's feelings of control over noise and sound privacy, and these qualities affected their Functional Comfort. **GLW-IP2**, an employee working in the open space, mentioned, "*If I had a little more privacy, I think I probably wouldn't get distracted . . . more privacy or something that would break up the sounds in the office."* Sources of noise and distractions found in the open-plan are colleagues, phone calls, HVAC system, and printers and copy machines, which also cause crowding of the space. According to **GLW-IP3**: *"Copy and everything is right in the middle of the open space, so it may be that is an annoyance for some people, because usually it gathers population around it and it's noisy and that sort of things."* However, a participant

actually liked the noise coming from the HVAC system when it works as the temperature drops; he found that the sound masked the noise coming from employees, hence it worked better for him. Though the open space is perceived as conducive to work collaboration, one of the occupants, **GLW-IP2**, suggested that there "*should be closed workstations to get your work done and if you want to collaborate go somewhere else.*" This suggests a balance is needed for having privacy and work collaboration when needed. The participants who had an enclosed office found the space more enabling for getting their work done, and the main reason was the privacy and control obtained from having a door. **GLW-IP3** said that *"being able to shut the door is huge."*

In the WCB occupants perceived the open-plan layout as nice for the look, yet negatively affecting work efficiency. **WCB-IP3**: *"The focus part is an issue"* due to distractions from colleagues and lack of sound privacy and noise control. **WCB-1P3** expressed, *"I guess I like it for mood, but maybe it's less effective for work."* However, being in an open space that provides social interaction through the openness of the space or amenities is found to have a positive influence on Psychological Comfort from an inspirational and social quality perspective. According to one of the interviewees,

> "*I feel inspired . . . like I feel like I am being enabled to do my work, like I don't feel like I have barriers that I had in my previous world—and it's all relative, I guess . . . Having an open space, having a social environment, having very similar specs to my office, lots of open space— I think it does enable me to have these emotions*."**(WCB-1P1)**

Other issues related to the Layout Quality included the "*work or meeting rooms' availability."* Occupants in the CDC complained about the insufficient number of rooms, as stated by **CDC-IP2:** "*Sometimes it is tough to book room sometime . . . we have so many people and staff . . . to have a treatment space or an assessment here is a kind of big challenge."* In the **GLW**, however, there were no issues with that as they have a computer lab and enclosed offices available for more privacy. In the WCB, it is considered a managerial issue rather than an environmental quality related to the building itself; however, it does affect the QoL through Functional Comfort and efficiency, based on what one of the interviewees, **WCB-IP2**, said: "*Sometimes it is tricky to get a meeting room, so sometimes what I have to do in order to get people together to facilitate a decision. So getting work done if I can get them*

together to get a decision made because I can't find room or whatever then it delay the outcome of the decision so the decision being made and it result for work"

6. Spatial organization: In the CDC occupants perceived the space as crowded due to the workstations being close to each other, leaving not enough space for visitors or comfortable circulation. Also, occupants with workstations close to the kitchenette had issues with smells of food; the smell from bathrooms was a problem for those located close to them. In the GLW occupants' only issue was with the location of printers—in the middle of the space, causing traffic crowding and noise. In the WCB, **WCB-IP1** complained about the "*location of services"* (bathrooms) and **WCB-IP2** said, *"The bathroom is kind of far, so I guess that takes a little while to get to the bathroom and back."* This may lead to wasted time and affect work efficiency.

7. Personal Workspace/Workstation Quality: Issues raised in the CDC associated with the quality of personal workstations are the insufficient storage, and workstations' locations. As described by **CDC-IP1:** "*Well, the storage is always an issue*" and perceived it as "*not enough storage."* It is found that people put lots of stuff on the desk, under desks, around the chairs, etc. That caused people to sit in uncomfortable postures, which, in turn, caused some complaints about neck and back pain. Workspace location is perceived to affect Functional Comfort in terms of the time wasted to access resources or to get or submit work to colleagues.

Similarly, in the GLW, workstation location was also found to affect the ability to get work done by participants such as **GLW-IP3**: *"Well, I get distracted; just because of what my job demands for where I sit."* It is found to affect occupants' QoL from a Psychological and Cultural Comfort perspectives through feelings of privacy and status, as stated by **GLW-IP3**: *"I get frustrated because there [are] so many people walking by my desk, and I am trying to concentrate or whatever I am trying to do. Sometimes I can block it out—ignore it—and sometimes I can't. It's mostly frustration would be the big mood"*.

In the WCB the personal workstations were perceived as comfortable and described as spacious, and according to **WCB-IP1**, "*efficient, effective, positive, clean, robust—it's multipurpose."* Qualities liked are the openness and connection with other employees, as well

as the sufficient storage space for work and personal items, which contains details described by **WCB-IP2**: "*Something that locks, storage for things, elevated shelves for binders; just little things like that make big difference."* There was only one complaint about workstations away from windows; **WCB-1P2** said he/she needed more connectivity with nature through a view or indoor plant: "*I would like some plants but I don't think I am close enough to a window."*

8. Ergonomics and Furniture: In the CDC the Ergonomics and Furniture factor affected occupants' Physical Comfort in the kitchenette and the personal workspaces. Due to the lack of enough storage space and uncomfortable furniture in personal workstations, **CDC-IP1** suffered from "*shoulder and neck pain because it is not ergonomically set up at all, and part of that is lack of space, so I had to store stuff. Like, I have stored stuff under my desk, I have stuff stored beside my desk, and because there is no sufficient storage space at all for anyone in this building . . . that changes ergonomically where my seat is.*" Furthermore, the ergonomics in the kitchen/lounge area are *"so poorly designed . . . you have a very poor access to getting plates and things . . . It is an occupational hazard . . . that they put the cups up so high that you get on steps to get a plate and somebody one day will have an accident"* (**CDC-IP1**).

Several complaints are also found in the GLW from either the desk and chair together or the chair only. They are found to cause an exhausting situation on the Physical, Psychological, and Functional Comfort levels. On a physical level, they may lead to neck stiffness and back pains due to uncomfortable postures; psychologically, they cause frustration and mood annoyance. **GLW-IP3**: "*I get really frustrated when I bang my knees or hit my head; that's also health."* Their discomfort may affect the work performance through distraction and time wasted to cope with uncomfortable postures, and as mentioned by one of the interviewees, the effect on Functional Comfort varied between positive and negative effects. The desk size is considered a positive quality. **GLW-IP2**: "*I like the desks that we have; there is enough space for people to spread out, and people can have multiple things at a time, so that's an enabler."* But the design itself and the ergonomics between the desk and chair is a complaint and considered distracting:

"Well, I guess there [are] two things. So, the desks . . . because of the board, so my legs are facing this way and my head is facing this way, and I think I have a stiff neck because of that . . . and then, like, the chair—if I have it set, like, there, [there are] only two setting[s]. Either it's locked in, so you cannot lean back, or it just leans back, like really, really far, so either I am sitting like this: straight, leaning too far forward, or I am leaning way too far back. Like, there is no in-between . . . I think they are kind of a little bit distracting, because I find myself sometimes, like, sitting there and I realize that I am horribly uncomfortable, and my feet are, like, twisted and, like, trying to fit against this wall, and I just kind of stop and sit back and I look at it and think, "What I am gonna do to fix it in the future?" because I have designs, like, of getting rid of that plate (the board in the desk) and just kind of wondering whether I am just gonna do it myself or I don't know. I think about it a little bit too much— it's distracting." (**GLW-IP1**)

In the WCB occupants had a positive experience due to three reasons. First, the fact that occupants' complaints are listened to and responded to, as mentioned by one of the interviewees: After the maximum adjustments **WCB-IP1** he/she did to his/her chair, it was still uncomfortable for his/her body size, hence *"they changed the chair*." This emphasized the positive experience he/she had when his/her needs were met. Second, the high adjustability and customization of furniture is found to affect occupants' (Physical) Health. **WCB-IP2** mentioned, "*Because everything was able to be adjusted, I am very comfortable."* The third factor is the good quality of furniture, as it increased the people's feeling of safety. "*The quality of the furniture itself is very good so I don't feel like that it could break or, you know, you have something that is tippy or. . .so you feel comfortable that it is safe and again not going to waste any of your time by having to get it fixed.*" **(WCB-IP3)**

9. Equipment and Resources: in the CDC occupants' experience was also affected by the technology used and outdated computers. They are found to be slow and delaying work. Also, sometimes they crack and the time spent for technical maintenance to fix problems or avoid the destruction of data affected occupants' Functional Comfort.

Occupants in the GLW did not raise any issues regarding the technology and resources. However, it was suggested to have two large computer screens that can be hung and wireless keyboards to provide more desk space on personal workstations.

In the WCB technology is found to be affecting people 1) Psychologically, by decreasing stress and frustration; 2) Culturally, as a reason for pride; and 3) Functionally, as a work enabler. However, to better facilitate work it was suggested to have flexibility in technology,

using Wi-Fi, intranet, and laptops. This could also positively contribute to the work efficiency, hence, to Functional Comfort, as described by one of the interviewees:

> ***"****I think the biggest thing is if I have a laptop . . . that would enhance my work [efficiency] and my mood and because I could customize my environment and I could take it downstairs if I needed some sun; but I have a desktop computer, so I am stuck at my desk. I am a designer, so I think better if I can move around . . . and sometimes I just need some thinking time, you know . . . like, any kind of desks [are] not really that conducive to that. I have flexibility to work at home and I find that is better for focus."* (**WCB-IP2**)

10. Building Amenities: lounge, kitchenette, cafeteria, etc.: In the CDC occupants had one small kitchenette that was problematic to them, as **CDC-IP1** complained: "*There [are] 85 that work in this part and there [are] 8 chairs, 2 tables . . . there is no stove because, apparently, we would exceed the limitations for LEED."* Issues raised in **the GLW** regarding the amenities are noise coming from the kitchenette and insufficiency in size, as sometimes it is congested by people. Also, the occupants wished for more amenities that provide some relaxing benefits, such as showers and relaxing places. In the WCB occupants had a sufficient amount of amenities such as cafeteria, small kitchenettes on each floor, lounge, and gym; the only issue raised is noise coming from the cafeteria.

11. Aesthetics and Indoor Décor: In terms of colors and artwork, the CDC is found to influence occupants' Psychological Comfort (mood, and level of inspiration). They are considered fine but not contributing to a "*happier mood or more content mood,"* according to **CDC-IP1**, as well as not suitable for the type of tasks being performed. *"Because we are in pediatrics, having something that's more colorful, more child orientated"* (**CDC-IP1**) would be more appropriate. The colors are perceived by the occupants as *"very subdued"*; **CDC-IP2** said, "*They are not in-your-face kind of look-at-me bright and sunshiny and cheer, you now. I like to see things like flowers and sunshine and primary colors—things that you know, if you look into research, can help to lift people's mood. We know that dark or somber colors like these are meant to be calming but they are not utterly inspiring either."* In the GLW colors are described as relaxing, yet **GLW-IP2** perceived them as *"a bit boring after a while; if I am having a bad day. . .I feel like I could have some more things on the walls —bring a little more color; it's blue and white, but having more accent color or something to change that."*

In the WCB the colors and materials contributed to a positive experience, and **WCB-IP 1** perceived them as *"very calming colors and materials. . .so that's good because sometimes work can be stressful."*

4.3.2.3 Theme 3: IEQ Factors in the Behavioral Environment Interacting with Occupants' QoL Experience

12. Privacy: Visual and Sound Privacy: Occupants in the CDC worked in either an open-plan layout or in enclosed private offices. Interviewees working in the enclosed offices had less issues with privacy in general due to better Visual Privacy, but still some issues with the Sound Privacy factor are found due to the lack of soundproof wall; they were also more comfortable with having the ability to control and obtain the level of privacy they needed. To the contrary, occupants in the open-plan had complaints about the lack of privacy, as **CDC-IP1** explained: "*You know, privacy is always gonna be an issue [if] you don't have walls*." Phone calls in specific are problematic, as the type of tasks performed in the CDC require confidentiality of the patients' information. Hence, a higher degree of privacy is required. Two phone booths are available in the work environment. However, they are found to be insufficient and inadequate. First, because they are very few for 82 employees working in the office. Second, because (some occupants commented that) it is just impractical when you are already receiving a phone call at your workstation to end the call and go to talk somewhere else. A significant response the interviewees working in the enclosed office had is being upset due to the inequity with other colleagues, as **CDC-IP3** explained:

> ***"****I am kind of socialist at heart. This whole thing about offices has been a dilemma, and you know, it continues to be controversial, and I think everybody, especially of a certain level of training, educational background, and type of work requires acknowledgment that they require some privacy, and they think that in terms of the design and the decisions of this building that wasn't really taken into consideration. It was taken for some and not for others. That's my political point of view."***(CDC-IP3)**

The type of tasks performed in the GLW didn't require special privacy or confidentiality between colleagues, and the personal privacy of occupants varied according to their workstation location and type and whether they worked in an enclosed office or in the open-plan. Occupants working in enclosed offices felt more privacy than others. No issues were found regarding the Sound Privacy factor, even in the open-plan, because there are empty

offices that can be available for conducting personal phone calls. However, some occupants in in the open-plan had issues with the Visual Privacy, while others didn't mind, as they thought it is all about work; they didn't take it as a *too personal* issue.

In the WCB all the three interviewees agreed that there is no privacy due to the open-plan layout; however, they were not so bothered by that either because they found means of adaptation or just learned to accept it and have nothing to worry about. **WCB-IP3** discussed that it is all about "*just understanding what is the culture of privacy, understanding how loud is loud, talking on the phone or having meetings in cubicle spaces where people are gonna hear. You know what's appropriate for holy conversations . . . just the culture of privacy*." Yet he/she still thought it is a challenge because "*whether you like it or not, [you] overhear people's conversations and some of them are meant to be private."* He/she mentioned that the walls in the boardrooms are not soundproof and that *"we can hear everything that had happened, so whether they think that they are embracing the culture of privacy and they are doing the right thing, we can still hear everything they are saying."* He/she considered privacy an issue with all people and that some seek means of adaptation. For example, *"The headphones thing; find most people working with it, myself included. So I have, like, sound-blocking headphones"*

For the Visual Privacy factor, **WCB-IP2** managed to find some coping and adaptation behaviors to deal with the desk and chair positioning in workstations, where the back of the employee faces the entrance of his/her workstation. She explained, "*I medicate that by actually putting the guest chair in the middle of the space so that the person would have to say something to me before they enter the space. Because if you have someone coming behind you and it's very close as you're concentrating on whatever, it can be uncomfortable*".

13. Personal Control: Very limited occupants' control over the environment is found in the three buildings, such as the operable windows in the CDC and the WCB. However, occupants used their own means to feel more comfortable with factors in the Ambient Conditions or the Designed Environment, such as dressing in layers, using desk task lighting, getting personal fans or personal heaters, wearing ear plugs and headphones, or adding a board in the workstation for privacy, like in the GLW. Occupants' need for control also differed from one building to another depending on how comfortable they are with the environment. In the CDC

occupants had several issues with the Ambient Conditions and Privacy, where Personal Control forms an important requirement to them. In the GLW, Personal Control was a factor of average importance, as the situations in the work environment didn't require many changes. However, it increases the positive experience; the first interviewee, **GLW-IP1**, said "*I guess, like, it would be great if I could kind of have my own kind of lighting, but I don't think, like, with an open office environment like that one light control; it's not going to happen."* **GLW-IP2** noted, "*Yeah, just turn on my lights, turn on my desk lamp, and open my blinds,"* and this indicated the dependence on extra task lighting in addition to the fluorescent lighting, as well as windows, to adjust the amount of illumination. Personal Control was raised by all the four interviewees, but on different conditions: lighting, temperature, and noise. The HVAC system is found responsible for the quality of other factors such as Thermal Comfort, Personal Control (of temperatures), Noise Control, and Maintenance Quality. **GLW-IP4** said, "*In winter it gets really cold and in summer it's really hot, so depending on what it's like in there, I need to either turn on a heater or turn on the fan."* But Maintenance Quality seems to improve the situation of Noise Control. **GLW-IP4**: "*It's either too hot or too cold, and we really can't control any of the heat. It just kind of comes the way it is. Sometimes it's noisy, but that has got a lot better*." The Personal Control factor in the WCB is perceived as not essential because occupants were generally comfortable with the environment, according to **WCB-IP1:** "*There is nothing that negatively impacts.*" **WCB-IP3** agrees**:** "*The building does a pretty good job of regulating itself."*

14. Personalization: Occupants in the CDC tend to use a lot of personalization for two reasons. First, because they were told otherwise: that they can't personalize the workspaces, as workstations are not owned and should be shared with everyone. **CDC-IP1** elaborates on this: "*The space is meant to be utilitarian, so it is meant to be that I could go to somebody's office and sit down and do my work in there or share an office space with somebody and not deal with personal mementos or diplomas or pictures of other families or whatever.*" However, the occupants did the contrary to create territoriality and feel that they have a choice. This helped in determining territoriality from others "*because they feel it is not their things and they feel they are encroaching somebody else's space*" (**CDC-IP1**). The second reason is some occupants felt the work environment is boring and has very institutional and neutral colors that

are not kid-friendly, so they wanted to do something different to feel better. **CDC-IP1** mentioned: "*I have chosen not to follow that because I had to personalize it to make it tolerable to work here; because it's very bland and boring and dull and kind of depressing the color scheme here.*" Regardless of whether some people preferred personalization or not, it is suggested by **CDC-IP3** that having a say is important: "*It's nice when people have choice in the matter that they can or can't do that*."

This concept of freedom of choice was so apparent in the GLW, where personalization is allowed; however, less desire for personalization is found as compared to the CDC. Occupants' experience revealed some concerns about the conflict between personalization and privacy as they viewed personal photos to be a personal issue; while others had neutral preference toward personalization. The same concept of freedom of self-expression was also emphasized by **GLW-IP1**, who said, "*If I needed something different, I just go and talk to them,*" referring to the managers. This rose the issue of how it is important for occupants' QoL experience to feel that they can be listened to.

In the WCB personalization is also allowed. **WCB-IP3** said, "*Most people have something, have pictures of their kids, or their family or their dog. It is very few that you would see nothing at all. So it is an acceptable cultural practice here."* This gave the control and choice for occupants to decide whether to do it or not. Responses varied from liking to disliking it, where it is found to be attached to the sense of belongingness. One of the interviewees even perceived the customization of furniture as a kind of personalization because they make her workspace different from others. Occupants who disliked personalization thought it looks unprofessional for an office building.

15. Crowding: Was an issue only raised by occupants in the CDC working in the open-plan, who were unsatisfied with the Spatial Organization, Personal workspace (workstation sizes, lack of enough storage for work documents and personal items), as well as Personalization (the excessive personalization of workstations) factors—all contributed to their feeling regarding crowding.

16. Territoriality: In the CDC, occupants showed territorial behaviors through the personalization of their workstations to ensure no one else uses them and defeat the culture of

shared spaces declared to them as an organizational culture. This issue in specific didn't show significance in the experience of occupants in the GLW and the WCB, as everyone already has an assigned space that protects their ownership of it.

17. Connectivity with Nature: Several features are found to connect occupants with nature, such as plants, water, views, and daylighting. Connectivity with Nature factor is described in the CDC as a health issue. **CDC-IP2** points out Physical and (mental) Psychological effects: "*I think the fact the I can see the sky each day allows for the circadian rhythm to be managed a little bit better by your body and your brain. . .the vision of the sky. . .you know is it day. . .is it night."* The only contributor to the Connectivity with Nature factor in the CDC is found through views for workstations proximate to windows. In the GLW several interviewees also mentioned their need for daylighting. In the WCB daylighting is maximized through the all-glass south façade and entering through the glass staircase, as well as the open-plan layout with low-partitioned cubicles or the high-partitioned ones with the upper part made of glass, which allowed more sunlight to penetrate. People like **WCB-IP1** perceived it positively: "*The Sun definitely impacts my mood"* in a good way. It is also perceived to have a Psychological influence:

> *"I find it gives me a relaxing mood to be outside, so in the summer or whenever, it's nice. I just get out and I like that there is a patio out there that's a big thing for me. I like to be outside for as long as I can in the lunch time, and there [are] also nice pathways around the building, and you can count that; it's good because you can walk and that sort of stuff. So I think those are mood like, relaxing and uplifting the mood.*"(**WCB-IP**)

18. Safety and Security: Many indicators in the CDC are found to influence the feeling of Safety and Security, such as the inadequate hygiene due to lack of hot water and antibacterial soap, the open-plan layout that is perceived as enabling more spread of infections, the organizational culture of shared spaces that also encouraged more transfer of infections, and also the lack of access to wheelchairs in case of emergencies where the elevators cannot be use and the only other way is stairs. Furthermore, the ergonomics as described in two situations; first, in workstations' postural hazard, and second, in the high cupboards in the kitchenette, where things could fall on someone. Safety and Security wasn't a raised issue in either of the GLW or the WCB.

19. Social Interaction: According to the interviewees, this quality could be achieved from the open-plan layout, as well as the presence of social amenities such as kitchenettes, lounges, and cafeterias. Those roles were found as positive experiences both in the GLW and the WCB, while in the CDC only the open- plan was found to influence Social Interaction positively.

20. Pride: In the CDC none of the interviewees had shown pride from working in a LEED green building. In fact, **CDC-IP1**'s reply was harsh. "*No. Absolutely not. No, no*." However, reasons for Pride factor came from either the job itself or privileges found in the personal workspace: **CDC-IP2** said, "*Well, I take pride of my space because it is clean, because it is tidy."; or "I have larger desk. . .I have a window near me that is able to open. . .larger space than a cubicle."* Regarding the building pride, **CDC-IP2** said,

> *"I wanna come to work in and feel I am proud of where do I come to and have others that come to our space like it as well. Am I disappointed with it? Yeah, and I guess having families and children coming into this front waiting room—that would probably be my biggest source of disappointment because it is not family-friendly, it is not child-friendly, it's not fun, there is no colors, there is no bubbles—you know, there is just nothing."*(**CDC-IP2)**

His/her words emphasized on how—when the image of the building is irrelevant with the tasks performed inside—the building can cause disappointment and decrease the feeling of the Pride factor in environmental quality. The interviewee who worked in a private office and had a window felt that she is proud and her status at work is well represented, according to her own words:

> *"I feel great. I feel acknowledged, and I got this office because I've been around a long time, so my manager said, 'You know, you deserve a nice office because you've been around a long time, so would you like this office?' and I said, 'Sure,' and I did—I felt acknowledged. I felt respected for the seniority that I have."* (**CDC-IP3**)

In the GLW, the Pride factor is found to be influenced by the location and type of workstation, type of company, and type of work done. In some cases the personal workspace, if is not valuing the employee's status at work, is a disappointment and lack of pride occurs. The first interviewee, **GLW-IP1,** said, "[I] *have no issues with that,*" while the third interviewee, **GLW-IP3**, is a senior engineer, and he complained about his workstation location and type: "*Absolutely. I was so angry when they assigned me this workstation because, like, I am a senior engineer and this is where you're gonna sit me? Definitely a link*

[between status and pride] and I was unhappy and still I am unhappy, and I think they could probably do a little better job in finding me a nicer place to sit."

The three interviewee, working in the WCB felt proud due to different reasons. According to **WCB-IP1,** "*I feel lucky. I feel fortunate to be able to live in such a great place and to work in such a great environment.*" Reasons contributed to the Pride factor are the building image, building location, building accessibility, getting natural sunlight, physical work environment, having a privileged personal workspace (location, window, look and image through personalization and presenting her identity or personality), as well as their organizational culture that promotes equity and equality. **WCB-IP3** also thought that there is a link between his/her feeling of pride and the congruency of beliefs, as he/she said, "*It kind of works with congruency of beliefs. I am proud to work in a place where everyone is treated equally. So we make decisions as a business how we're going to use our space and even decisions like how we operate the building.*"

21. Status: In the CDC occupants perceived that the type and location of their personal workstations affected their feeling with the Status factor, such as having an enclosed office or a bigger corner desk beside a window. Also, personal workstation affected occupants' feelings concerning the Status factor in the GLW. Located on an internal corridor in the open-plan as a senior engineer is perceived very humiliating to his/her Status factor (at work) because it lacked privacy. No issues were raised regarding Status in the WCB, probably because it has a non-hierarchical culture, where managers and employees share the same open-plan.

22. Image and Value: In the CDC the occupants' were uncomfortable with the image of the building, perceiving it as unfriendly, not suitable for children, bald, and as having a few irrelevant artworks. In the GLW no issues were raised regarding occupants' experience with the Image and Value factor. In the WCB, occupants perceived the building as inspiring. **WCB-IP3** described his impression about the design: "*I like the design. I think the design is kind of inspiring. You know, challenges people to think differently*." That also affects Functional Comfort of the employees.

23. Congruency with Beliefs: In the CDC the organizational culture is about shared workspaces rather than owned ones, and this elicited issues as personalization, territoriality, sense of belongingness, and the ability of having choice. **CDC-IP1** said**,** "*I think that was a*

real struggle for people because everyone likes to have a feeling that they belong somewhere in the organization they call their own, so as a result, people being people have done that." All of the three interviewees were incongruent with the prohibition of personalization, but regarding the shared spaces concept the responses varied. It is found that the interviewees working in the open plan are fully or partially incongruent with this belief. **CDC-IP1**'s comment on this issue was, "*No. We have just done our own thing.*" **CDC-IP2** said that, regardless of his/her understanding of why spaces should be shared, she agrees with that, but she doesn't agree with the idea that if it is a shared space "*you can't do anything to personalize it or you are not allowed to do x, y, and z, or that in the sense it could be demeaning to the staff in terms you can't do that or you are not allowed to do that.*" To the contrary, **CDC-IP3**, who works in an enclosed office, was more accepting of the culture of shared spaces: "*There is efficiency in that,"* especially when some people work part-time—then it is good to have the opportunity to use their spaces, and in specific "*colleagues who're in that open area who need privacy and this could be a quiet place for them to come and work, and I think that is great*." However, he/she is still in solidarity with the ability and freedom of personalization, as she believes it's "*a positive thing*" that gives "*more a sense engagement, a more of investment of the space*."

In the GLW beliefs are conveyed to the occupants in terms of three means: the motto of the company, the design of the workplace layout, and the culture and behavior of the company through its managers. **GLW-IP1** stated that the company motto "*is quality, consistency and repeatability*," which the interviewees found themselves congruent with; also, the managers' behavior and the culture that encourages the openness of listening to the occupants is explained by **GLW-IP2**: "*We do if the people need things that we don't have available for them. We just tell them to ask and then we get it for them . . . we don't have like fixed . . . as long as within reason.*" The work environment also creates congruency between the occupants, yet there was a controversial reaction toward the workplace layout and design. **GLW-IP3** even thought they don't reflect much of the company's motto about quality, as it was too open: "*Screwed it up, so let's bring it back. Let's get some separation between spaces. You can still be opened but more separated,*" where open-plan in his viewpoint compromises the quality of workspace in enabling the work to be done efficiently without distractions.

In the WCB all the three interviewees consider themselves congruent with the beliefs of their current work environment, which can be summarized as equity, collaboration, connectivity with everyone else, accessibility, honesty, integrity, modernity, sophistication, and environmentally progressive. They are conveyed through the open-plan design of the workplace and the modern, sustainable, technologically-updated building, and through their culture. **WCB-IP2** justified the reasons for the open-plan design: "*If I don't want to interact with colleagues, then why should I be in an office then? I should be, like, work from home. Because I think why else do you get people to a building except to interact? So it should be enabling that."*

4.3.2.4 Theme IV: IEQ Factors Associated with Occupants' Building Operation and Maintenance that Interact with Occupants' QoL Experience

Building Operation and Maintenance included factors as Hygiene and Cleanliness (hot water, vacuumed carpets, clean washrooms, clear toilet flush water, anti-bacterial soap, clean water), and Maintenance Quality (frequency, fixing broken fixtures), though those two qualities' influence may alter occupants' experience with Ambient Conditions or Designed Environment. The researcher found it best described as a separate category related to building operation and maintenance as it is not something that can be achieved during the design stages of the building.

24. Hygiene and Cleanliness is an operational issue within the building; however, it is found to affect occupants' experience from Psychological and Physical Health perspectives. The occupants of the CDC are not ordinary employees; they work in healthcare, and part of their job is actually meeting patients in the treatment rooms and then reporting, documenting, and doing further assessments in their workstations. Hence, they are more sensitive toward Hygiene and Cleanliness, which affect their Psychological Comfort and physical health. **CDC-IP1** said, "*The cleanliness of the building and how it's taken care of, no; nobody wants to go into a dirty washroom; that's kind of embarrassing—produces some of frustration, embarrassment, disappointment, perhaps a little bit of disdain."* This interviewee said other reasons for discomfort with Hygiene and Cleanliness were "*we don't have hot water, so when we can wash our hands, we are getting ice cold water. So there is no hot water ever."* In the GLW there were no issues regarding the Hygiene and Cleanliness of the work environment;

however, the washrooms in the floor corridor were a concern and perceived as smelly. During interviews no issues were raised regarding Hygiene and Cleanliness in the WCB.

25. Maintenance Quality: An interviewee in the CDC discussed maintenance as an issue on two levels: (1) on the time of response when something needs fixing, as it takes three to four weeks to fix it, and (2) on the daily operational needs, such as soap and tissues for the washrooms. That also affected the quality of Hygiene and Cleanliness factor when the employees find no soap or sanitizers. Maintenance in the GLW was described as responsive. While there were no issues regarding the Maintenance Quality was raised during the interviews in the WCB.

4.3.2.5 Theme 4: Other Non-IEQ Factors that Interact with Occupants' QoL Experience

This category included convenient Parking, and Building Location: orientation, accessibility, and less commuting.

26. Building Location: Although it is not an IEQ factor, it is found to affect occupants' experience with the work environment in both the GLW and the WCB**.** The location of the building is found to influence the access to daylighting, transportation means, parking, and accessibility. This further affects Physical and Psychological Health.

27. Parking: Parking is an issue with occupants in LEED-certified buildings. In both the CDC and WCB, it was an essential quality. When asked about the best quality in the CDC, **CDC-IP1** stated, *"I have underground parking; I am sorry. That is all I can say . . . this is a spectacularly awful building to work in."* Occupants in the WCB expressed frustration coming from the lack of enough parking slots and being late at work due to searching for a place to park in. One of the respondents in the WCB, **WCB-IP2**, said, *"I didn't expect that the parking would be a pain."* LEED strategies work on decreasing parking lots; however, this might be stressful for some occupants, but that would be okay, according to **WCB-IP1**, "*if they encourage people in some other way to take a different transportation.*" She suggested providing bus passes, for example. **WCB-IP2** mentioned, "*They reduce parking, thinking that people will use less cars; but, actually, they just park farther.*"

4.3.2.6 Significances of IEQ Factors in the Interviews Based on their Frequency of Repetition

The researcher elicited the IEQ factors in each building from occupants' own words during the interviews; thereafter, the researcher counted the repetition of each factor to find the significance and relative importance of it on occupants' QoL experience. First, the factors are counted for each building separately and compared, as in Figure 107.

For the CDC the most significant top five IEQ factors are Thermal Comfort, Personal Control, Personal Workspace Quality, Acoustical Quality and Noise Control, and Hygiene and Cleanliness respectively. This is due to the several complaints from temperature inconsistencies, lack of personal control over building systems, small size and lack of storage of personal workstations, several noise distractions in the open-plan, and lack of disinfecting soap, hot water, and insufficient carpet cleaning.

For the GLW the top five significant IEQ factors are Personal Control, Ergonomics and Furniture, Lighting Quality, Acoustical Quality and Noise Control, and Aesthetics and Indoor Décor. Several complaints were found about uncomfortable desks and chairs, as well as insufficient lighting in some places in the office.

In the WCB the top five significant IEQ factors are Layout, Personal Workspace Quality, Thermal Comfort, Lighting Quality, and Spatial Organization. The (open-plan) Layout is perceived as inducing social interaction and work collaboration, yet causing noise from colleagues. The Personal Workspace Quality, is perceived as a good contributor to occupants' QoL due to spaciousness and enough storage space, adjustability, and customizability. Similarly, consistency in Light Quality, Daylighting, and Thermal Comfort, were all factors contributing positively to occupants' QoL in the WCB.

Second, the factors are combined and classified into conventional versus green buildings, as shown in Figure 108. Frequencies were converted into percentages to be able to compare the two building types (Green vs. Conventional), with different numbers of respondents. The combination of green buildings finds Thermal Comfort, Personal Workspace Quality, Personal Control, Acoustical Quality and Noise Control, and Layout as the top five significant IEQ factors on occupants' QoL.

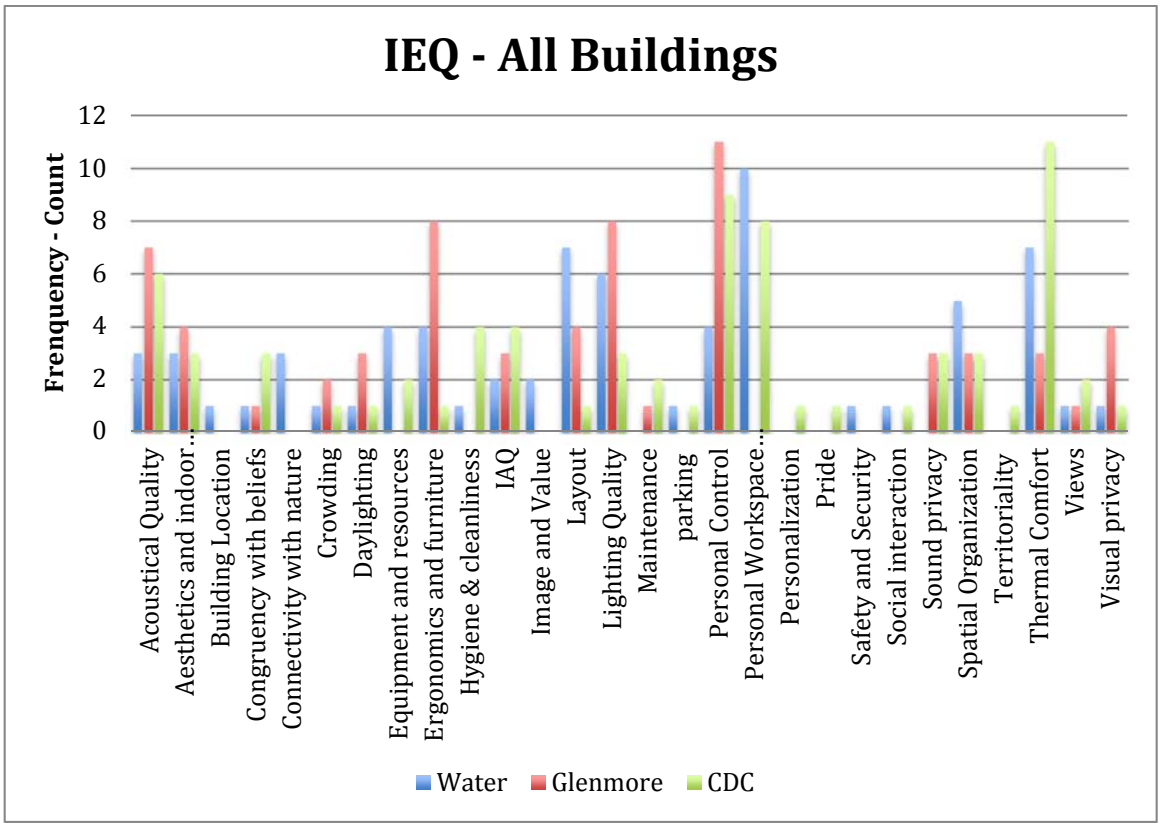


Figure 107 Ranking of IEQ factors from interviews in each building

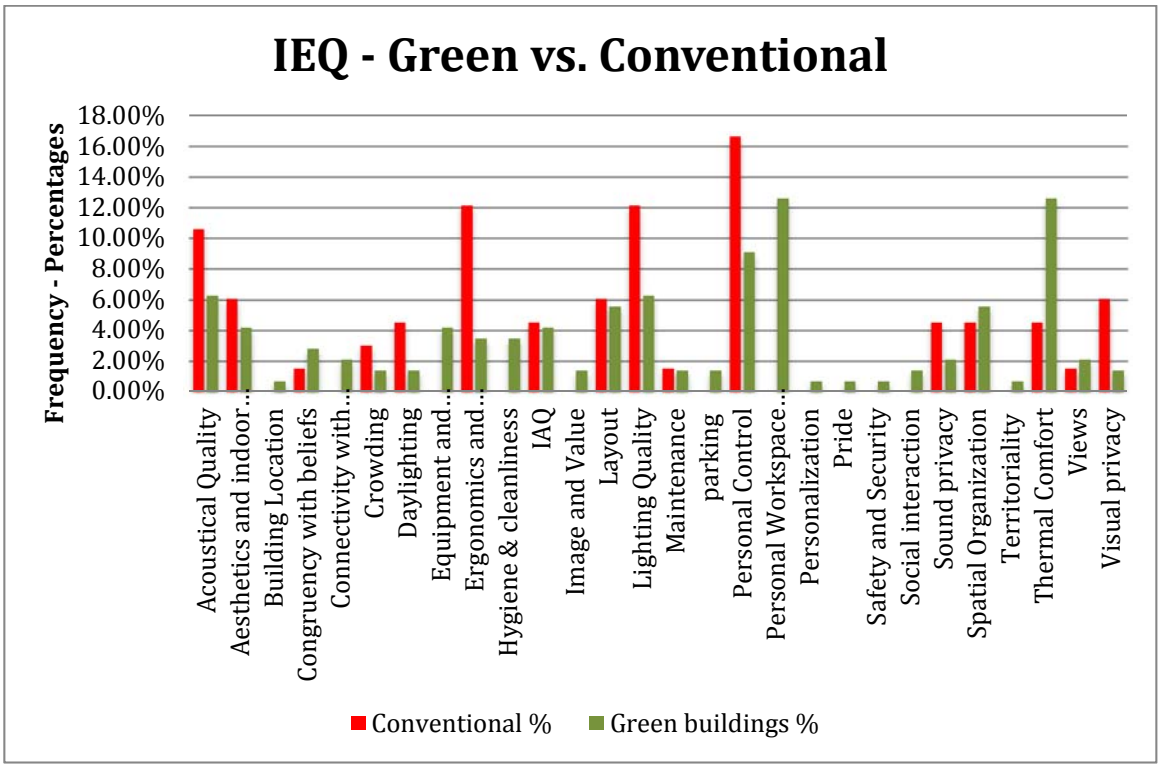


Figure 108 Ranking of IEQ factors from interviews in conventional and green office buildings

4.3.3 OBJECTIVE V: Defining Constructs of a Humane Work Environment.

The present research is concerned with the concept of a humane workplace from occupants' point of view. The target here is developing occupants-oriented criteria to create a space that meets and supports occupants' needs and activities, hence providing the objective and subjective dimensions of human QoL. To better understand this concept, listening to the people's own words through interviews is believed to be the most suitable way for constructing a humane work environment based on real, lived experience.

In the CDC-LEED Platinum building **CDC-IP1** perceived that "*humane has little to do with the building than it has to do with the management stuff*." She explained, "*You know, does the roof leak? No. Are the toilets backing up? Where there is water over the floor? No. So it is humane. Is it pleasant? No. So humane is is there light? Is there heat? So it is fulfilling the basic needs."* **CDC-IP2** defined humane more as the concept of human friendly or *user-friendly design* in terms of color, design, flooring, as well as adequacy in size or ergonomics. He/she said, "*Well, humane means to me that this building or floor would be designed with comfort and efficiency of the people, including the public that come here."* This interviewee also supported his/her definition by giving an example of how the kitchenette in the CDC is not humane because it is too small for the number of people working there, it has no warm water, the cabinets are too high to be reached, it is dark, it has no daylighting, and it has no ventilation—so the smell of food fills the space and is not inviting. **CDC-IP3**, who works in an enclosed office, defined humane as "*feelings supported or comforted and respected."* He/she viewed herself as having a humane workplace because his/her environment treats him/her humanely; he/she said that the other people in the open space are probably not treated humanely because they need a "*larger space*" and "*[have] no privacy*." The place there is "*loud,*" "*distracting,*" and all of this is hard when you need to do a sustained cognitive task as report writing. He/she said, " *I find that not acceptable.*" He/she also raised the dimension of being "*equitable*" as an important value to the meaning of humane, as he/she mentions that inequity "*can create hard feelings. Why do those people get offices and we don't? And we are all seeing kids, and we are working with them, and we are doing assessment, and we are doing reports and talking to families."*

In the GLW, **GLW-IP1** defined humane as "*I am not in a discomfort in a situation where there is nothing that I could do about it."* Hence, he/she pointed out to the importance of control as the main core of his feeling of being in a humane environment. **GLW-IP2** said, "*I think humane means you treat people as humans and treat people equally, specifically what you get in here. The goal is to have everyone in a comfortable, happy environment that they like. You know you are trying to provide that to everyone equally. I think that's humane."* He/she emphasized the concept of equity and mentioned examples like *"everyone has the same type of furniture. Everyone has the same privileges. Everyone has a phone,"* but points out the importance given to the *control* aspect of occupants over their environments and how *flexible* the workplace could be to suit different preferences and needs. **GLW-IP3** viewed humane as "*if your basic needs are met, you're in a humane situation. In my opinion, is it the greatest workspace I've ever worked in? No. In fact it's probably one of the worst in terms of comfort, but it works and I get my job done. So would I like it better? Yes, please?"* He/she further described his basic needs. *"I am not cold. I am not working in the dark. I have a chair. I own a desk and a computer . . . we don't have massive temperature fluctuations."* **GLW-IP4** defined humane as "*not causing anybody harm. Nobody is hurt. People are respected."*

In the WCB, humane for **WCB-IP1** meant "*no negative detractor from the QoL, and no negative impact to the person physically, mentally, and humane is almost the middle point to it, so something be inhumane and it come to the middle and it be humane, then you go to the other side and be extra good."* This can be interpreted as giving a positive QoL and safe, in terms of health and psychology. **WCB-IP2** defined humane as "*acceptable for human inhabitants. Like, inhumane would be like a dirty cell or something like that."* An important interpretation that could be taken from that is that the concept of humane has a subjective value to it because what is acceptable may vary from one person to another; however, not having an adequately-sized, clean space is an unacceptable space. He/she further explained the idea of acceptable and unacceptable spaces, where an unacceptable workspace can be envisioned like this: "*You just have rows of people on a little table and just typing away. No personality. No personal space. You are not allowed to talk. You are not allowed to listen to music."* Here we can find more emphasis given to respecting people's psychological needs, such as personalization and sense of territoriality, as well as freedom or control. Furthermore,

he/she added, "*Dark. If it was dark, we wouldn't really work in a place like that or felt really closed, cold."* **WCB-IP3** defined humane as "*causing the least amount of impact on people.*"

According to the occupants' perception of a humane work environment, 11 themes are elicited. The themes and the factors that apply to them will follow. **Theme (1) Fulfilling Basic Needs** (Physical and Functional Comforts): An environment that provides comfortable thermal comfort, good Illumination, comfortable furniture, adequate tools (computers, etc.). **Theme (2) User-friendly Design** (Physical, Psychological, and Social Comforts): An easily comprehended designs and systems, ergonomically-designed, supporting wayfinding, color is appealing, comfortable design, appealing finishing materials. **Theme (3) Comfortable** (Physical and Functional Comfort): An environment that has adequate size, good ventilation, daylighting, comfortable ergonomics. **Theme (4) Efficient** (Functional Comfort): A functionally comfortable and productive environment. **Theme (5) Respectable** (Social and Cultural Comfort): An environment that supports, respects, comforts people's feelings. **Theme (6) Supporting tasks** (Physical, Functional, & Psychological Comforts): An environment that provides the needed amount of privacy, acoustical comfort, not distracting, and adequate size. **Theme (7) Equitable** (Social Comfort): An environment that ensures equity and equality through the use of same type of furniture, same privileges, same tools and facilities, same space sizes, same privacy, same ambient conditions. **Theme (8) Controllable** (Psychological Comfort): An environment that enables occupants' control. **Theme (9) Happy** (Psychological Comfort): An environment that makes people happier, supported and mood lifting. **Theme (10) Safe** (Physical & Psychological Comforts): An environment that is healthy physically and mentally, not causing anybody harm, no negative impact to the person physically, mentally, causing the least amount of impact. **Theme (11) Acceptable** (Physical, Functional, Psychological, and Cultural Comforts): An environment that has adequate size, clean space, flexible, respects different needs/subjective reality), allows self-expression, personalization, provides sense of territoriality, allows personal freedom and control. The themes' significance according to the three buildings compiled together is shown in Figure 109.

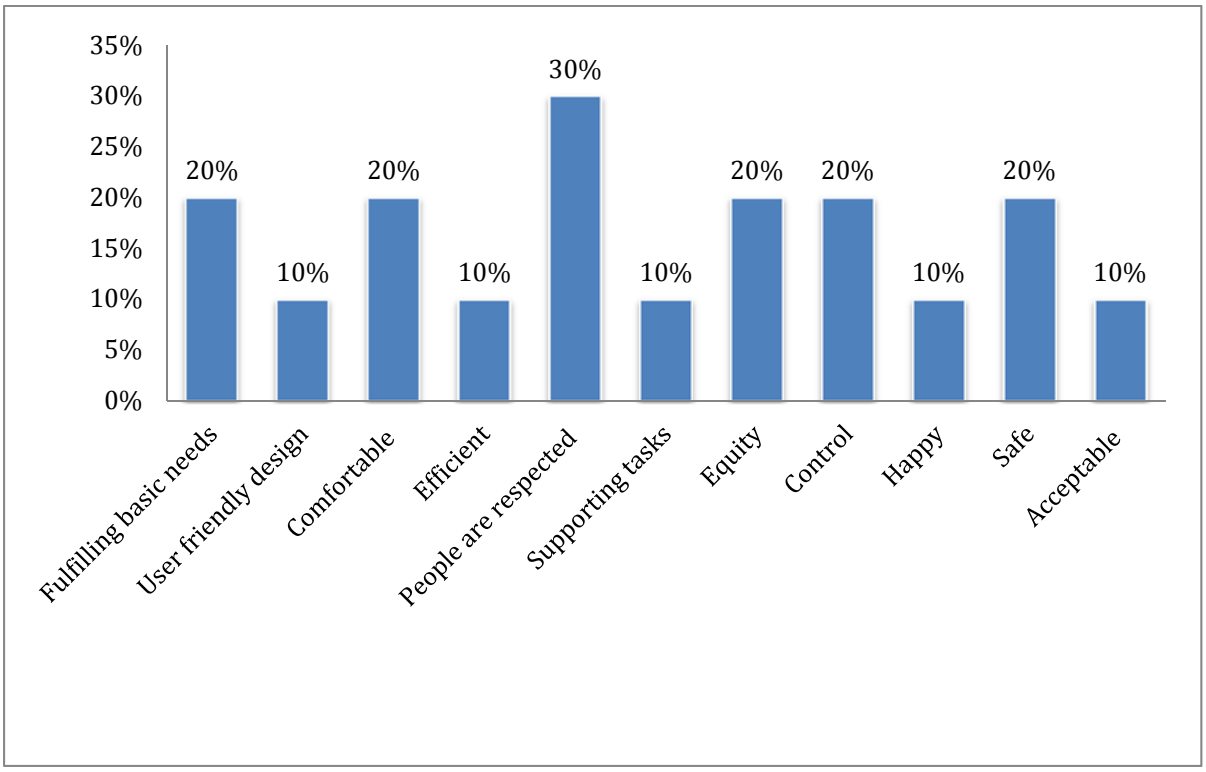


Figure 109. Themes of a humane work environment from the three buildings compiled together

The influences of these themes and their factors are grouped to form five categories of comfort: Physical, Functional, Psychological, Social, and Cultural Comfort. The frequency of repetition of each category is counted to indicate the relative weight and importance of each category for occupants' own definition of a humane work environment. Physical and Psychological Comfort are found to be equally repeated six times, followed by Functional Comfort (five times), then Social Comfort (three times), and Cultural Comfort (two times). This indicates the importance of fulfilling basic needs and psychological needs for occupants to feel they are treated humanely in a workspace. The more humane a work environment is, the more it respects social and cultural requirements.

4.4 Findings from the Focus Groups

Focus groups (see **Sec. 3.2.1.3**) were part of the qualitative strand in this study and were conducted as the final stage of inquiry in **Phase III.** Focus Groups helped to converge and reassure the findings of the IEQ factors from the interviews and questionnaires and gave the

internal validation to research results. The repertory grids used in the Focus groups helped in confirming the construct laddering of IEQ factors significant with occupants' QoL, as well as give a clearer understanding of all raised issues in **Phases I and II**. The repertory grids are analyzed using the hierarchical clustering technique using repgridtool (RGT)[8] and presented on the dendogram in Figure 110; a zoom-in is made just for the first five factors to give a clearer display of results.

The ranking of IEQ factors based on the constructs of QoL showed that, in the GLW, Views, Aesthetics and Indoor Décor, and Pride are perceived as the most healthy IEQ factors. Aesthetics and Indoor Décor, and pride are perceived as the most comfortable IEQ factors, and Aesthetics and Indoor Décor is perceived as the most IEQ positive on supporting task performance. When combining the evaluation of IEQ on all the QoL constructs, it is found that Pride is the best perceived IEQ factor regarding occupants' QoL, followed by Building Amenities in the 2nd rank, Equipment and Resources in the 3rd rank, Maintenance Quality, Status, Congruency with Beliefs in the 4th rank, Views, Safety and Security, Connectivity with Nature in the 5th rank, Personal Workspace, Ergonomics and Furniture in the 6th rank, Image and Value, Cultural Identity in the 7th rank, Aesthetics and Indoor Décor in the 8th rank, Hygiene & Cleanliness, Personalization in the 9th rank, and IAQ, and Layout in the 10th rank. The ranking of IEQ factors rated for QoL, Satisfaction, and Meeting Needs in the GLW are also presented on bar charts and shown in Figure 111.

In the WCB the IEQ factors perceived as the healthiest are Building Amenities, while pride, and Equipment and Resources as the most comfortable, are Maintenance Quality, Equipment and Resources, and Congruency with Beliefs as the IEQ factors most supportive to task performance. When combining the evaluation of IEQ on all the QoL constructs for the WCB, it is found that Aesthetics and Indoor Décor has the highest rank, followed by Pride, then Views in 3rd rank, Equipment and Resources, Hygiene and Cleanliness, Social Interaction in 4th rank, Personal Workspace, Safety and Security, Cultural Identity in 5th rank, Lighting Quality, Daylighting, Layout, Spatial Organization, Ergonomics and Furniture,

[8] Can be found at www.repertorygridtool.com

Personalization, Crowding, Territoriality all in 6th place, Maintenance Quality, Status, Image and Value in 7th, IAQ, Building Amenities, Wayfinding in 8h place, Congruency with Beliefs in 9th, and Visual and Sound privacies in 10th rank. The ranking of IEQ factors rated for QoL, Satisfaction, and Meeting Needs in the WCB are also presented on bar charts and shown in Figure 112.

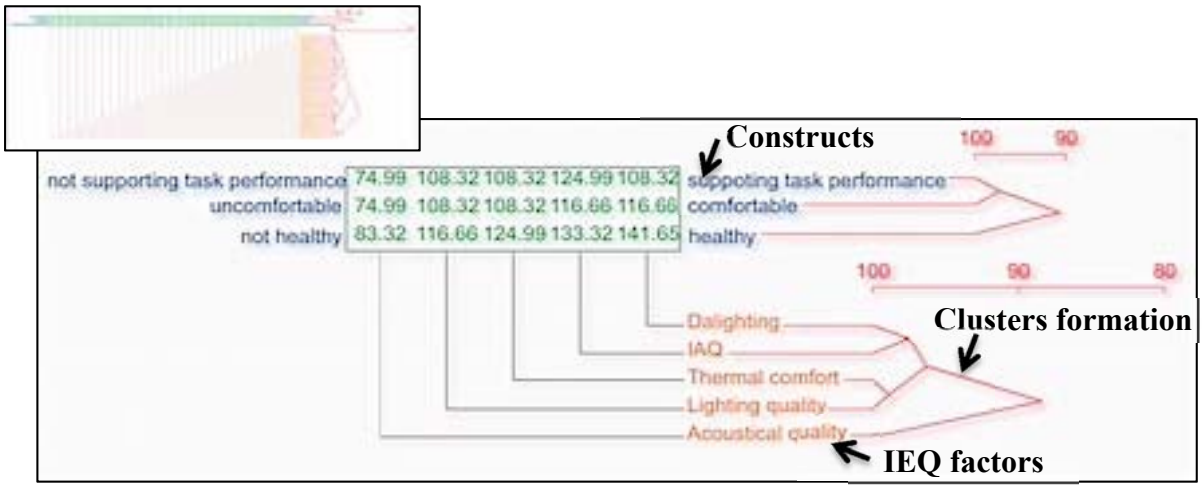


Figure 110 A zoom in the dendogram for part of the IEQ factors in green buildings

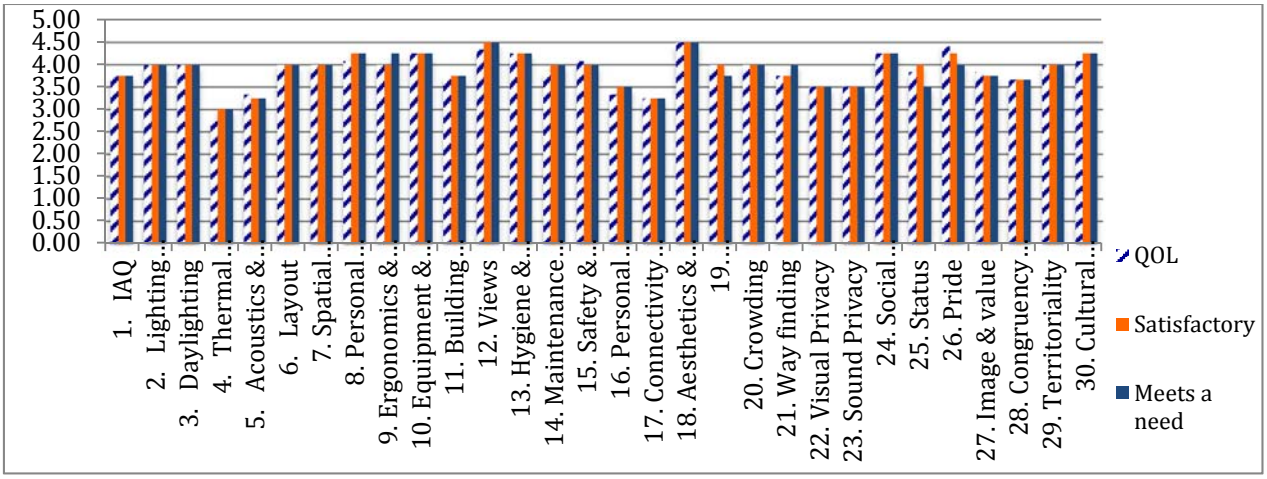


Figure 111 GLW IEQ factors significances

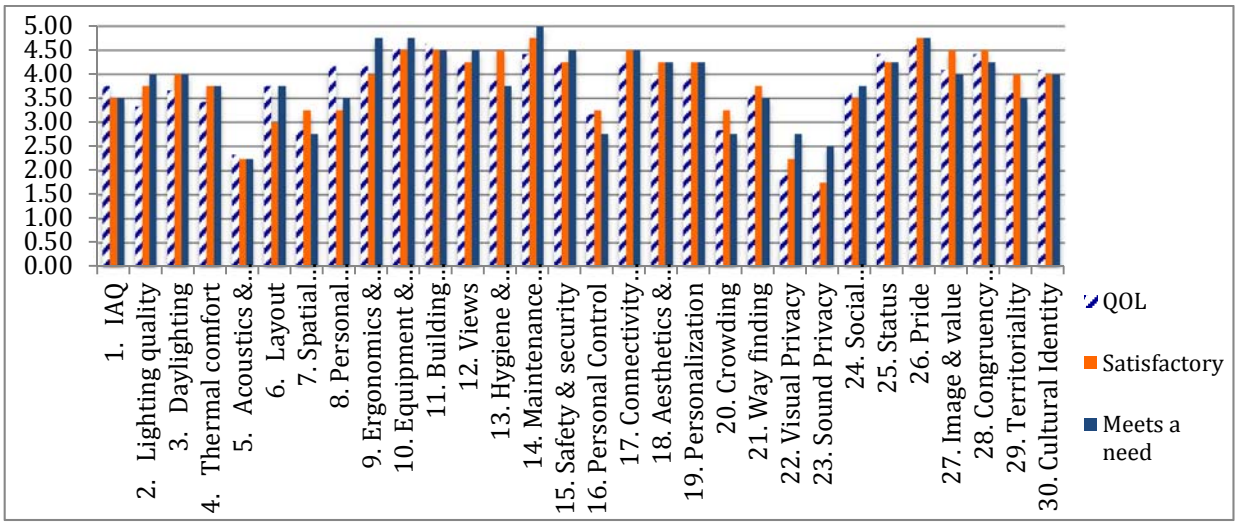


Figure 112 WCB IEQ factors significances

4.5 Summary

This chapter has presented the results and findings of each method separately and according to their phases of inquiry, along with the stated objective of each tool and phase. The main results of the study documented and explained occupants' QoL experience in work environments of both LEED and conventional office buildings. It identified the IEQ factors that are interacting and significant with overall occupants' QoL, and elicited the constructs of a humane work environment based on occupants' own definitions. The triangulation of the results and findings from different methods, as will be presented in **Chapter V**, enable the researcher to draw a comprehensive picture of the relationship between occupants' QoL and the IEQ factors in their work environment in both green and conventional office buildings. This comprehensive understanding also allows the researcher to test the proposed theoretical framework and propose a new fitted theoretical framework, as will be presented in **Chapter V Section 5.6.**

The photos in observations were found useful to describe the current quality and features in the work environment, as well as document any occupants' behaviors that resulted from their interaction with the work environment. These observations were then further investigated during the interviews in phase II, where justifications were understood from the occupants' responses. For example, the observation of a lot of personalization items in the CDC would

have never been elaborated upon except after listening to the occupants and knowing that the organizational culture commanded shared workspace. This was a rule occupants rebelled against; hence, it caused several territorial behaviors, driving some employees to add personal items to take *ownership* of their workstation and add self-expression to reinforce their identity. The results from both observations and interviews were then compared to the significance and assessment found in the questionnaires (closed and open-ended questions). This allowed the corroboration and elaborated the reason beyond occupants' perceptions and assessments. Moreover, the list of IEQ factors found significant (from the observations, interviews, and questionnaires) and the constructs of QoL (elicited from interviews and open-ended questions in the survey) were further tested in the focus groups. This allowed the convergence of results, construct laddering (ranking), and clustering of IEQ factors into categories. Those categories also confirmed the testing of the proposed theoretical framework.

For the individual assessment of IEQ factors, several studies in the literature have indicated that green buildings are rated lower in Lighting and Acoustical and Noise Control qualities (more complaints from noise in LEED –certified office buildings) compared to conventional office buildings (Leaman et al., 2007; Leaman & Bordass, 2007; Abbaszadeh et al., 2006; Paevere & Brown, 2008; Lee & Kim, 2008). This study corroborates with other studies that found Acoustical Quality and Noise Control factors to be rated higher (more comfortable) in the GLW (conventional building) than in the CDC and WCB (green buildings). However, this current study contradicts with previous literature for the result of Lighting Quality, as there were no complaints about lighting in the CDC (green building) in the summer or the WCB (green building) in both summer and winter, and the highest rating among the three buildings belonged to the WCB (green building). This study corroborates with the literature regarding findings about daylight's psychological benefit, yet occupants complained about its inconsistent illumination level, reflections, and glare on their computer screens. However, those results were not restricted to green buildings. Also, to the contrary, the inconsistent illumination problem was solved in the WCB (green building) by having responsive lighting that adjusts the illumination level accordingly, while the CDC (green building) and the GLW (conventional building) had issues with Daylighting too. Hence, this study indicates no

significant difference has been found between green and conventional buildings for Daylighting Quality; it is rather dependent on the design strategies used to solve the problem.

Some studies in the literature have indicated that green buildings are perceived to perform better on IAQ (Huizenga et al., 2005; Abbaszadeh et al., 2006; Paevere & Brown, 2008; Lee & Kim, 2008), while other studies showed that the ratings for IAQ were lower for green buildings than conventional ones (Leaman et al., 2007; Leaman & Bordass, 2007). This study shows that occupants in the CDC (green building) perceived it as uncomfortable and had several complaints, while occupants in the GLW (conventional building) and WCB (green building) were comfortable with the IAQ. Results on Thermal Comfort in previous literature fluctuated between studies that showed it had higher ratings (satisfaction and comfort) in green buildings than in conventional ones (Huizenga et al., 2005; Abbaszadeh et al., 2006; Paevere & Brown, 2008); other studies that showed it had lower ratings for green buildings than conventional ones in summer and slightly better in winter (Leaman & Bordass, 2007) or was too hot in summer and too cold in winter (Leaman et al., 2007). This current study also finds satisfactory results for Thermal Comfort in the WCB (green) and GLW (conventional), but discomfort in the CDC (green building). Hence, green buildings can vary in their Thermal Comfort and are not guaranteed to perform better. Other factors studied in the literature, such as Furnishings, Cleanliness and Maintenance, and Building Image, are all perceived as better in green buildings (Abbaszadeh et al., 2006; Lee & Kim, 2008; Paevere & Brown, 2008; Leaman et al., 2007; Leaman & Bordass, 2007). Layout results in previous literature varied between being less comfortable in green buildings (Lee & Kim, 2008) to having no significant difference between green and conventional buildings (Huizenga et al., 2005), similar to Aesthetics (Paul & Taylor, 2008). This current study suggests no significant difference between green and conventional buildings in Furnishings, Cleanliness and Maintenance, Building Image, Layout, and Aesthetics, as all of them were perceived comfortable and with higher ratings in the WCB-green and GLW-conventional buildings, while rated lower (uncomfortable) in the CDC-green building.

For occupants' overall experience, as described in terms of health, comfort, satisfaction, productivity, and meeting needs, most of the studies in previous literature have found them rated higher in green buildings. Moreover, this study contradicts with this result, finding that,

regardless of the certification, lack of qualities pertinent to occupants' experience will result in more complaints from occupants and less satisfactory environments.

The results ascertain that generally, the WCB-green had fewer complaints from occupants and higher ratings on most of the individual IEQ factors and overall QoL experience. The CDC-green building had the lowest rating among the three buildings in both the individual IEQ factors and overall experience, as well as most of the complaints. These findings indicate that there was no significant consensus of results based on being in a green or conventional building; rather, it should be viewed as the results of individual cases under study. This study also suggests that other factors may have a greater influence on occupants' experience than the sustainable strategies. Examples include Personal Control, Nature of Work (functional considerations in design), Workplace Design (Layout, Spatial Organization, Furniture, Aesthetics, etc.), humane considerations (Privacy, Social Interaction, Congruency with Beliefs, etc.), Cleanliness and Maintenance, Building Orientation and Location, and Parking.

It is found that people working within green buildings may suffer from uncomfortable Ambient Conditions, Designed and Behavioral Environments due to sustainable strategies, such as the excessive openness in layout or between different floors (causing more noise and lack of visual and sound privacy), the use of low partitions in cubicles for daylighting penetration (causing sound and visual privacy conflicts), the dependence on daylighting, and the use of cold forced air from floor air vents. Some other issues are the use of recycled finishing materials (require more responsible occupant behaviors, such as no pins used for hanging stuff) like the case in the CDC, recycling and composting behaviors (need designated space in order not to interfere with circulation, as well as require extra effort from the occupants, and composting is found to cause some allergies to some sensitive occupants) like the case in the WCB, and the reduced amount of flush water and grey water in toilets (less clean toilets). The feeling of pride in green buildings is very significant with the overall QoL experience; it is found to be associated with the occupants' sense of environmental responsibility, expectations about a green work environment, and their comfort with the different IEQ factors. This is to say that generally, occupants who are satisfied with the IEQ factors and perceive the overall QoL as comfortable find that the work environment meets their needs and expectations; this instils a sense of Pride and contributes to their general well-

being and the protection of the environment. Occupants that had higher expectations about the performance of green buildings and had a negative QoL experience felt very uncomfortable and had low evaluation of the Pride factor.

To the contrary, some design strategies that were used in the conventional building selected in this study (GLW) are found to be more favorable and more comfortable to occupants' QoL than in the green buildings. Examples included the mixture of open-plan and enclosed offices (compared to the WCB), the use of task lighting and adjustable furniture (compared to the CDC). This is not to say that conventional buildings are more comfortable than green buildings. However, in order to be humane, good interior design in the work environment cannot be compromised to satisfy energy and waste requirements. It is found that learning from and understanding occupants' experience is necessary to incorporate comfortable IEQ factors, and that regardless of the certification of the building, green buildings need to incorporate design strategies that enrich occupants' QoL experience.

In conclusion, results and findings showed that occupants' needs are similar, whether in green or conventional office buildings. Hence, the necessity for IEQ factors contributing to the quality of the Behavioral or the Designed Environments is as important as the IEQ factors contributing to better Ambient Conditions.

5 CHAPTER V: TRIANGULATION AND DISCUSSION OF RESULTS AND FINDINGS

This chapter presents the discussion of the results and illustrates the triangulation of these results from all the different research tools used (observations, questionnaires, interviews, and focus groups). The objective of triangulation is to comprehensively understand the relationship between occupants' QoL and the IEQ factors in the physical work environment. The emergent findings of the relationship between the IEQ and occupants' QoL reassure the proposed theoretical framework and add new categories to it. Those categories and their interaction are inferred from observations and interviews, tested in the correlational analysis of the questionnaires, and reconfirmed in the cluster analysis of the repertory grids in the focus groups. As previously mentioned in **Section 3.1.1.2**, triangulation means integrating the results and findings from the qualitative and quantitative methods, and finding their corroborations or contradictions and justifications. Triangulation is found very useful in this research as it benefits from both explanatory (quantitative) and exploratory (qualitative) methods to give a rich understanding of the relationship between occupants' QoL and IEQ factors in the work environment. This also increases the validity of the research, as it offsets the bias of one method with another.

5.1 Triangulation of Occupants QoL Experience with the IEQ in LEED and Conventional Office Buildings

The results of the study classified comfort in work environments into five components: the Physical, Functional, Psychological, Social, and Cultural. The more quality the environment has, the more comfort components are achieved. At the same time, they mutually interact and affect each other. Their combination is what creates a healthy, comfortable, and productive environment. Those categories confirm the comfort components used in the proposed theoretical framework (**Chapter II. Section 2.8**), yet two more comfort components are elicited from the study and added (social and cultural comforts).

Different components of comfort are a result of IEQ factors, where some qualities may influence more than one comfort component. For example, an uncomfortable chair could cause back and neck pain, affecting Physical Comfort. It may also hinder the ability to get the work done, increase absenteeism, and decrease productivity; hence, it affects Functional Comfort. Furthermore, it may cause stress and frustration from the inability to focus, affecting Psychological Comfort. Following are the findings of IEQ factors, according to each comfort component. The definition for each comfort theme is as follows.

5.1.1.1 Physical Comfort Findings

Occupants perceive Physical Comfort as the degree to which the work environment supports their body health and safety and avoids physical annoyances. IEQ factors in the work environment found to be associated with the Physical Comfort are IAQ that doesn't have allergens, odors, contaminants, and is well ventilated; Thermal Comfort; Acoustical Quality and Noise Control that avoids unwanted sounds causing fatigue; Lighting Quality that is comfortable for the vision and doesn't cause eye strain; Ergonomics and Furniture suitable for body comfort and doesn't cause neck and back pain or health hazards resulting in injuries; Hygiene and Cleanliness, such as clean space, carpets and washrooms; and Safety and Security.

5.1.1.2 Functional Comfort Findings

Occupants perceive Functional Comfort as the degree to which the work environment supports tasks and enables getting the work done. IEQ Factors in the work environment found to be associated with Functional Comfort include Lighting Quality, perceived in terms of overall amount of light adequate for performing the required tasks, lack of reflections and/or glare and/or shades on computer screens and/or desk surfaces from artificial lighting or daylighting, flickers from electric lighting, and the colour of artificial lighting. Other IEQ factors found are Noise Control from mechanical systems and colleagues; a Layout that allows collaboration, yet is flexible to provide privacy when needed. Furthermore, efficient Equipment and Resources (equipment, tools, and technologies and comfortable access to job-related resources, such as paper and printers), are needed. In addition, the Personal Workspace must be considered: adequate size (to accommodate work, materials, and visitors, etc.), suitable amount of desk space, and sufficient amount of storage are necessary. Moreover,

Visual Privacy and Sound Privacy can compromise Functional Comfort and affect Psychological Comfort too. Hygiene and Cleanliness a Physical Comfort factor that can also impact Functional Comfort, as in the case of the CDC, where the tasks performed are related to health; hence, the lack of soap, hot water, and general hygiene and cleanliness hindered the occupants' ability to perform tasks comfortably. This is to say that factors that impact physical (e.g., Hygiene and Cleanliness) or Psychological Comfort (e.g., privacy) affect the Functional Comfort as well. Other factors included Ergonomic and Furniture that are comfortable, adjustable, and customizable furniture; and frequent and efficient Maintenance Quality of broken fixtures, light bulbs, malfunctioning HVAC, etc.

5.1.1.3 Psychological Comfort Findings

Occupants perceive Psychological Comfort as the degree to which the work environment supports their mental health, through fulfilling psychological needs to obtain satisfaction and contentment. IEQ Factors in the work environment found to be associated with Psychological Comfort are Personal Control, perceived in the adjustability and flexibility of personal workspace furniture, having operable windows, and having manually-controlled blinds. In addition, controllability of systems such as temperature thermostats, lighting dimmers, and task lighting also played an important role. Crowding is another factor, and it is perceived through spatial organization and distance between the occupant and his/her colleagues. Further significant factors are Connectivity with Nature (using views, indoor plants, water fountains, daylighting, patios, and outdoor landscapes); Personalization; Visual Privacy; Sound Privacy; Wayfinding (through signs or different colours in the corridors and lights); and Aesthetics and Indoor Décor (presented in colours, finishing material, and architectonic details).

5.1.1.4 Social Comfort Findings

Occupants perceive Social Comfort as the degree to which the work environment supports social life and values. Social Comfort is found to be very essential for occupants in work environments as it relieves a lot of work stress and reinforces better relations between people at work, hence supporting better collaboration. IEQ factors found to be associated with Social Comfort are Social Interaction factors indicated in places for social gathering and for informal meetings, such as a lounge, kitchenette, and cafeteria; as well as other Building Amenities, such as a gym hall. Spatial Organization and Layout are also found to support Social

Interaction, as in the WCB, where it is found that people are comfortable with being able to see, salute, and have a little chat with each other in the morning—a privilege supported by the open-plan layout and how workstations are positioned.

5.1.1.5 Cultural Comfort Findings

Occupants perceive Cultural Comfort as the degree to which the work environment supports Cultural Identity, in terms of respect to people of different cultural backgrounds, has cultural awareness, promotes cultural values, and allows self-expression. IEQ Factors in the work environment found associated with Cultural Comfort are the Aesthetics and Indoor Décor presented in architectonic details as artwork, symbols, icons, logos, proverbs, pictures, etc. Cultural Identity is presented through Personalization indicated in workspaces, harmony, and Congruency with the Beliefs of the organizational culture. It was found that organizational culture can be conveyed in terms of values such as listening to the occupants and mottos. It can even be witnessed in the design of the space. Equity is presented in the form of equal furniture between managers and employees in the WCB and the GLW, as well as in the sharing value presented in no owned workstations in the CDC. Other factors found to influence Cultural Comfort are the Image and Value of the building; for example, in the WCB, the symbol of being in a sustainable building gave pride to the occupants.

5.2 Factors Shaping Occupants' QoL Experience in LEED and Conventional Work Environments (causation & explanation)

This study is not a traditional POE study that intends to measure and compare the performance of green versus conventional buildings. In fact, it is about studying occupants' experience, with the hope of achieving a deep understanding of what and how qualities in the work environment interact with occupants' experience and of the consequences those qualities have on their QoL. This is to develop an IEQ assessment framework to guide future designs and GBRS. The intention of the comparison between green and conventional buildings in this study is pertinent to better investigate the effect of sustainable strategies on occupants' QoL experience, to study the same IEQ factors in different circumstances and see what emerges (for example, occupants' tolerance and influence of expectations), and to test whether the IEQ

factors measured LEED system (the most popular GBRS) is sufficient for creating healthier, more comfortable, and productive places, for occupants to live and work. Hence, test whether the systems that incorporate the sustainable development in buildings needs more attention to improve occupants' QoL (as an ultimate goal).

Occupants' QoL experience in workspaces as described in Health, Comfort, and Productivity is found to be influenced by the quality of the physical work environment presented in the IEQ factors, occupants' needs, expectations, comparisons with previous experiences with work conditions, operation and maintenance of buildings, and other external factors, such as Building Location and Parking. It is found that the occupants' experience with the indoor environment cannot be fully separated from other factors in the outdoor environment that influence it. The study elicited 30 IEQ factors that interact with occupants' QoL in work environments and two other external factors. The factors were grouped into categories according to the themes constructed from the IEQ factors elicited in the interviews, as well as the categories guided by the proposed theoretical framework. Furthermore, they were confirmed by the clustering technique that analyzed the repertory grids in the focus groups. All the quality factors are grouped into five quality categories (Figure 113):

IEQ factors in Ambient Conditions: IAQ, Thermal Comfort, Lighting Quality, Daylighting, Acoustical Quality and Noise Control.

IEQ factors in Designed Environment: Layout, Spatial Organization, Personal Workspace, Ergonomics and Furniture, Equipment & Resources, Building Amenities, Aesthetics and Indoor Décor, and Views.

IEQ factors in Behavioral Environment: Visual Privacy, Sound Privacy, Personalization, Territoriality, Personal Control, Safety and Security, Connectivity with Nature, Wayfinding, Crowding, Social Interaction, Status, Pride, Image and Value, Congruency with Beliefs, and Cultural Identity.

IEQ factors in Building Operation and Maintenance: Maintenance, Hygiene and Cleanliness.

External factors: Building's Location (accessibility, less transportation time, low carbon commuting, access to amenities and services, and access to sunlight), and Parking Availability (sufficiency and proximity).

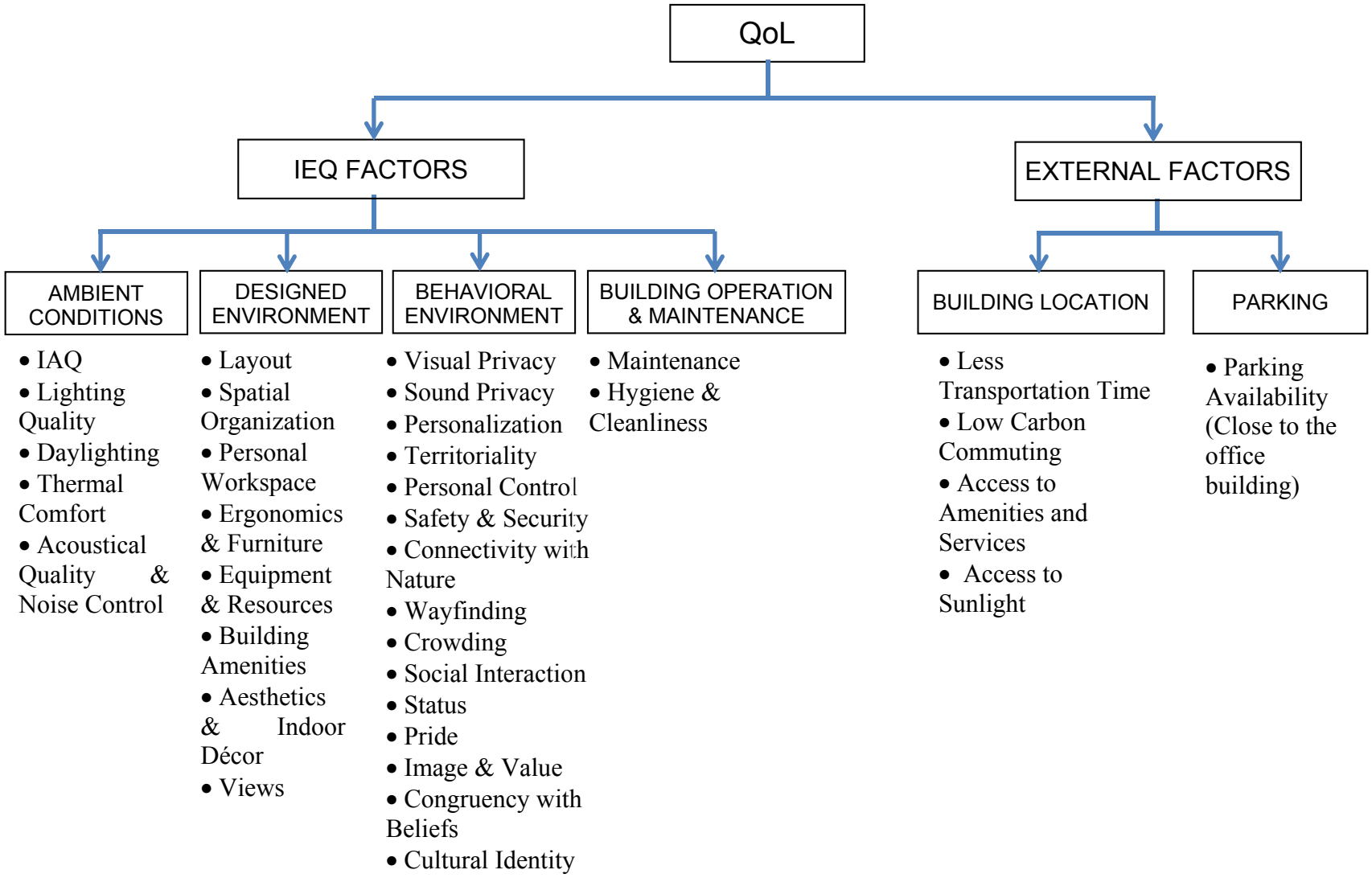


Figure 113.The classification of IEQ factors interacting with occupants' QoL experience in work environments

The IEQ factors as classified into Ambient Conditions, Designed Environment, Behavioral Environment, and Operational Maintenance are found to influence QoL (health, comfort, and productivity) through five components of comfort: the Physical, Functional, Psychological, Social, and Cultural Comfort. Those results were inferred from the interviews and corroborated in the correlational analysis of the questionnaires, as well as the clustering technique in the focus group analysis.

It is also found that a sustainable QoL experience in green buildings cannot be separated from a humane QoL, which respects all different aspects of occupants' needs. A sustainable building should still satisfy occupants' five components of comfort.

The comparison of results between the two LEED-certified green buildings and the conventional office building is found very useful to investigate whether the IEQ factors pertinent to occupants' needs in work environments are fulfilled by the LEED criteria. It also tests whether the higher certification level among the different LEED-certified buildings implies a better QoL for occupants. The comparison reveals many differences between the occupants' experience in the CDC-LEED Platinum office building and the WCB-LEED Gold Office building. Though the certification of the CDC is higher than the WCB, occupants' experiences had much to tell about their unsatisfactory QoL experience. During the researcher's observations in the walk-through tours, in addition to the interviews, questionnaires, and focus groups, it was found that regardless of what the LEED checklist evaluates, people may perceive things differently.

A large consensus and saturation is found in the occupants of the three buildings. (Saturation in qualitative methods means that, while conducting interviews, the researcher keeps getting the same repeated information from occupants, and no new data can be gathered.) Occupants' experiences showed the same complaints when facing the same conditions, such as working in enclosed offices or in shared cubicles with high partitions (pods), or while sitting at a corner in their pods, or when proximate to windows, etc.

Occupants in the CDC had many negative experiences with the Physical, Functional, Psychological, Social and Cultural Comforts. More complaints are found associated with the work environment in the CDC as compared to the other two buildings, although it is

accredited the highest level of certification for LEED, and the occupants were involved in the decision-making during the design phase. Occupants' involvement in decision-making could provide a better understanding, satisfaction, and feeling of choice from the occupants' side due to the ability to express their needs. However, in the CDC it created two types of responses. The first type is tolerant but disappointed, because the choices made were not truly of their own free will; rather, they chose from what was possible. They did not get a say in the type and colour of finishing materials used, number of private rooms, or available space, therefore possible compromising some personal needs. On the other hand, some occupants were intolerant and disappointed because things were even worse than expected in terms of Thermal Comfort regarding temperature regulation, consistency, and degrees, as well as regarding the implementation mismatch with what was anticipated; for example, the missing heat radiator that had a cover without an actual heater behind it. Possible reasons for the unsuccessfulness of outcomes from occupants' involvement in decision-making could be due to (1) implementation differences from what was planned and (2) design constraints due to budget, LEED strategies, and organizational culture that have limited and compromised occupants' design needs.

Experiences associated with IEQ factors are presented as follows. IEQ factors are presented according to the category they belong to and the level of meaning in each quality is stated (levels of meaning found confirms the proposed theoretical framework).

5.2.1 The Triangulation of Quality Factors in the Ambient Conditions

IAQ is an instrumental quality that is measurable but is perceived in terms of odors, allergens, dryness, stuffiness, and ventilation. The survey results have shown that IAQ is uncomfortable in the CDC. That was further supported by the interviews, as the occupants in the CDC complained that the air felt too cold in the open-plan layout and too hot in enclosed private offices. Other complaints included odors from the kitchenette reaching workstations close to the kitchenette area and irritated eyes and runny noses. Furthermore, in the survey, it was perceived as comfortable for the GLW in winter and comfortable in the WCB office building in summer and winter. During interviews, no complaints were attributed toward the IAQ in the WCB or the GLW.

Lighting Quality is an instrumental quality that is measurable but is perceived in terms of amount (sufficient for the tasks to be performed), type, colour, consistency, and flicker. The survey results have shown that Lighting Quality is comfortable in all the three office buildings whether conventional or green in summer, while only comfortable in the GLW and the WCB in winter too. During interviews and open-ended questions in the questionnaires, it has been further clarified that the amount of illumination is less sufficient and inconsistent in the winter, where it caused discomfort in the CDC in specific due to the lack of desk task lighting. The fluorescent lighting (colour and flicker) is found to be harsh on the eyes, contributing to more eye stains and headaches in both the CDC and the GLW; it wasn't an issue in the WCB due to the greater incorporation of Daylighting that overcame the artificiality of fluorescent lights. Generally, eyestrain is found to occur less with occupants whose workstations are located near windows. This is suggested to be due to the presence of Views and Daylighting. Views allow the eyes to relax and not be as susceptible to the possible negative effects of staring at a computer screen all day. Daylighting also help reducing eyestrain because it has a more comfortable natural colour, that causes less eye fatigue.

Daylighting is found to be a favored feature in both conventional and green office buildings. Concerns were mainly about the fact that Daylighting provides an inconsistent amount of illumination through the day or year, so it cannot be used independently from artificial lighting. Reflections and shades on the desk surfaces and computer screens (for workstations located beside windows) were observed. However, no complaints were reported regarding this issue in the CDC and GLW. It was also observed that the presence of manually-controlled blinds enabled occupants to feel comfortable with controlling it when they get bothered. However, glare and reflections were a complaint in the WCB due to the lack of manually-controlled blinds.

Thermal Comfort is an instrumental quality that is measurable but is perceived in terms of temperature, consistency, and frequency of regulation. The survey results have shown that thermal conditions are uncomfortable in both the CDC and the GLW, while only comfortable in the WCB in summer and winter. In the CDC many complaints about Physical Comfort are found associated with temperature consistency, shifts and control. Several coping behaviors were observed, such as adding small throw blankets, and coats for warmth. This is suggested

to be due to the combination of multiple reasons. One reason was the cold air coming from the air diffusers on the floor, causing many people to put books on them to avoid the cold air coming out of them. This was solved differently in the WCB, where people had control over air vents; they can close them or change the direction of the airflow. Other reasons in the CDC included insufficient temperature regulation and inconsistent temperatures within different locations in the work environment. Motion sensors also caused problems because unoccupied rooms had lower temperatures than others and they take a long time to get regulated. In the GLW, the HVAC was the most significant complaint as well, followed by the ergonomics of the furniture, then the fluorescent lighting. The HVAC being old has affected Thermal Comfort in the GLW, which is also perceived by the occupants as either too hot or too cold.

Acoustical Quality & Noise Control is an instrumental quality that is measurable but is perceived in terms of internal noises from colleagues or buildings systems, external noise, background noises such as white noise, transmission of sounds, and sound privacy. The survey results have shown that sound and acoustical comfort is uncomfortable in both the two green buildings the CDC and WCB, while comfortable in the GLW in summer and winter. During interviews it was found that the occupants of the CDC perceived it very noisy due to the noise from colleagues and systems, as—a result of the open-plan layout. Crowding, flickering from lighting, and even the white noise (which is supposed to mask sounds, not make them worse) were also found to be uncomfortable and caused disturbances. The WCB dealt with this open-plan challenge by hanging acoustical pins/panels from the ceiling to control noise; also, higher walls/partitions are used for workstations that require higher sound privacy, such as the ones located at the circulation spine or at the entrance of the department. However, most of the occupants had low partitions. Altogether, the open-plan layout, the continuity between floors without full walls, and the location of the cafeteria in the main floor underneath the workspaces contributed to a high level of noise disturbances in the WCB too. Several behaviors were observed or mentioned by occupants in the two green buildings, such as the use of headphones and earplugs. In the GLW occupants had no complaints about noise. The workplace is perceived quiet, except when the HVAC initiates (to regulate temperatures and ventilation) and makes noise, but it wasn't annoying to the occupants because it actually broke some of the silence they had. Reasons for Acoustical Quality and Noise Control are suggested

to be due to less Crowding of space as a result of a smaller number of workstations and less employees (25 in total, compared to 85 in the CDC, and 400 in the WCB). Also, no phones calls were undertaken in the open-plan work environment. All the work-related phones were in the managers' rooms in enclosed offices to decrease the disturbances, and occupants who want to perform personal calls can go to private rooms.

5.2.2 The Triangulation of Quality Factors in the Designed Environment

Layout and Spatial Organization are instrumental qualities that are measurable. The Layout Quality is perceived in terms of openness or closure, as well as circulation and accessibility. The Spatial Organization is perceived in terms of the furniture distribution, location of resource such printers, etc. Layout and Spatial Organization factors were perceived in the survey as comfortable in both the GLW and WCB, and uncomfortable in the CDC. In the CDC, having a bathroom within the open area where the cubicles are located, creates an uncomfortably-designed environment. People working in the cubicles close to this washroom were bothered by odors if the door was left open; this also caused more traffic and disturbances. The organization of workstation into pods, where multiple workstations are beside each other, caused more Crowding and insufficient place to put chairs for visitors. In the GLW the location of printers and copy machines within the open-plan also caused more traffic, disturbances, and noise, making the employees located near them uncomfortable. Occupants located at corridors also complained from distractions due to the circulation of other colleagues and perceived more lack of privacy as compared to other locations in the open-plan layout or the enclosed offices. No issues or complaints were found associated with the organization of space in the WCB, but the open-plan was found to cause noise disturbances and lack of visual and sound privacies. Hence, the Layout and Spatial Organization can affect Functional Comfort as they affect people's ability to focus on work when they cause distractions like crowding and noise from colleagues. They can also affect Psychological Comfort as they impact people's feeling of privacy.

Personal Workspace / Workstation is an instrumental quality that is measurable in dimensions but is perceived in terms of comfort with sufficient storage space, desk space, location, and privacy. It was perceived comfortable in both the GLW and the WCB and

uncomfortable in the CDC. Reasons, clarified in the interviews, were that the CDC had smaller desk sizes and fewer places for storage, causing overcrowded workstations. In the GLW and WCB there were coat hangers, cabinets, and shelves or overhead cabinets for storing documents and personal items.

Ergonomics and Furniture is an instrumental quality that is measurable in dimensions but is perceived as comfortable depending on the amount of support it provides, the flexibility, adjustability, height, and size. In the survey, it was found comfortable in both the GLW and the WCB and uncomfortable in the CDC. In the interviews, it was found that the CDC occupants complained of inadequate size of workstations and lack of storage, which caused a physical threat to occupants' health because it led them to adopt poor postures and to be subject to possible injuries from people tripping over the cables or stuff on the ground. Flexibility and customizability were the major qualities and reasons for comfort with Ergonomics and Furniture in the WCB. To the contrary, interviews with occupants in the GLW showed discomfort and complaints with the ergonomics of the workstations' furniture (desk and chair) and the overhead cabinets, which could possibly cause unintentional head-banging. In addition, the position of computers (depend on the location of plugs) with the support board underneath the desk, caused insufficient place for the occupants' legs to extend. Furthermore, more complaints were associated with the chair than the desk due to two issues. First, its adjustability: as you can either lean too far or not close enough, there is no comfortable position. Second is the mesh material that causes soreness in sitting and insufficient back support. However, using the same type of furniture for managers and employees gave a sense of equity and fairness that positively affected occupants' Social, and Cultural Comforts.

Equipment and Resources is an instrumental quality that is measurable by numbers and types, but is perceived as contributing to comfort levels because of its accessibility, location, task supporting, its age, and whether it's being updated regularly. This factor was elicited from the interviews, and it was found to influence work performance from the delay of slow equipment, as well as the feeling of pride about the image of the building being modern and progressive. In the CDC, some complaints were found due to the unreliable computers, unorganized cables (causing tripping injuries), and the motion sensor lighting or heating, as

they go off when no one is in the room or simply not moving, causing tele-videos, lights, and heating systems to stop working during meetings or presentations. Concerns in the WCB were the unlabelled and messy cables in meeting rooms; other than that the building has updated technologies that were appreciated by the occupants. Furthermore, in the GLW there is a computer lab, employees have two computer monitors, and technology that is not too complicated for occupants to deal with; however, computer innovations, such as hanging monitors and using wireless keyboards and mouse, were suggested to give a larger working desk space.

Building Amenities*, such as cafeteria, lounge, and places for social informal gathering,* are instrumental qualities that are measurable by size and number, but perceived as comfort features with adequacy for the number of occupants, availability, the quality of service provided, the noise they may cause, how relaxing they are, how they reinforce social interaction, how ergonomically designed and furnished they are, and how aesthetically pleasing they are perceived. People tend to rely on them for functional purposes like eating and also as a break from work stress; their quality influences occupants' QoL. During walkthrough tours in the WCB, the researcher was introduced by the interviewee to another employee, and on this day one of the water pipes in the building was broken and water leaked, so they had to close the cafeteria area until they fixed it. This accident showed how important this facility is to people's QoL experience; during those short moments of the informal talk in the corridor, the first things mentioned between employees was missing the cafeteria. Similarly, in the GLW, the occupants appreciated having good coffee and food in the kitchenette. To the contrary in the CDC occupants' had several complaints from the kitchenette due to its small size and inadequate furniture.

Aesthetics and Indoor Décor is a latent quality that represents physical architectonic details, colours, and textures of materials but is perceived in terms of beauty, relevance to the tasks performed in the building, and the message they convey. In the survey, it was perceived comfortable in both the GLW and WCB, and uncomfortable in the CDC. Interviews revealed reasons for discomfort caused by neutral and institutional colours and unfinished concrete slabs, as well as irrelevant artwork. Similarly, the image of concrete and neutral colours (beige and grays) were disliked by occupants in the WCB, but the Daylighting coming from the tri-

colour curtain wall and the staircase—together with the modern materials—balanced the look. In the GLW, the office had white and blue colours that mimic the company's logo and are calming and relaxing. There are a few, but relevant, pieces of art. Artwork is an important factor raised by several occupants from all three buildings and is found to be a significant quality in the image of the building. People didn't want just any artwork to be there: relevant artwork made a difference to their perception of the building's image and how much they liked the décor. For example, in the CDC, there was some artwork that had sailing pictures and was brought to the office by one of the doctor's wife from her sailing trips. Some of the occupants were actually offended by the irrelevance of the pictures to the type of work they do. One participant made a sarcastic comment in the questionnaire, which had open-ended questions: "*To our knowledge, no one in the office sails*" and called this "*meaningless art.*"

5.2.3 The Triangulation of Quality Factors in the Behavioral Environment

Safety and Security is a latent quality that is perceived as a result of Hygiene and Cleanliness, Maintenance, Ergonomics and Furniture, and Ambient Conditions factors. In the survey, it was perceived as comfortable in all the three buildings in the questionnaires. However, the interviews showed health concern in the CDC: the IAQ and shared workspace can spread infections, the Crowding factor can cause falling injuries, and poor Hygiene and Cleanliness can lead to diseases.

Personal Control is a latent quality that is perceived as a result of being able to adjust and control IEQ factors in the Ambient Conditions (amount of illumination, temperature, noise, ventilation) or the Ergonomics and Furniture factor. In the survey, it was found uncomfortable in all the three buildings. However, the interviews suggested that Personal Control influences occupants' QoL more when the occupants need to deal with more uncomfortable situations, as in the CDC. In both the GLW and WCB, less need for Personal Control was found due to better Ambient Conditions in both, and the presence of manually-controlled blinds in the GLW and adjustable furniture in the WCB.

Connectivity with Nature is a latent quality that is perceived as a result of *natural features* enabling connectivity with nature, such as indoor plants, water features, views, patios, and outdoor landscapes. It affects occupants' overall QoL experience via Psychological Comfort.

Though the Views Quality was perceived in the survey as comfortable in all the three buildings, the Connectivity with Nature was perceived as uncomfortable in all of the three buildings. In both the CDC and the GLW there is a lack of Connectivity with Nature, except from sunlight and a few trees visible from workstations proximate to windows. The WCB building has a very remarkable tri-colour curtain wall on the southern façade. This curtain wall allowed connectivity with the designed landscape outside the building; it permits the penetration of natural Daylighting, together with the window sizes, its narrow long footprint, and glazing. These features allow maximum daylight to be present deep into the building. In addition, the WCB has an open office plan on four floors, which are connected by a grand exposed staircase in the atrium on the south-facing façade. The open design and vertical connectivity allow natural light from the all curtain walls façade enter through the workspaces areas. Despite this, occupants did not feel connected with nature. Reasons suggested from interviews show that, though views are comfortable because nothing is actually bothering the occupants, the deep open-plans and cubicles disconnect occupants from the window views. Though external landscape was provided in the WCB, lack of indoor plants and harder access to the outdoors are among the reasons suggested for the feeling of low Connectivity with Nature.

Personalization is a latent quality indicated through the use of personal items to express the identity, territoriality, familiarity and sense of belongingness. In the survey, it was perceived as comfortable in all the three buildings. Most of the occupants agreed on liking to personalize their spaces, or, at least, to have it as a free choice. Few disagreements were found in the WCB, that over-personalization might give an unprofessional look to the office. The GLW had some privacy concerns that made some occupants seem uncomfortable with Personalization. During observations and interviews, the tendency to personalize was average in both the GLW and the WCB, where only a few occupants were found to personalize their workstations. However, in the CDC, excessive personalization was used to adapt to the discomfort in the environment and rebel against the organizational culture of shared workspaces. Hence, each occupant wanted to define his or her workspace so as not to be used by others.

Crowding is a latent quality that is perceived as a result of a number of items or people compared to the size of the space, such as too much furniture, narrow corridors, close distance

between cubicles, small space dimensions, messy workstations, and lack of enough storage. In the survey it was perceived as uncomfortable in all the three buildings and significant but negatively correlated with QoL in the conventional building and with meeting needs in green buildings. That means the more Crowding, the less perceived QoL is and the less needs are met. Reasons for Crowding was observed only in the CDC: lack of storage, small workstation sizes, narrow corridors, dark wall colours, recycling bins, and printers and copy machines in corridors.

Wayfinding is a latent quality that is perceived as a result of the ability to find one's way using signage and other benchmarks within the space, allowing for easier circulation (Passini, 1992). In the survey it is perceived as comfortable in both the GLW and the WCB and uncomfortable in the CDC. It is observed that the WCB managed wayfinding through giving different colours to different zones and using floor maps and signs. The GLW is a small office, so there were no issues with wayfinding. However, there were reasons for discomfort with wayfinding in the CDC, such as the presence of several long and narrow parallel corridors.

Visual Privacy is a latent quality that is perceived as a result of an open-plan layout, low partitions, and transparent glass. In the survey, it was perceived comfortable in the GLW, neutral in the WCB, and uncomfortable in the CDC. However, observations and interviews showed more details about occupants' experience with Visual Privacy. All the occupants working in open-plan, whether in green or conventional buildings, complained about the lack of Visual Privacy. Occupants in the CDC worked in group workstations or pods and had translucent glass doors for meeting rooms, which still could show who is inside. In the GLW complaints mostly came from occupants situated on corridors or near the entrance. It was observed during walk-through tours that they added boards for Visual Privacy. Occupants in low-partitioned cubicles are the ones suffered more in the WCB, especially those whose chairs and desk backs face the entrance of the cubicle, so they can't tell if someone is looking.

Sound Privacy is a latent quality that is perceived when occupants feel that sounds are transmitted and overheard as a result of the absence of soundproofing. In the survey it was perceived comfortable in the GLW, while uncomfortable in the two green office buildings under study (the WCB LEED-Gold and the CDC LEED-Platinum). During interviews and open-ended questions this was found to be one of the most repeated complaints in green

buildings due to the transmission of sounds in the open-plan and the low partitions. However, the GLW has an open plan, yet noise has been controlled due to the presence of enclosed offices (where phone calls with clients are performed with mangers), and a fewer number of employees in the open-plan.

Social Interaction is a latent quality that is perceived as a result of availability of informal gathering areas and amenities, as well as a layout conducive to social interaction. During interviews, the open-plan was found to be conducive to social interaction, as people get to see each other, chat, and greet. Facilities like kitchenettes, cafeterias, and gyms are desired, and the WCB has them, whereas the GLW has less of them. However, they were found to be most lacking in the CDC, which has an open plan and more than 85 employees, but there are less sufficient and less adequate amenities, such as a small cafeteria (with poor variety), a kitchenette with only eight seats, and no lounge or gym.

Status is a latent quality that is perceived as a result of workstation quality and location, layout (open-plan or enclosed offices), and furniture. In the survey, it was perceived as comfortable in both the GLW and the WCB and uncomfortable in the CDC. During interviews Status was found to be greatly affected by the location of personal workstations.

Pride is a latent quality that is perceived as a result of Personal Workspace Quality (such as size, proximity to windows, location at corner, tidiness and cleanliness), Congruency with Beliefs (organizational culture, organizational respect, and acknowledgment.), Image and Value of the building, occupants' work Status, Type of Work (tasks), Layout (enclosed office rather than open plan). In the survey it was perceived comfortable in both the GLW and the WCB and uncomfortable in the CDC. Reasons for Pride in the WCB were working in a green building that promotes environmental responsibility, while in the GLW, they were a comfortable organizational culture that listens to the occupants and promotes equity. Discomfort in the CDC is suggested due to the discomfort with the IEQ in general.

Image and Value is a latent quality that is perceived as a result of aesthetical design, modern progressive look of materials, technologies used, and environmental responsibility. In the survey it was perceived as comfortable in both the GLW and the WCB and uncomfortable in the CDC. As previously discussed in Aesthetics and Décor, the technology used in

Equipment and Resources, organizational culture, and environmental comfort with Ambient Conditions or the Designed Environment contributed to occupants' perception of Image and Value in the three buildings.

Congruency with Beliefs is a latent quality that is perceived as a result of organizational culture and architectonic details used in the décor and artworks. In the survey, it was perceived comfortable in both the GLW and the WCB and uncomfortable in the CDC. From interviews it was found that this factor results from organizational culture and Aesthetics and Décor in the three buildings. Organizational culture can influence occupants' perception of Hygiene and Cleanliness and Ergonomics and Furniture comfort. For example, in the CDC the culture is that all workspaces belong to everyone, so they share workspaces. Hence, the adjustments needed for comfort with furniture need to be done every time one works on a different workstation. Furthermore, this kind of sharing was perceived as increasing the probability of getting occupants sick from each other (if a sick person was just using the desk before a healthy user).

Territoriality is a latent quality that is perceived as a result of Personal Control, degree of enclosure (created by your workstation via walls, partitions, furniture, etc.), Privacy (visual and sound) and Personalization. In the survey it was perceived as uncomfortable in all the three buildings. This is probably due to the open-plan layout, side-by-side workstations in the CDC compiled in pods, as well as the culture of shared workspaces, low partitions used in the WCB, and no partitions in the GLW.

Identity is a latent quality that is perceived as a result of Congruency with Beliefs (with organizational culture), Status, and Personalization factors. In the survey it was perceived as comfortable in both the GLW and the WCB and uncomfortable in the CDC. This is most likely due to the free will of self-expression found in the Personalization factor in the GLW and the WCB. The sustainable design of the WCB also met the environmental sustainability of occupants working in water resources and services in the City of Calgary. Occupants in the CDC didn't feel their identity is recognized in the workplace, as the building didn't have any design orientation toward children or health; the building was also perceived by the occupants as not welcoming.

5.2.4 The Triangulation of Quality Factors in Building Operation and Maintenance

Hygiene and Cleanliness is an operational latent quality applied to the Designed Environment and is perceived positively in terms of an odor-free work environment and washrooms, clean carpet and washrooms, no dust on desks or window sills, antibacterial soap, hot water, and no factors that risk the occupants' health. In the survey it was perceived as comfortable in both the GLW and the WCB building and uncomfortable in the CDC. There is no doubt that how clean the workplace gets is important to everyone. However, the degree of importance and priority in their QoL experience may vary according to the tasks they perform. This was emphasized in the CDC, as the lack of hot water, antibacterial soap, unclean carpets, shared workstations, and gray water used in toilets all caused a great hygienic concern to the occupants, especially because they are dealing with health services.

Maintenance Quality is an operational latent quality applied to factors in the Ambient or Designed Environments and is perceived as the frequency of responses and the ability to fix the problem. In the survey, it was perceived as comfortable in both the GLW and the WCB building and uncomfortable in the CDC. Interviews revealed that discomfort in the CDC is caused by the slow responses in fixing problems, as well as the lack of direct communication between employees and the maintenance team.

5.3 Triangulating the Ranking of Significant IEQ Factors with Occupants' QoL in Conventional and Green Office Buildings

This section attempts to rank the IEQ factors according to their significance with occupants' QoL based on the triangulation of different data gathering tools. This is done to give insights on the relative importance of IEQ factors among each other. Hence, it helps to guide the weights of credits assigned to IEQ factors in LEED and GBRS criteria. However, it is pertinent to state that, because of the limited number of cases studied and sample size used in this research, the results found are case-dependent rather than general. Occupants experience buildings via the IEQ factors, in each of the three buildings under this study, they experienced their work environments differently. Reasons suggested are the variation in the quality conditions in each building and the type of work. Being surrounded by different building

features and IEQ factors made the ranking of IEQ factors interacting with occupants' QoL experience perceived differently among the three buildings. This also applies to the changing nature of the work itself that impacted the workplace design and occupants' needs.

Using different data gathering tools is found enriching to the amount of information the researcher learned from each case under the study. The ranking of IEQ factors is found to differ in strength from one research tool to another. However, the explorative tools, such as interviews and open-ended questions, in the survey gave a clear understanding of occupants' perceived condition of IEQ factors, how they may influence their overall QoL, and the reasons for occupants' assessments.

The Child Development Centre (CDC)

During the observations phase in the CDC, the researcher observed personalization among the most significant IEQ factors related to occupants' behaviors. It was found in most of the personal workstations, as well as on walls in the internal corridors. Other behavioral observations included the use of headphones, throw blankets and jackets, storing personal items or work-related boxes beside and under desks, and adding fans in some locations. For the building features, the researcher observed a darker illumination in deeper locations in the open-plan that were further away from the windows. Also observed were several issues with the Hygiene and Cleanliness factor, in the washrooms specifically, and several broken fixtures like light bulbs in treatment and assessment rooms, and in the washrooms. Those observations were found corroborating with the interviews and supported by the ranking of significant IEQ factors elicited and counted by the frequency of repetition.

Twenty-three IEQ factors were found significant with occupants' QoL in the interviews. For the top five factors, Thermal Comfort was found to be the most repeated and mentioned factor, indicating that it was the most significant complaint and the most significant IEQ factor that influenced occupants' perception of the overall QoL experience in the building. Personal Control came in second, and among the reasons was the lack of control over temperature, an issue that is still connected with Thermal Comfort. The third rank goes to Personal Workspace, and reasons for discomfort and dissatisfaction were found to be the lack of enough storage and the small size of desk working space. This also is corroborated with the observation of several

boxes stored beside and under desks. Then came Acoustical Quality And Noise Control as the fourth significant IEQ affecting occupants' QoL. Occupants complained about several sound distractions from colleagues and printing machines, an issue that justifies the observation of using headphones to cope with it. Hygiene and Cleanliness were also found significant and came in fifth. Lighting Quality is ranked sixth. Reasons for this include the fact that workstations varied locations in the building, so not all occupants had the same experience with Lighting Quality. Some also favored Daylighting (located beside windows), and this may have compensated for their evaluation and perception of overall Lighting Quality.

The ranking of significant IEQ factors in the interviews was previously illustrated in **Chapter IV- Section 4.3.2.6.** The mean values in the questionnaires also supported the complaints found from the same factors as: Personal Workspace (2.93), Lighting Quality (summer: 3.08) (winter: 2.67), Thermal Comfort (summer: 1.92) (winter: 1.93), Acoustical Quality and Noise Control (1.79), Hygiene and Cleanliness (1.5), and Personal Control (1.44). Those mean values are all below 3, indicating discomfort. Lighting Quality in summer is the only exception, and it is found to be due to better Daylighting in summer than winter. The overall assessment of QoL gives the CDC a mean value of (2.48), which is below 3, indicating a negatively perceived overall QoL experience.

The Glenmore Workplace (GLW)

In the GLW during the observations phase, the researcher made several behavioral observations, such as tables added to enlarge desk space, occupants placed wooden boards between their personal workstations and colleagues, and that manual window blinds were semi-closed. The very few personalization items were observed mainly in enclosed offices or workstations on the corner and facing windows. There were several bulletins and hung papers on walls in the enclosed offices. Building features observed included several empty workstations, lack of washrooms inside the office (located in external corridors of the building), shades on desk surfaces for workstations located on the windows' side, some hung artwork on the walls. It was a quiet and well-lit work environment. In the interviews, those same factors were found significant and repeated in the occupants' words. We have to note here that the factors elicited in the interviews were significant to occupants' QoL; that means there is an association between them, but not necessarily as a complaint or negative experience.

To the contrary, from the CDC, in the GLW several IEQ factors were perceived as comfortable and satisfactory and mentioned in a good way. This was further confirmed during the survey analysis. In the questionnaires, it was found that overall numerical assessment of QoL in the GLW was a mean value of 3.69, which is above 3, indicating a positively-assessed QoL experience.

The ranking of significant factors (top five factors) elicited from the interviews follow: Personal Control is in the first place, showing complaints from some privacy issues in the open-plan layout. This explains the observation of a board: it was placed to obtain Visual Privacy. Ergonomics and Furniture is in the second rank and, though it was not among observations, the interviews showed several complaints regarding the support and customizability of the chairs, as well as desk comfort from a posture point of view. Lighting Quality is tied for second place as well, and interviews showed the favoring of Daylighting and an adequate amount of illumination in most locations, while task lighting was available on request. Complaints were only about the fluorescent lighting's harsh colour, which causes fatigue. Acoustical Quality and Noise Control is in the third rank and was also among the significant factors with a positive experience, followed by Aesthetics and Indoor décor, which was perceived as relaxing and has colours that match the logo of the company.

The mean values in the questionnaires also supported the observations and interviews, that the same factors were rated: Acoustical Quality and Noise Control (3.62), Aesthetics and Décor (3.62), indicating comfort and Personal Control (2.14) indicating discomfort, while only Ergonomics and Furniture (3.62) result contradicted and indicated comfort regardless of the complaints found in the interviews. In the correlational analysis, Visual Privacy was the most significant IEQ with occupants' QoL, followed by Congruency with Beliefs, and Lighting Quality came as the third, corroborating with the interviews' results. Personalization, Aesthetics and Indoor Décor and Acoustical Quality and Noise Control were also significant, but their ranks contradicted with the interviews. This is suggested that they were rated as comfortable qualities, but people during interviews usually tend to speak more about their complaints and the lack of qualities they encounter rather than the good qualities. This justifies why in the CDC the results from interviews and questionnaires were more aligned than the results of the GLW. In focus groups, the factors were questioned among all the 30 IEQ factors

found in the study, but the ranking differed. However, the relativity between them has some similarities, as the order of these factors among each other were Ergonomics and Furniture, followed by Personalization, Lighting Quality, Personal Control, and Acoustical Quality and Noise Control.

The Water Centre (WCB)

In the WCB, no significant behavioral observations were found, other than the addition of some indoor plants and personalization items. However, regarding the building features, it was observed that there was deep penetration of daylighting from the curtain wall façade, that there were acoustical pins coming from the ceilings, and that the noise and smell of food beside the cafeteria on the main floor was quite prominent. During the interviews, the researcher found Connectivity with Nature, Acoustical Quality and Noise Control, Daylighting, and Image and Value factors significant with occupants' QoL. The ranking of IEQ factors in order from most to least significant (top five factors) was Layout, Personal Workspace, Thermal Comfort, Lighting Quality, and Spatial Organization. All the IEQ factors were rated comfortable in the mean values of the descriptive analysis in the questionnaire, except for Acoustical Quality and Noise Control, Crowding, Territoriality, and Connectivity with Nature. These results suggest that Layout (open-plan) and Spatial Organization factors caused issues with Noise Control. The workstations being too close with high partitions (an issue for some occupants located at corridors) contributed to the feeling of Crowding and lack of Connectivity with Nature via window views.

The overall assessment of QoL in the WCB is a mean value of (3.6), which is above (3), indicating a positively assessed QoL experience. The focus group ranking of IEQ factors showed Aesthetics and Indoor Décor, Pride, Views, Equipment and Resources, Hygiene and Cleanliness, Social Interaction, and Personal Workspace as the most significant IEQ factors. Those results corroborate with the interviews as the most satisfactory qualities experiences by the occupants in the WCB. It is suggested that customizable furniture and adequate storage contributed to comfortable personal workstations. Furthermore, the image of the building as being high-tech and sustainable, the use of materials as glass and metal and light colours, the statement staircase, and the Daylighting all contributed to a highly-perceived Aesthetics, Image and Value, and Pride IEQ factors.

Correlational analyses were done by combining the CDC and the WCB results together to test the association of IEQ factors with occupants' QoL experience as related to green buildings. The ranking for the top five significant factors was Pride, followed by Territoriality, Maintenance Quality, Aesthetics and Décor, and Hygiene and Cleanliness. Those results have some corroborations with the CDC ranking and the WCB observations, and interviews emphasized the importance of Hygiene and Cleanliness; however, not all of the IEQ factors corroborated. A justification of why the significance of IEQ factors differed between the two green buildings is that the occupants' experience varied a lot. Hence, a high quality in the CDC was insignificant with the overall QoL, which is perceived low, while when the same quality was high in the WCB, it turned out to be significant with the overall high perceived QoL. This is to say that the results were not confirmatory based on the certification of the building rather than the missing qualities that did not fulfil building occupants' needs.

5.4 What is a Humane Work Environment

The findings from this research provide important indicators of the indoor environment factors that contribute to people's QoL in office buildings. A work environment providing a humane QoL is an environment that fulfils occupants' needs. Regardless of how needs could vary from one occupant to another, there are still common needs for the occupants of work environments. Based on the study results, it is concluded that:

A humane work environment encompasses all the meanings of environmental quality: the instrumental, latent, and symbolic qualities covered in the three categories of human experience in a work environment: ambient conditions, designed environment, and behavioral environment, and operation and maintenance. A humane environment fulfils all the components of comfort—physical, functional, psychological, social, and cultural—to provide a humane QoL for building occupants.

According to the comfort themes found in this study, the qualities found to define a humane workspace can be grouped into five levels of comfort: Physical, Functional, Psychological, Social, and Cultural Comforts. This indicates the importance of fulfilling basic (physical and functional), psychological, social, and cultural needs for occupants to feel they are treated humanely in a workspace. Physical and functional needs are essential for a healthy work life

and for getting work done comfortably and productively. The more humane a work environment is, the more it respects psychological, social, and cultural requirements.

5.5 The Interaction between IEQ Factors and Occupants' QoL

From the investigations of occupants' QoL and IEQ factors using quantitative and qualitative methods, the research finds 30 IEQ factors and two other external (non-indoor) factors that impact occupants' QoL. The factors are classified into five categories: (1) IEQ factors in the Ambient Conditions, (2) IEQ factors in the Designed Environment, (3) IEQ factors in the Behavioral Environment, (4) IEQ factors in Building Operations and Maintenance, and (5) External factors. It is also found that the same factor could have multiple influences on occupants' experience. For example, Daylighting is an instrumental quality that can affect the Physical Comfort of occupants by adding glare and shades in the workspace surfaces and computer screens, causing physical discomfort that can lead to health issues, such as eye strain and headaches. Daylighting can also affect Thermal Discomfort from heat gain in summer. In addition, Daylighting may cause functional discomfort (glare on computer screens), hindering work productivity. Furthermore, it may influence the Psychological Comfort of occupants positively by helping with stress relief. Therefore, one factor could have Physical, Functional, and Psychological influences on Occupants' Comfort, which in turn impact their QoL: Health, Comfort, and Productivity.

This study views the relationship between IEQ factors and occupants' QoL as a system that has a dynamic interaction all the time, and the change in one changes the others. Hence, even IEQ factors that apparently have one direct influence on occupants' comfort may eventually and indirectly affect other comfort components, causing an impact on the three descriptors of QoL at the end. That means that when a person is physically uncomfortable he/she might also be functionally performing with less efficiency, and that in turn may raise his/her stress levels, causing psychological discomfort as well. The list of IEQ factors found in the study as interacting and impacting occupants' QoL are listed in Table XXVI. Only direct impacts of IEQ factors on occupants' comfort and QoL are presented, while as-previously-mentioned indirect influences may also occur.

Table XXVI. The Relationship between IEQ factors, their Meaning, Comfort Component, and QoL Outcome

IEQ Factor	Level of Meaning	Comfort	QoL Descriptor
IEQ Factors in the Ambient Conditions			
1. IAQ	Instrumental	Physical Comfort	HEALTH & COMFORT
2. Lighting Quality	Instrumental	Physical Comfort & Functional Comfort	HEALTH, COMFORT & PRODUCTIVITY
3. Daylighting	Instrumental	Physical, Functional & Psychological Comfort	HEALTH, COMFORT & PRODUCTIVITY
4. Thermal Comfort	Instrumental	Physical Comfort & Functional Comfort	HEALTH, COMFORT & PRODUCTIVITY
5. Acoustical Quality & Noise Control	Instrumental	Physical Comfort Functional Comfort	HEALTH, COMFORT & PRODUCTIVITY
IEQ Factors in the Designed Environment			
6. Layout	Instrumental	Functional & Psychological Comforts	HEALTH & PRODUCTIVITY
7. Spatial Organization	Instrumental	Functional & Psychological Comforts	HEALTH & PRODUCTIVITY
8. Personal Workspace	Instrumental	Functional Comfort	PRODUCTIVITY
9. Ergonomics & Furniture	Instrumental	Functional Comfort	PRODUCTIVITY
10. Equipment & Resources	Instrumental	Functional Comfort	PRODUCTIVITY
11. Building Amenities	Instrumental	Social Comfort	COMFORT
12. Aesthetics & Indoor Décor	Instrumental	Psychological Comfort	HEALTH
13. Views	Instrumental	Psychological Comfort	HEALTH
IEQ Factors in the Behavioral Environment			
14. Visual Privacy	Latent	Psychological Comfort	HEALTH
15. Sound Privacy	Latent	Psychological Comfort	HEALTH
16. Personalization	Latent	Psychological Comfort	HEALTH
17. Territoriality	Latent	Psychological Comfort	HEALTH
18. Personal Control	Latent	Psychological Comfort	HEALTH
19. Safety & Security	Latent	Psychological Comfort	HEALTH
20. Connectivity with Nature	Latent	Psychological Comfort	HEALTH
21. Wayfinding	Latent	Psychological Comfort	HEALTH
22. Crowding	Latent	Psychological Comfort	HEALTH
23. Social Interaction	Latent	Social Comfort	COMFORT
24. Status	Symbolic	Social Comfort	COMFORT
25. Pride	Symbolic	Social Comfort	COMFORT
26. Image & Value	Symbolic	Cultural Comfort	COMFORT
27. Congruency with Beliefs	Symbolic	Cultural Comfort	COMFORT
28. Cultural Identity	Symbolic	Cultural Comfort	COMFORT
IEQ Factors in the Building Operation and maintenance			
29. Hygiene & Cleanliness	Instrumental	Physical Comfort	HEALTH & COMFORT
30. Maintenance Quality	Instrumental	Physical & Functional Comforts	HEALTH & COMFORT PRODUCTIVITY
Other non-IEQ factors impacting occupants QoL experience			
1. Building Location	Instrumental	Physical & Functional Comforts	COMFORT& PRODUCTIVITY
2. Parking	Instrumental	Physical, Psychological & Functional	HEALTH, COMFORT & PRODUCTIVITY

5.6 Fit with the Theoretical Framework: The IEQ-QoL Model of Humane and Sustainable Work Environments

These research findings result in the evolution of a new comprehensive, humane, and sustainable theoretical framework: the **IEQ-QoL Model of Humane and Sustainable Work Environments**. This framework guides the relationship between occupants' QoL and the IEQ in the office work environment as an integrated environment-behavior system.

This study finds 30 IEQ factors influencing occupants' QoL experience in work environments. Those factors are classified under Ambient Conditions, Designed Environment, Behavioral Environment, and Building Operation and Maintenance. These results both build on and modify the previously proposed framework (**Chapter II Section 2.8)** that was framed using the categories of the Interior Design Human Ecosystem Model (Guerin, 1992), incorporating the Operation and Maintenance as a sub-category in the Ambient and Designed Environment categories that considers Hygiene, Cleanliness, and Maintenance IEQ factors.

This **IEQ-QoL Model** brings together the emergent findings by considering all the IEQ factors that were proved to be significant with occupants' QoL experience in the workplace. Each IEQ factor has a meaning that is either instrumental, latent, or symbolic. Through these emergent meanings, the factors that influence occupants are found to be the five components of comfort: Physical, Functional, Psychological, Social, and Cultural. These findings make the **IEQ-QoL model** also modify the levels of comfort in the Environmental Comfort Model (Vischer, 2005) to include the social, and Cultural Comforts in addition to the original Physical, Functional, and Psychological Comforts. The two new comfort components (social and Cultural Comfort) correspond to the latent and symbolic meanings of environmental quality. These new five components of comfort affect occupants' QoL in work environments described in Health, Comfort, and Productivity. The model shown in Figure 114 describes that the Ambient Conditions (AC) encompass the IEQ factors that create the atmosphere of the work environment, such as IAQ, Lighting Quality, Thermal Comfort, and Acoustical Quality and Noise Control. IEQ factors in the Designed Environment (DE) include the physical design of the work environment, such as Layout, Personal Workspaces, and Ergonomics and Furniture; both categories have instrumental qualities that affect occupants' Physical and

Functional Comforts. The features of the Ambient Conditions and Designed Environment also have latent and symbolic meanings that may affect occupants' Psychological, Social, and Cultural Comforts (Behavioral environment). The Behavioral Environment (BE) includes IEQ factors such as Visual Privacy, Territoriality, Personalization, Cultural Identity, Congruency with Beliefs, Status, and Pride. The IEQ factors in the three categories interact with the Building Occupants (BO) as an environment-behavior system. A humane work environment should not lack any of the components of comfort. The five components of comfort (Physical, Functional, Psychological, Social, Cultural) are complementary to environmental quality; the more humane the work environment is, the more components of comfort are achieved.

How the IEQ-QoL Model Represents Sustainability Dimensions

The different meanings of IEQ factors—with the five components of comfort they provide—are found to be a good representation of the three dimensions or pillars of sustainable development.

Instrumental IEQ factors provide Physical and Functional Comfort. Latent IEQ factors provide Psychological and Social Comfort. Symbolic IEQ factors provide the Cultural Comfort. These IEQ factors fulfil the environmental, social, and economic dimensions of the sustainable development. This is because they are designed according to sustainable practices that reduce GHG emissions and negative impacts on the environment (environmental sustainability). The combination of physical, functional, psychological, social, and cultural comforts support occupants' physical health (social sustainability), mental health (social sustainability), and productivity (economic sustainability) resulting from more work efficiency, less absenteeism, greater motivation, morale, sense of belongingness, and less turnover.

This, in turn, results in an improvement in occupants' Health, Comfort and Productivity; the descriptors of QoL. Therefore, this framework can be used to guide our understanding of the comprehensive relationship between IEQ factors in the work environment and occupants' QoL. It can also guide future LEED criteria and GBRS to incorporate more possible significant IEQ factors. This is to provide more comprehensive assessment for an improved occupants' QoL.

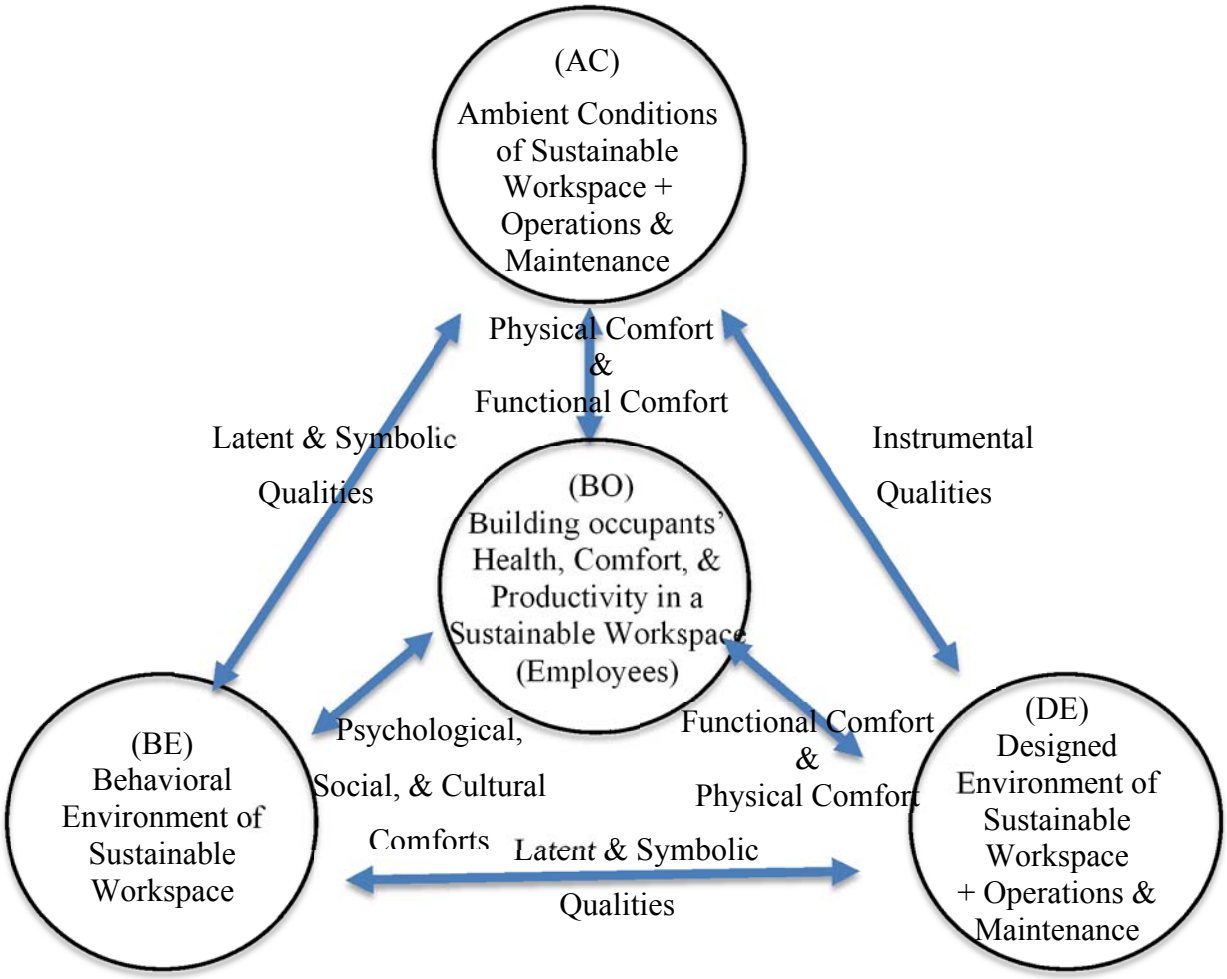


Figure 114.The IEQ-QoL Model of Humane and Sustainable Work Environments

5.7 Conflict between LEED Strategies and Occupants' QoL Experience

The separation of IEQ factors related to workspace design from the GBRS sustainable criteria of assessment may cause conflicts between the strategies used by rating systems as LEED and the occupants' experience; it may also result in lack of qualities that are pertinent to occupants' QoL. This emphasizes the importance of knowledge about human perception.

In practice, there are some factors caused by the LEED strategies that may contradict and negatively influence other factors affecting occupants' QoL in work environments. Examples of such factors follow.

Daylighting: LEED strategies depend on daylighting to reduce the energy use, but using daylighting without control causes undesired glare and reflections, especially with computer screens and overhead cabinets that contain glass, and could also cause heat gain. Designers need to deal with such criteria innovatively and include some sorts of controlled blinds or building orientations that ensure a better quality of daylighting. There are also other design criteria that can save energy and do not rely much on active technological systems currently used in LEED and green buildings. Other alternatives could include passive strategies such as operable windows that enhance ventilation. These operable windows could be used at night to cool the buildings and reduce dependence on air conditioning modes.

Open-plan Layout: An open-plan layout and low partitions are features used to help distribute daylighting to the various workstations to save energy. However, this strategy conflicts with Visual Privacy and Noise Privacy. The noise levels, distractions, interruptions, and lack of privacy influence occupants' Psychological and Functional Comfort. However, there are positive ramifications: open-plans facilitate communication and rapid exchange of information between workers, supports openness, transparency, equity, and social interaction. Therefore, designers need to balance the positive and negative sides of open-plans by finding ways that are flexible, enabling collaboration and communication, but at the same time providing privacy when needed.

IAQ: Air vents used to blow fresh air into the building for ventilation need to be located in

appropriate places that do not contradict with the organization of the space and furniture. In addition, the temperature of the air blown should be appropriate for Thermal Comfort because cold air vents were uncomfortable for building occupants.

LEED IEQ credits also have Minimum IAQ Performance and Environmental Tobacco Smoke (ETS) Control as prerequisites; this is done to ensure a minimum IAQ necessary for health based on how health symptoms are fundamentally influenced by the IAQ. However, other factors, such as excessive air temperature and/or low humidity, also increase unpleasant symptoms of upper respiratory tract problems and skin dryness. Thus, Thermal Comfort should also become a precondition to reduce dryness and health symptoms.

Controllability of Systems: In reality, there are some practical considerations needed when it comes to the controllability of systems, as building occupants do not tend to use the thermostats and thermostatic valves to control the temperatures if their perceived Thermal Comfort is low. They suggested that the control device is not recognized at all or the purpose of the equipment is unclear; hence, building users may believe that these devices are for service personnel only. Therefore, the control systems need to be planned and installed based on the building users' viewpoints. The complexity of systems not only affects occupants' comprehension of how to control them, but it also may put green buildings in danger and make them more *fragile* if one system does not work well, as that could affect the overall performance. It is therefore very important that everything works well together and that maintenance should be regular, efficient, and well managed.

Parking: Reducing parking area is one of the LEED strategies to discourage the use of single vehicles to reduce CO2 emissions. However, several occupants' complaints are found to be associated with difficulty in parking. In the CDC some occupants found that the only benefit they are given is underground parking, while in the WCB the difficulty in finding a parking lot is found to cause stress for some occupants, especially in the morning when they struggle to arrive on time. An inadequate place for eating with less variety of food is also found to be associated with parking stress; as explained by some occupants, they tend to seek other food alternatives outside the building, and this means driving to the food place and dealing with the parking hassle again. Surrounding Density and Diverse Uses is one of the LEED V.4 credits in the Location and Transportation (LT) category that requires diverse uses

(food retail, community serving retail, services, civic and community facilities, etc.) to be located within 1/2-mile walking distance, and a new construction project can earn 1–5 points in this credit category. However, the LEED system does not require the fulfilment of all credits, so qualities affecting occupants' experience may vary from one building to another, even if they have the same level of certification. Furthermore, the 1/2-mile walking distance is from any diverse use, not necessarily food retail; moreover, the walking distance can be perceived differently from one region to another. For example, in Canada the winter weather may reach -30 °C, which may make any walking distance unfavorable.

Water Waste: The use of low-flow flush or gray/reclaimed water to flush toilets often resulted in the presence of a brown substance floating in them or discolouration and sometimes odors, which were uncomfortable for building occupants. Furthermore, using non-flush urinals also created a conflict with hygiene (Physical Comfort) as well as Psychological Comfort.

Finishing Materials: Finishing material can influence occupants' experience aesthetically and in other ways. For example, in the CDC the materials used for wall finishes met LEED requirements (such as recycled materials) but disabled building occupants from hanging any pins on them; that affected their personalization needs.

Carpets: Carpets are usually associated with trapped dust and less hygiene; hence, the CDC had a gray linoleum floor that was depressing in colour and caused an extra amount of noise when people walked on it with heels, affecting occupants' Physical and Functional Comfort. Occupants were told to wear specific sneakers only, an issue that also affected their freedom and Psychological Comfort. Thereafter, it had to be changed to carpet to suit occupants' experience. Therefore, it is required to balance between hygiene and health, as well as other components of comfort, by finding materials that do not trap dust and crumbs as carpets, yet do not cause noise or are depressing to building occupants.

6 CHAPTER VI: CONCLUSIONS

This chapter summarizes the study, how the research goals and objectives were met, the lessons learned and the implications for further work, including how this research contributes to the advancement of knowledge in this field.

6.1 A Summary of the Study

In September 2014 the World Green Building Council (WorldGBC) released a report with overwhelming evidence of how office design significantly impacts the health, well-being, and productivity of employees. Their report states that:

> *"This complex relationship between health, well-being, productivity and 'green building' points to a need to reinterpret – some might say rescue – the term 'green' from an association purely with the environmental movement; or we may need to move 'beyond green' to talk much more about sustainable buildings. Either way, the goal should be buildings that maximise benefits for people, and leave the planet better off as well. Low carbon, resource efficient, healthy and productive - really what we are talking about is higher quality buildings."* (WorldGBC, 2014)

In this era of sustainability, we are faced with mounting evidence of the potential negative impacts of IEQ on the QoL of building occupants. At the same time, there is a lack of comprehensive knowledge about what constitutes the experience of occupants working in LEED-certified green buildings. This is combined with a lack of comprehensive assessment mechanisms of the IEQ in sustainable offices, as well as other research problems mentioned in **Chapter I**, **Section 1.1.** This research had, as one of its goals, to contribute to understanding quality of work environments, to improve occupants' QoL and to help shrink the gap between technically-measured building performance and a building's performance as perceived by its occupants. The object of the study was to develop a comprehensive framework that can guide future IEQ assessment criteria in office buildings as a means to provide sustainable and humane work environments. To achieve this object, the research had to comprehensively understand and investigate (using both qualitative and quantitative methods) occupants' perceived and experienced QoL, as a result of their interaction with the IEQ factors in their

physical work environment in both LEED and conventional office buildings. The other goal was to find out what factors constitute a humane work environment from the occupant's viewpoint. Hence, five objectives were developed:

OBJECTIVE I: To document occupants' overall perceived QoL experience in LEED-certified and in conventional office buildings.

OBJECTIVE II: To explain occupants' overall perceived QoL experience in LEED-certified and in conventional office buildings.

OBJECTIVE III: To determine the IEQ factors that interact with occupants' QoL in LEED-certified and conventional office buildings.

OBJECTIVE IV: To Identify IEQ factors' significances with occupants' QoL in LEED-certified and conventional office buildings.

OBJECTIVE V: To define the constructs of a humane work environment based on occupants' own words.

A mixed methods (MM) approach was chosen to investigate the research questions and objectives, as it is the most appropriate approach that could both explain and explore the phenomena of occupants' QoL with the IEQ of their physical work environment, thus making it possible to investigate and understand the phenomena comprehensively. This integration of methods helped to better measure, understand, assess, explain, explore, and interpret occupants' QoL experience and the meaning and perceptions of IEQ. It gave a more comprehensive understanding of the relationship between IEQ and occupants' QoL. Each method was analyzed separately and then triangulated with the rest of methods at the end. One method may explain or justify the result of another one, corroborate or contradict it, but the final outcome will give more insights and enable a better understanding of the phenomena.

The objective of the qualitative strand was to document the occupants' QoL experience as a whole in LEED-certified and in conventional office buildings, as well as to elicit the IEQ factors that shape their QoL experience. This allowed the theoretical framework to encompass all the possible IEQ factors and to identify the criteria that lead to a humane and sustainable work environment. The objective of the quantitative strand in the study was to explain the relationship between the list of IEQ factors derived from the literature and the occupants'

perceived QoL in LEED-certified and conventional office building. This involved assessing the perception of each IEQ factor and of the perceived QoL and examining the correlations associated between each of the IEQ factors and occupants' perceived QoL.

Results of the study have shown that occupants' in the CDC (the highest level of certification in LEED) perceived their overall QoL, all the IEQ factors in the Ambient Conditions (except Lighting Quality in summer), the Designed Environment, and Operation and Maintenance as uncomfortable. While both the GLW and WCB were perceived comfortable in terms of the overall QoL, and the IEQ factors in the Ambient Conditions Designed Environment, and Operation and Maintenance. Results of the three building varied in the Behavioral Environment, where also most of the IEQ factors in the CDC were perceived uncomfortable except for Personalization, Safety and Security, and Views. Also the GLW conventional building was found to perform better than the two green buildings (CDC and WCB) for the IEQ factors in the Behavioral Environment. This is to say that the certification of the buildings doesn't necessary imply a better occupants' experience. Furthermore, the constructs that constitute a humane work environment are found to be more preceded by factors affecting occupants' Social, Psychological, and Cultural Comforts than factors affecting Physical or Functional Comforts. This is to say that their summed weights (repetition of the theme) are more than Physical Comfort or Functional Comfort alone.

The study found 30 IEQ factors in the work environment that interact with the occupants' experience to shape their QoL, as well as two other influential factors outside the work environment that influence occupants' QoL. Those factors are Building's Location and Parking. The IEQ factors in the work environment are classified according into three main categories: Ambient Conditions, Designed Environment, and Behavioral Environment. Building Operation and Maintenance is a sub-category that relates to the Ambient and Designed Environment. It is concluded that IEQ factors shape occupants' QoL via their influence on the five components of comfort, namely Physical, Functional, Psychological, Social, and Cultural Comforts. The study also determined a definition of a humane work environment based on the occupants' own constructs. Several overarching issues are presented and discussed, such as the potential conflict between LEED criteria and workplace design and

the essentiality of their integration. Finally, a new IEQ-QoL Model of a Humane and Sustainable Work Environment was developed.

6.2 What Emerges?

Achieving a comprehensive understanding of factors shaping people's quality of life (QoL) when working in office environments was the foundation of this study. To be able to achieve this understanding, the study was conducted using a mixed-method approach, to comprehensively investigate and understand the relationship between occupants' QoL and IEQ factors in the physical work environment in both green (LEED-certified) and conventional office buildings. The mixed-method approach and its triangulation of the results was very suitable for a comprehensive understanding of the phenomena. It allowed for the testing of IEQ factors using different methods, eliciting the possible measurable indicators and determining what effect each IEQ factor may have on occupants' QoL. Conditions regarding the IEQ factors or behavioral actions of occupants (observed during walk-through tours and in the photos taken) were further tested and understood in the interviews. The interviews also enabled the researcher to elicit IEQ factors that were not tested in the questionnaire, providing a documentation of the description of the overall QoL perceived by occupants in each building under the study. Interviews also provided a definition for what constitutes a humane work environment from occupants' point of view. Reasons of the ratings the occupants' gave to the assessment of IEQ factors tested (in the survey) were also justified and understood when triangulated with the open-ended questions (in the survey), interviews, and observations. Furthermore, the data analysed from focus groups confirmed the possible IEQ factors that interact with occupants' experience in work environments and as found from observations, interviews, or questionnaires. Focus groups also confirmed the relationship between IEQ factors and the constructs of QoL (Health, Comfort, and Productivity); the analysis of the repertory grids used in the focus groups reassured the clusters (categories) used in the theoretical framework and the systematic relationships between them. Hence, the triangulation of inferences from the qualitative methods (observations, interviews, open-ended questions in the survey, and focus groups), merged with the analysis of the quantitative methods (questionnaires), allowed the final fitting of the proposed theoretical framework to develop a

new model for the comprehensive assessment of work environments that provide a humane and sustainable IEQ for occupants' QoL.

This study and its approach produced several lessons learned about providing better indoor environments for an improved QoL. First, the study found that environmental quality is best understood when expressed by the occupants themselves in their own words, based on their lived experience, and as some factors can never be known about or understood via self report-scales (in questionnaires) alone. The open-ended questions in the questionnaire and in the interviews helped to understand the assessment of each IEQ factor, to justify its necessity in occupants' QoL experience, as well as to elicit other factors that were not tested in the designed survey.

The occupants' experienced their work environment through the IEQ factors that can be categorized into Ambient Conditions, Designed Environment, Behavioral Environment, and Building Operation and Maintenance. Their interactions with these categories resulted in the identification of five comfort components: Physical, Functional, Psychological, Social, and Cultural. These different comfort components are interdependent; the higher the quality of the IEQ factors, the more comfort components are achieved, and the better the perceptions of improved Health, Comfort, and Productivity, resulting in a better QoL in work environments. Since these comfort components are interdependent, a change in one can influence the status of the others. For example, employees working in an open-plan layout exposed to noise from colleagues are physically uncomfortable, which may hinder their ability to concentrate and get their work done and hence affect their Functional Comfort. This situation could also cause stress, a Psychological Comfort issue. Occupants' experience is, in fact, multi-dimensional and has additional aspects other than the workspace itself that may contribute to it, such as the building's amenities, the parking situation, the public transportation, and the building's accessibility. Expectations and comparisons with previous workspaces did also influence occupants' experience in both LEED-certified (green) and conventional office buildings. In a research by Leaman and Bordass (2007), they found that occupants in green buildings are more tolerant toward a lack of quality than occupants in conventional buildings. However, this present study has found a contradictory result. Regardless of a building's LEED certification level, when the basic needs of Physical Comfort (such as Thermal Comfort and Noise Control)

were not within a comfortable range, people tended to complain more and attempted to remedy their situation by adding features that provide Psychological Comfort, such as personalization, as a compensation for uncomfortable stressful Ambient Conditions causing physical discomfort. When similar physical discomfort was experienced by the conventional building occupants, their overall QoL was still perceived as being higher than those in the LEED-certified green buildings. This could be explained because people have the expectation that a green work environment offers improved environmental conditions, and hence, they were less tolerant with such issues.

The connection between the categories of IEQ factors and their impact on occupants' comfort occurs via their level of meaning (instrumental, latent, or symbolic). The meanings of IEQ factors must be well understood by designers, policy makers and GBRS, as they determine the perception of how each factor will influence the occupants' QoL. The Ambient Conditions such as the IAQ, Thermal Comfort, Noise, and Lighting Quality have an instrumental meaning of quality, as they can be measured instrumentally using physical measurements—so can aspects of the Designed Environment, such as the Ergonomics and furniture (size and dimensions of furniture), Personal Workspace/Workstations, the Spatial Organization and Layout. They all have a direct effect on occupants' Physical and Functional Comfort, impacting their QoL in terms of Health, Comfort, and Productivity. Meanwhile, the Behavioral Environment has latent and symbolic meanings of quality, presented in Personalization, Territoriality, Personal Control, Visual Privacy, Sound Privacy, Connectivity with Nature, Cultural Identity, Status and Pride, as well as Congruency with Beliefs. Those qualities are important for achieving Psychological, Social, and Cultural Comforts, further impacting QoL in terms of perceived Health and Comfort, which, in turn, also affects perceived Productivity.

Due to the subjective nature of the occupants' assessments, it is difficult to agree on the preference of some IEQ factors in the occupants' QoL experience. However, knowing the positive and negative meanings of a quality could help designers and researchers better understand this IEQ factor and what it could be used for, depending on the design message they want to convey. For example, Personalization was an IEQ factor favored by some people, as it gives a sense of identity, helps to define Territoriality, gives a feeling of familiarity, and

reminds them of happy life moments; thus, it can play a role in stress relief and also reinforces the concept of Personal Control through self-expression and the ability to choose. Other occupants disliked Personalization because it gives an unprofessional look to the building and workspaces, interferes with their Privacy, and reduces the working space on desks. The level of Personalization and how much of the workspace is personalized are also significant, as it can be a delicate balancing act to create a personalized workspace while maintaining a professional appearance. This research showed that offering an adequate amount of freedom of choice and self-expression to occupants is psychologically healthy, as long as common sense is applied to establish general rules that ensure a desired level of respect and professionalism are communicated and maintained.

Working in a green building was found to be an insignificant factor in terms of a sense of Pride when people are dissatisfied, uncomfortable, and feel the building environment compromises their QoL. To the contrary, when people feel positive about their QoL, they have the ability to start thinking about how positive it is to be part of the sustainable image in the city and hence may feel some Pride. This was one of the differences between the CDC and the WCB.

People's needs do not vary according to a building's certification. Rather, it is the type of task performed and the missing qualities that are the major drivers of occupants' complaints. People tend to express other needs when their comfort is not at risk and they have minimum complaints about the building; they are more apt to think about the positive qualities and to appreciate them as important needs. This is the luxury of asking for more. Hence, basic needs come first, because when they are not fulfilled, occupants are less able to think about other qualities and under-evaluate the whole QoL experience as a result. Basic needs include Thermal Comfort, IAQ, Lighting Quality, Acoustical Quality and Noise Control, and Personal Workspace features (such as the desk size, chair comfort, sufficient storage, and adjustability or customization of furniture) for Physical Comfort. Therefore, it is essential for GBRS to consider the workplace design, because the separation of such criteria from sustainable design criteria, may create conflicts on both levels (see **Section 5.7**). Sustainable design criteria, as evaluated by GBRS, need to be sensitive to the nature of the tasks performed in order to provide comfortable spaces, as the type of activities performed in the building greatly affect

the significance and importance of each IEQ factor. In the CDC office building, when the occupants were performing health-related tasks, Hygiene and Cleanliness had a greater significance and was more of a priority for the occupants' QoL experience, as compared to other office buildings where engineering tasks were performed.

The concept of sustainability states that there are three bottom lines to consider: economic, environmental, and social. Based on the USGBC, the goal of the triple bottom line, in terms of the built environment, is to ensure that buildings and communities create value for all stakeholders, not just a restricted few. For example, an energy-efficient building that saves the owners money—but makes the occupants uncomfortable or compromises their health or productivity— is not sustainable.

It was found that there are some factors caused by the LEED strategies that may contradict and negatively influence other factors affecting occupants' QoL in work environments. In addition, LEED assessment criteria are proven to be insufficient, as employees still complain and do not feel comfortable with some environmental qualities in LEED accredited buildings. Criteria may include and fulfil the following suggestions.

How might more humane criteria for occupants' QoL be better integrated into existing LEED evaluation criteria

There are multiple issues that emerge within this study that suggest a need to consider how best to integrate QoL within LEED criteria assessment. For example, for the IAQ, in addition to the considerations of allergens and toxins, LEED evaluation might consider the design of the air diffusers (vents) used for ventilation and blowing air inside the work environment. A sub-criterion could be added to credit the customizability of air vents (being able to open and close the air vents and change the orientation of the air blown); another sub-criterion could consider the location of air vents in relation to workstations and furniture.

Lighting Quality is another example of considerations that might be added to the criteria of IEQ in LEED, including sub-criteria that includes the colour of lighting, amount of overall illumination (combined with Daylighting), types of bulbs (that are more favorable and natural than fluorescent lights and may cause less eyestrain and fatigue, e.g. LED lights); the addition

of a criterion for the ability to control lighting is recommended (possible task lighting additions).

Acoustics Quality is an added criterion in the new LEED V4, (it was not considered in LEED 2009, the time of this study), but even the new version needs to be changed: it still needs sub-criteria that includes innovations in sound masking, sound-absorbent finishing materials in walls, partitions, and ceilings.

Layout Quality is not a factor considered in the LEED criteria of IEQ and is found to be an essential quality affecting occupants' QoL experience. It needs design innovations that allow flexibility between work collaboration and individual work (being able to focus without distractions) when needed.

Spatial Organization is not a factor considered in the LEED criteria of IEQ and is found significant with occupants' QoL experience. A sub-criteria might be created for an organization of space that doesn't cause Crowding and provides comfortable circulation and accessibility to resources needed for working more efficiently, without wasting time and energy unnecessarily. For example, meeting rooms may be required to have a certain size and location within a certain distance from employees (Sound Privacy issue).

Personal Workspace Quality is also not considered in LEED and could be incorporated with sub-criteria for enough desk space and sufficient storage for work and personal items.

Ergonomics and Furniture Quality can be also incorporated in LEED with sub-criteria for adjustability and customizability of desks and chairs and comfortable support of chairs (to allow for good posture).

Equipment and Resources can be incorporated in LEED in terms of sub-criteria for innovations in providing equipment comfortably (computer screens, keyboards, hand mouse, cables that do not interfere with desk space or cause injuries), as well as a criterion for having updated and advanced equipment.

Building Amenities are also found to be one of the significant humane factors for the work environment. LEED can add credits for the availability of lounges, cafeterias, gyms, showers, social gathering places, and other facilities that could contribute to occupants' well-being and social support. Guidelines may also recommend a minimum required space for a

lounge/kitchen for a certain number of employees. This lounge/kitchen may require a number of appliances for a certain number of employees. It may also be required to assign design standards for a location within a certain distance from employees' workstations. For example, lounges that are located on the building exterior may have Views and Daylighting, which are advantageous for employees who do not have these privileges at their workstation.

Aesthetics and Indoor Décor can be also added to the credits of IEQ in LEED, as it is one of the factors that contribute to occupants' QoL. Although this is a subjective quality, a sub-criteria could include artwork or architectonic details that are relevant to the type of tasks performed in the building, adding some colour variations, and using variety in finishing materials (to avoid pale, monochromatic, and boring looks).

Thermostats, blinds to control Daylighting, operable windows, task lighting, light dimmers, etc. may also be incorporated to support a credit for Personal Control over building systems in the LEED IEQ category.

Other credits could be added for the availability of natural Views, indoor plants, or other features that contribute to Connectivity with Nature.

Design innovations that improve Sound Privacy and Visual Privacy should be implemented, such as a credit for layout innovations that allow controlled privacy when needed (extra private rooms, phone booths, etc.) or translucent partitions that give Visual Privacy but still allows some illumination.

A Safety and Security credit can be added as well. It can be measured by sub-criteria for hygiene standards, alarm systems, and regular maintenance of building systems.

Other considerations in the LEED criteria could include that the relative weights given as credits should better reflect the significance of IEQ with occupants' QoL. Credits could also have partial scores; for example, a criterion that is not fully achieved could have a score reflecting the percentage of its achievement rather than being not credited.

6.3 Research Achievements and Implications

The study developed a new, comprehensive IEQ-QoL Model of Humane and Sustainable Work Environments (see **Chapter V, Section 5.6**). This model guides the relationship between IEQ in work environments and occupants' QoL as an environment-behavior system. It considers all the possible IEQ factors classified in the Ambient Conditions, Designed, Behavioral Environments, and Building Operations and Maintenance, shows how they interact with occupants via their conveyed instrumental, latent, or symbolic meaning. Those meanings in turn influence occupants' Physical, Functional, Psychological, Social, and Cultural Comfort components, which impact occupants' QoL in terms of Health, Comfort, and Productivity. This framework implies providing guidelines for the design criteria of IEQ in office buildings by integrating both workplace design and sustainable building design. Occupants' QoL experience in green and conventional work environments was investigated comprehensively. It also states that the different IEQ categories work together as a system, where a change in one may affect the other. This also means that an improvement in occupants' QoL experience cannot be achieved with instrumental IEQ factors (mostly considered in LEED criteria) only, as the Designed and Behavioral Environments have significant influences as well. The study documented and determined occupants' perceived QoL in green and conventional office buildings. The study also identified 32 quality factors that influence the QoL experience in office work environments, of which 30 are IEQ factors. A humane work environment was also defined based on occupants' own constructs. The research findings proved that the LEED criteria are insufficient to provide humane for occupants to live and work and several missing factors from the LEED criteria are found to be significant with occupants' QoL experience. This is to say that green buildings are not necessarily humane and that they may have similar problems as conventional ones, in addition to problems caused due to the conflict between sustainable strategies (used in LEED-certified buildings) and occupants' experience (previously mentioned in **Section 5. 7**). For occupants' experience, it doesn't matter if the building is green or not; if it is not humane enough, occupants will have a negative QoL experience. The results of the study also found that occupants' prior expectations about a green work environment (found from their engagement in the design process, as in the CDC)

caused several occupants to be less tolerant with the lack of quality perceived after building implementation and operation.

The implications of this dissertation are four-fold: First, to support the use of a comprehensive systematic framework for the assessment of IEQ in various building types. This framework can be used for the design and evaluation of IEQ in offices. Second, to support the integration between workplace design and sustainable building design in LEED IEQ criteria, where the integration contributes to better human QoL and a protected sustained environment. Third, to encourage the use of the mixed-methods approach to investigate occupants' QoL experience, as the procedures used in this approach give a rich comprehensive understanding of the phenomena. Fourth, to outline ways that LEED and other GBRS can incorporate IEQ credits pertinent to occupants' QoL.

6.4 Contribution to the Advancement of Knowledge

The most significant contribution of this study is the conceptualization of a sustainable and humane environmental quality framework for an office work environment as a complex system. This system is presented as the **IEQ-QoL Model of Humane and Sustainable Work Environments**. This model is composed of different categories of IEQ factors, their levels of meaning, and their influence on occupants' comfort, that evaluate how this impacts their Health, Comfort, and Productivity as the descriptors of occupants' QoL in this research. The model has been tested empirically, thereby making it possible to further guide GBRS criteria by offering more detailed information on the hierarchy and relative importance of IEQ factors from the occupants' perspective. The results of the study support the proposed theoretical framework and its important proposition that IEQ factors in the Behavioral Environment affect occupants' QoL, and that a comprehensive assessment of IEQ should not neglect the latent and symbolic meanings of IEQ factors that affect occupants' Psychological, Social, and Cultural Comfort, and hence the Health, Comfort, and Productivity descriptors of their QoL. In addition to the identification of the IEQ factors, this research investigated a number of measuring indicators for each significant IEQ factor. This would support better decisions for designers in the design process and facility managers during the operation phase. This model may be pertinent to practitioners of design and design education as it proposes new ways to

understand people and their QoL within office work environments. It also comprehensively provides them with the knowledge about occupants' needs in work environments, the IEQ factors that can fulfil these needs and their measuring (perceived) indicators. The model also deepens their understanding of how those IEQ factors shape occupants QoL experience via which levels of meanings that impact which component of comfort. Furthermore, the IEQ factors (with their indicators) proposed in this model can be translated into suggestions for future design criteria and standards, and as potentially of interest to the development of appropriate interior products.

Studies that compared green office buildings with conventional office buildings in the literature are found to lack the same number of IEQ factors that are found in this study. Only 11 IEQ factors were measured in previous literature, including in the two most popular surveys on IEQ: the CBE and the BUS surveys. The 11 IEQ factors are IAQ, Lighting Quality, Acoustic Quality & Noise, Thermal Comfort, Space Layout, Office Furnishings, Design, Aesthetics, Maintenance & Cleanliness, Personal Control, and Image (Lee & Guerin, 2010; Paul & Taylor, 2008; Leaman & Bordass, 2007, Cao et al., 2012, Frontczak et al., 2012; Sakellaris et al., 2016). The current study has found 30 IEQ factors influencing occupants' QoL experience in office buildings.

This study contributes to the understanding of occupants' experience with offices from multiple dimensions. It provides the opportunity of listening to the occupants' viewpoints and knowing the QoL based on their own constructs and perceived assessment. The study measures the IEQ factors previously tested in the literature, and adds considerably more factors that were not identified or previously tested in green buildings. The mixed-methods approach used in this present study and the triangulation of different research methods is unique for the studies on IEQ and occupants' experience in green buildings. Studies found in previous literature analyzed occupants' responses toward the IEQ using questionnaires. This mixed-methods approach reinforced the understanding of human experience and all the possible factors that interact with it. This is to advance the knowledge about how and why IEQ factors are perceived in occupants' lived experiences and justify the numeric results researchers find in questionnaires.

This research addresses the issue of how sustainability can improve architectural design and how workplace design criteria might be added in addition to environmental criteria. It contributes to sustainable building design practices by providing a better understanding of occupants' QoL experience with buildings' IEQ. It also proposes ways to widen GBRS's focus by suggesting more humane evaluation criteria that consider both the quantitative and qualitative aspects of the qualities shaping human experience. This work highlights the importance of the latent and symbolic meanings of IEQ that affect occupants' Psychological, Social, and Cultural experience, and thus gives a more complete picture to the social dimension of sustainable development. Further advances made possible by this work include being able to know the strengths and weaknesses in the IEQ criteria of current LEED-certified buildings and to explore other factors that have not yet been considered, thereby improving future LEED-certified buildings. Hence, this research proposes ways to assess IEQ factors proposed with the IEQ-QOL model. Potential new criteria for assessment includes factors that emerged and were addressed in the Ambient Conditions, Designed Environment, Behavioral Environment, and Operation and maintenance categories and incorporate them into the IEQ category. The perceived indicators of those IEQ factors are also important as a sub-criteria to allow better evaluation, credit weighing, and gives emphasis on the quality of the criteria from occupants' perspective. This knowledge might also help business managers make better decisions regarding the impact of sustainable choices on their employees and their work environments, which may affect their businesses' bottom line and organizational success.

6.5 Limitations and Future Research

This research is comprehensive and the results that emerged revealed new knowledge; nevertheless, there were limitations.

First, this research is only limited to three office buildings; a larger sample is recommended for future research for a better generalization of the results.

Second, in the present study only LEED office buildings were studied as examples of green buildings. Studying and comparing buildings constructed differently under different rating systems, such as BREEAM, Green Globes, HQE, and CASBEE would provide valuable

information about the different criteria and how they influence occupants' QoL experience, and thereby develop improved guidelines and reference systems for IEQ assessment based on more comprehensive IEQ factors. For more elaborate results, a larger sample of questionnaire participants would be useful and would allow for more accurate testing of the relative weights of IEQ criteria.

Third, a focus group in the CDC was not conducted, which may have limited the focus group results for green buildings, as the QoL experience in the CDC varied compared to that of the WCB.

Fourth, as a result of changes that may occur in the environment over time, occupants' complaints and perceptions of environmental quality are temporal. Such factors impact occupants' perception of the indoor environment and QoL experience. Examples include, renovations, system upgrades, natural aging or degradations, etc. that are sometimes difficult to follow or to identify, yet they have an effect on occupants' comfort from physical, functional, psychological, etc. dimensions.

Fifth, the occupants' perceived QoL experience has a subjective nature, and putting this subjective assessment into objective measures is complicated yet possible after several detailed mixed-method empirical researches and with bigger samples; that enables generalization of results, as well as informs better relative importance between the IEQ factors significant with occupants' QoL. Triangulation of results is also recommended as a useful method to connect the objective and subjective measures of environmental quality and occupants' QoL. More research is still needed to acquire guidance on the credit weighing for the LEED system IEQ criteria; further research is also required in order to develop design principals to address the significant IEQ factors affecting QoL.

6.6 The Study Trustworthiness

This research studied occupants' QoL experience with the IEQ in conventional and LEED office buildings in three cases of study. A limited number of cases and a relatively small sample can compromise the generalizability of the study. Case study research is also criticized for the possibility of researcher bias and for requiring a massive amount of documentation

(Yin, 1994). To overcome the previously mentioned limitations (**Section 6.5**), the study adopted several strategies to increase its validity/trustworthiness, reliability, and transferability (Becker, 1970; Kidder, 1981; Fielding & Fielding, 1986; Lincoln & Guba, 1985; Patton, 1990; Miles & Huberman, 1994; Maxwell, 1996; Shenton, 2004; Onwuegbuzie & Leech, 2007; Creswell, 2013, 2014). The strategies performed by the researcher follow.

Triangulation: This study triangulated the results of different data-gathering tools. The use of multiple methods increases the validity of the study by giving opportunity to corroborate results and offset the bias in one method by another.

Persistent observation: The researcher had set criteria prior to observation to ensure a consistent documentation process among the three buildings and to observe relevant building features, IEQ factors and indicators, and occupants' behaviors in a similar manner.

Questionnaires' validity and testing: The researcher adapted the questionnaire from previously adopted and recognized questionnaires (see **Section 3.6**) and then tested the new questionnaire in a pilot study for further refinement.

Member checking: The focus groups done after the data gathering process helped the researcher to member check the findings. This means to go to the occupants themselves and confirm the constructs that emerged and the interpretations of the researcher.

Extreme samples: The researcher selected the sample of the focus groups by choosing respondents who had extreme unique assessments, as found during the questionnaires phase. This was very helpful in giving a comprehensive picture about occupants' experience with its different dimensions and helped assess the researcher's interpretations.

Rich and thick descriptions: To obtain detailed descriptions of occupants' experience, the researcher recorded the interviews and used quotes from the participants' words as *verbatim transcripts* to facilitate the analysis and interpretations of findings. For observations, the researcher documented them by taking photos and filed notes to provide descriptive details of the building and occupants' behaviors.

Sample saturation: The researcher used a stratified random sample in the interviews (managers and employees). The interviews were stopped when saturation of information

occurred; that is, when the researcher kept getting the same information from different participants and no new information was found.

Several visits: Dealing with occupants' lived experiences using qualitative research methods might pose threats to the credibility of the study during the data-gathering, analysis, or interpretation stages, in addition to the possibility of researcher bias. Usually human experiences require prolonged engagements to build trust between participants, and the researcher takes more time to observe and document repeated patterns in the phenomena. However, the researcher was aware that a prolonged stay in a workplace could interrupt the work and interfere with the natural behavior of occupants, which is in itself a nuisance to occupants. Hence, several visits were performed instead.

Awareness about researcher's bias: To reduce the researcher's bias, the researcher kept the research questions in mind (to avoid distraction from the research scope and objectives) throughout her data gathering phases, made her intentions clear, used criteria for obtaining persistent observations, used occupants' own words in the interpretations of the interviews, used unobtrusive means during the walk-through tours, and used triangulation.

6.7 Conclusion

> *"User centred design offers a compelling alternative to the current obsession with style and iconography, delivering buildings that create value by enhancing the environment that people occupy, closing the performance gap and ultimately completing the social, economic and environmental circle required to achieve sustainable development."* (Paul Hinkin, MD of Black Architecture in WorldGBC, 2014)

The study has emphasized the importance of integrating workplace design criteria with green building design to fulfil the social dimension of sustainability in addition to the economic and environmental ones. By investing in the human component factors, along with the environmental (environmental dimension of sustainability) aspects, we can have building occupants who are physically and mentally healthier, thereby decreasing turnover rates and absenteeism due to sick building syndrome. We can create a sense of attachment, motivation, and belongingness to support the social dimension of sustainability. These improvements in outlook help occupants work more efficiently and thus increase productivity and, in turn, the

economic dimension of sustainability. Green building rating systems, and LEED in specific, need to find a balance between being system-centered (depending on building systems for the evaluation of building performance) and being user-centered (considering humane aspects in design). For GBRS and LEED systems, if the evaluation process only depends on codes and standards that are based on assumptions about occupants' experience, it's not useful for the occupants' QoL in the long term. Research on human behavior in green buildings will help advance building codes and ensure better decisions are made by policymakers and designers.

Occupants' experience in work environments cannot be complete without the fulfilment of various comfort components. In particular, the Social, Psychological, and Cultural Comforts should not be underestimated or compromised to the advantage of exclusively fulfilling the Physical and Functional Comforts, as they play a major role in stress relief, a health and comfort issue that also impacts productivity. For example, rewarding employees by providing some valued services that nourish their social life and health, such as a well-designed cafeteria with good food offerings, a lounge to relax and rest in, and a gym to help stay fit, all contributed to lowering employees' stress and increasing their appreciation for the building.

Having consistency in the environmental conditions, especially in temperature, was a problem when not achieved, as people tend to feel the lack of quality in their Physical Comfort level more than the presence of quality. The needs for freedom of self-expression and for Personalization, as well as the desire to select the most suitable level of privacy, are part of human psychological needs; they seemed to be exaggerated when they were not allowed and/or could not be achieved due to the organizational culture or to design restrictions in the materials used, while they appeared to be a minor concern when people were free to choose them. Storage, furniture comfort, and accessibility seemed to have a strong influence on occupants' Functional Comfort, Overall Comfort, and with their satisfaction with the work environment. These findings suggest that regardless of the level of a building's certifications or awards, the dependency on checklists and building commissions, where machines and systems are the only items measured, may mask or fail to measure some users' needs, as the occupants' may experience a different scenario. When people's humane and habitable needs are not fulfilled, they simply dislike the building they are in. Environmental psychology, as the science of human behavior and person-environment relationships, can help mitigate the

problems caused by sustainable practices in buildings. It can help in measuring, explaining, and predicting environmental quality as a result of the in-depth understanding of human behavior and occupants' perceived QoL. According to the research results, a Sustainable and Humane Office Work Environment can be defined as stated here.

A sustainable and humane work environment encompasses all the meanings of environmental quality: the instrumental, latent, and symbolic qualities necessary for the interaction of human experience in a work environment that has sustainable ambient conditions, a sustainable designed environment, a humane behavioral environment, and quality operation and maintenance. This work environment is achieved by fulfilling all of the components of comfort: physical, functional, psychological, social, and cultural.

In conclusion, a *sustainable and humane office work environment* is a user-centered work environment that provides a humane QoL, which fulfils the occupants' needs while using sustainable principles. This creates a work environment that is comprehensively healthier, more comfortable, and more productive for occupants' QoL.

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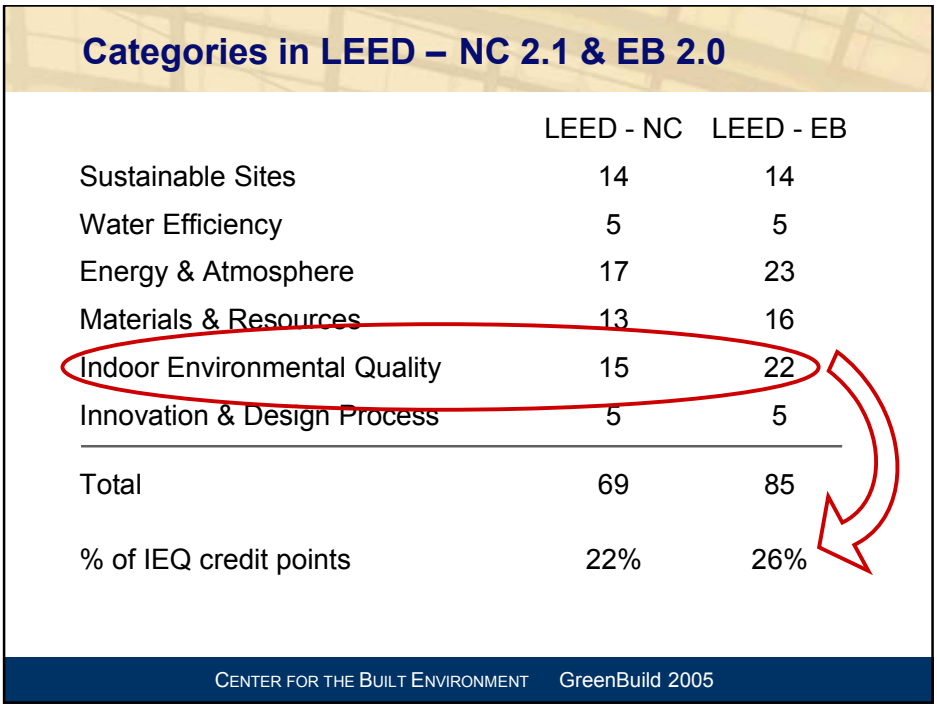
APPENDICES

APPENDIX A



Categories in LEED – NC 2.1 & EB 2.0

	LEED - NC	LEED - EB
Sustainable Sites	14	14
Water Efficiency	5	5
Energy & Atmosphere	17	23
Materials & Resources	13	16
Indoor Environmental Quality	15	22
Innovation & Design Process	5	5
Total	69	85
% of IEQ credit points	22%	26%

CENTER FOR THE BUILT ENVIRONMENT GreenBuild 2005

CATEGORIES IN LEED CANADA 2009; opened June 21, 2010		
	LEED-NC & CS	LEED-EB &OM
TOTAL POSSIBLE POINTS	110	110
SUSTAINABLE SITES	26	26
WATER EFFICIENCY	10	14
ENERGY AND ATMOSPHERE	35	35
MATERIALS AND RESOURCES	14	10
INDOOR ENVIRONMENTAL QUALITY	15	15
INNOVATION IN DESIGN	6	6
REGIONAL PRIORITY	4	4
% of IEQ credit points	13.6%	13.6%

Appendix B

Faculté de l'aménagement
Université de Montréal

Indoor Environmental Quality and Quality of Life

IEQ-QoL Questionnaire Draft 1

You are invited to participate in a study of **"workspace indoor environmental quality assessment "**. This research is being conducted by Mariam Wifi; a PhD candidate in the Faculty of Environmental Design at the University of Montreal. The purpose of this research is to develop comprehensive criteria for assessing indoor environments for work by proposing a more occupant-oriented framework. This study will use feedback from building occupants to determine how people's quality of life (QoL) is affected by their indoor environments. Your answers to the questionnaire will help improve building design criteria and ways of assessing indoor environments.

In the following pages you will find a series of questions about the quality of your work environment. Most of the questions are in the form of a scale from 1 to 5, where 1 is unsatisfactory or uncomfortable, and 5 is satisfactory/comfortable. The questionnaire takes 20-30 minutes to complete.

Please note that your participation is voluntary. You are free to ask any questions concerning the study and the data you provide. Your right to stop at any time is assured. Every effort is being made to protect the confidentiality and privacy of your information.

To protect the identity of participants the researcher will use a code for individual identification and no names will be used. The data obtained through your responses will not be linked to individual respondents nor to place of employment.

For any questions or concerns please contact the researcher, Mariam Wifi on [redacted]

Thank you for your time. Your participation is greatly valued!

Mariam Wifi
Candidat au doctorat
Faculté de l'aménagement
Université de Montréal
Courriel: [redacted]
Courriel: [redacted]

PLEASE PROVIDE YOUR: **Building's Name:** .....

Floor # where personal your workstation is located: .....

Cubicle # of your personal workstation: ..... **CODE:** .....

Code composed of the Initials of your name (three or two letters if you have only two) *and numbers of your date of birth. Please add zero if your birthday numbers are composed of one digit.*

e.g: **Sarah George Ken 15 October: SGK1510**

Phillipe John 7 August: PJ0708

PERSONAL WORKSPACE/WORKSTATION FEATURES

1. Please choose what type best describes your personal workspace/workstation

- ☐ Enclosed private office (four walls to ceiling and door)
- ☐ Cubicle with high partitions (1.5 m height or more)
- ☐ Open-plan (desks in the office with no partitions)
- ☐ Enclosed shared office (shared with other people)
- Cubicle with low partitions (less than 1.5 m height)
- ☐ Other: *please specify* ……
  ……..…

2. Position of personal workspace/workstation:

- ☐ Located at corner
- ☐ Located at the external walls beside windows
- ☐ Located on internal corridors
- ☐ Other: *please indicate.* ……

3. Proximity of Windows to Personal Workspace (within 15 feet) ☐ Yes ☐ No

4. Do you have blinds on the office building windows? ☐ Yes ☐ No

If yes, can they get controlled?

☐ Automatically controlled ☐ Manually controlled ☐ Uncontrollable

5. Do you have operable windows at your office?

☐ Yes the windows can be opened ☐ No the windows cannot be opened ☐ I don't know

6. Viewed scene from the window if available:

- ☐ Natural scene
- ☐ Traffic, buildings, streets
- ☐ Other: *please specify* ……..…

7. Do you have task lighting on your desk? ☐ Yes ☐ No

8. What color is the light coming out of the artificial lights at your office space

☐ White illumination ☐ Bluish illumination ☐ Yellowish illumination ☐ Other……..……

Please indicate the type of bulbs if you know it (incandescent, fluorescent, spotlights…etc.)

…….

1

Section 1: THE INDOOR ENVIRONMENTAL QUALITY

1.1 The Ambient conditions

Based on your lived experience in this building over the previous year, please assess the following aspects of your work environment on a scale of 1-5, where **1** means **uncomfortable/poor** quality, **5** means **comfortable/good** quality, and **3** means **average/neutral** quality

Please check one response on the scale for each of the questions that follow.

1.1.1. Indoor Air Quality

a) What is your assessment about the Overall Ventilation in your workplace?

Summer	Uncomfortable	1	2	3	4	5	Comfortable
Winter	Uncomfortable	1	2	3	4	5	Comfortable

Please explain the reasons for your rating

……
……

b) What is your assessment regarding the following elements of the indoor air quality?

Air movement /circulation

Summer	Stagnant	1	2	3	4	5	Circulated
Winter	Stagnant	1	2	3	4	5	Circulated

Air dryness

Summer	Dry	1	2	3	4	5	Comfortable
Winter	Dry	1	2	3	4	5	Comfortable

Air Freshness

Summer	Stuffy	1	2	3	4	5	Fresh
Winter	Stuffy	1	2	3	4	5	Fresh

Air Odors

Summer	Smelly/stinky	1	2	3	4	5	Odorless
Winter	Smelly/stinky	1	2	3	4	5	Odorless

Comment: *Please add any comments you may have for the **Indoor Air comfort** and what steps you might take to feel **more** comfortable:*

……
……
……

1.1.2 Lighting Quality

(a) What is your assessment of the Overall Lighting quality in your workplace *(how well it suits your tasks)?*

Summer	Uncomfortable	1	2	3	4	5	Comfortable
Winter	Uncomfortable	1	2	3	4	5	Comfortable

Please explain the reasons for your rating

……
……

(b) What is your* assessment *regarding the following elements of Lighting quality?

Overall amount of light in personal workspace suiting your tasks.

Summer	Insufficient	1	2	3	4	5	Sufficient
Winter	Insufficient	1	2	3	4	5	Sufficient

Reflections/Glare on computer screens from artificial lighting

Summer	Uncomfortable	1	2	3	4	5	Comfortable	☐ **N/A**
Winter	Uncomfortable	1	2	3	4	5	Comfortable	☐ **N/A**

Reflections/Glare on desk surface from artificial lighting

Summer	Uncomfortable	1	2	3	4	5	Comfortable	☐ **N/A**
Winter	Uncomfortable	1	2	3	4	5	Comfortable	☐ **N/A**

Flicker from electric lighting

Summer	Uncomfortable	1	2	3	4	5	Comfortable	☐ **N/A**
Winter	Uncomfortable	1	2	3	4	5	Comfortable	☐ **N/A**

Color of artificial/electrical lighting (bluish, yellowish, white…etc.)

Summer	Uncomfortable	1	2	3	4	5	Comfortable
Winter	Uncomfortable	1	2	3	4	5	Comfortable

Daylighting

Summer	Uncomfortable	1	2	3	4	5	Comfortable	☐ **N/A**
Winter	Uncomfortable	1	2	3	4	5	Comfortable	

Reflections/Glare from windows (natural daylighting) on computer screens

Summer	Uncomfortable	1	2	3	4	5	Comfortable	☐ **N/A**
Winter	Uncomfortable	1	2	3	4	5	Comfortable	☐ **N/A**

Reflections/Glare from windows (natural daylighting) on desk surface.

Summer	Uncomfortable	1	2	3	4	5	Comfortable	☐ **N/A**
Winter	Uncomfortable	1	2	3	4	5	Comfortable	☐ **N/A**

Shadows in the workplace

Summer	Uncomfortable	1	2	3	4	5	Comfortable	☐ **N/A**
Winter	Uncomfortable	1	2	3	4	5	Comfortable	☐ **N/A**

Comment: *Please add any comments you may have for the **lighting comfort** and what steps you might take to feel **more** comfortable:*

……
……

1.1.3 Thermal Comfort

a) What is your assessment of the Overall Thermal comfort in your workplace?

Summer	Uncomfortable	1	2	3	4	5	Comfortable
Winter	Uncomfortable	1	2	3	4	5	Comfortable

Please explain the reasons for your rating

……
……

b) What is your assessment regarding the following elements of thermal comfort in your workspace?

Room temperature

Summer	Uncomfortable	1	2	3	4	5	Comfortable
Winter	Uncomfortable	1	2	3	4	5	Comfortable

Temperature shifts

Summer	Uncomfortable	1	2	3	4	5	Comfortable
Winter	Uncomfortable	1	2	3	4	5	Comfortable

Humidity

Summer	Uncomfortable	1	2	3	4	5	Comfortable
Winter	Uncomfortable	1	2	3	4	5	Comfortable

Air Speed

Summer	Draughty/drafty	1	2	3	4	5	Comfortable
Winter	Draughty/drafty	1	2	3	4	5	Comfortable

Comment: *Please add any comments you may have for the **thermal comfort** and what steps you might take to feel **more** comfortable:*

……
……

1.1.4 Acoustical Quality (Noise and auditory comfort)

a) What is your assessment regarding the Overall level of background sounds in your workplace?

Uncomfortable	1	2	3	4	5	Comfortable

Please explain the reasons for your rating

……
……

b) **What is your assessment regarding the following aspects of office sound levels*:***

Sounds from colleagues or visitors

Uncomfortable/Noisy	1	2	3	4	5	Comfortable

Sounds from mechanical system, ventilation, printers and lighting

Uncomfortable/Noisy	1	2	3	4	5	Comfortable

Sounds from outside

Uncomfortable/Noisy	1	2	3	4	5	Comfortable

Comment: *Please add any comments you may have for the **acoustical comfort** and what steps you might take to manage **noise** and feel **more** comfortable*

……
……

1.2 THE DESIGNED ENVIRONMENT: WORKPLACE DESIGN

Based on your lived experience in this building over the previous year, please provide your assessment of you work environment qualities on a scale of 1-5, where **1** means **uncomfortable/poor** quality, **5** means **comfortable/good** quality, and **3** means **average/neutral** quality

Please check one response to each question.

1.2.1 Office/workplace layout

a) What is your assessment regarding the overall workplace organization/layout (the zone where your personal workstation is located)

Uncomfortable	1	2	3	4	5	Comfortable

Please explain the reasons for your rating

……
……

b) What is your assessment regarding the following elements of your workplace layout, or mark on not available (N/A) if you don't have?

Places for social gathering (lounge, coffee break...etc.) in your workplace ☐ **Insufficient** ☐ **N/A**

Uncomfortable	1	2	3	4	5	Comfortable

Places for communication and collaborative work ☐ **Insufficient** ☐ **N/A**

Uncomfortable	1	2	3	4	5	Comfortable

Places for working or meeting in privacy ☐ **Insufficient** ☐ **N/A**

Uncomfortable	1	2	3	4	5	Comfortable

Access to job related resources: papers, printers, tools …etc.

Difficult	1	2	3	4	5	Comfortable

Comment: *Please add any comments you may have for the **Office/workplace layout** and what steps you might take to feel **more** comfortable:*

……
……

1.2.2 Personal Workspace/workstation quality

a) What is your assessment regarding the overall workspace quality (personal workstation)

Uncomfortable	1	2	3	4	5	Comfortable

Please explain the reasons for your rating

……
……

b) What is your assessment regarding the following elements of your personal workspace quality?

Size of personal workstation *(to accommodate your work, materials, and visitors...etc.)*

Uncomfortable	1	2	3	4	5	Comfortable

Amount of desk space available for your daily tasks

Inadequate	1	2	3	4	5	Adequate

Amount of space for storage in your personal workspace

Insufficient	1	2	3	4	5	Sufficient

Location of your personal workspace in the space/office layout

Uncomfortable	1	2	3	4	5	Comfortable

Distance between you and other colleagues

Uncomfortable	1	2	3	4	5	Comfortable

The degree of enclosure created by your workstation via walls, partitions, furniture...etc.

Uncomfortable	1	2	3	4	5	Comfortable

Comment: *Please add any comments you may have for your **personal workspace quality** and what steps you might take to feel **more** comfortable:*

……
……

1.2.3 Ergonomics & Furniture

a) What is your assessment regarding the overall quality of ergonomics & furniture

Uncomfortable	1	2	3	4	5	Comfortable

Please explain the reasons for your rating

……
……

b) What is your assessment regarding the following elements of furniture quality?

Comfort of personal workspace furniture

Uncomfortable	1	2	3	4	5	Comfortable

Adjustability of personal workspace furniture

Fixed	1	2	3	4	5	Adjustable

Flexibility of personal workspace furniture for different work requirements or working in collaboration with colleagues:

Inflexible	1	2	3	4	5	Flexible

Comment: *Please add any comments you may have for the **ergonomics & furniture quality** and what steps you might take to feel **more** comfortable:*

……
……

1.2.4 Hygiene and Cleanness Quality

a) What is your assessment regarding the level of hygiene and cleanness of the work environment

Uncomfortable	1	2	3	4	5	Comfortable

Please explain the reasons for your rating.

……
……

Comment: *Please add any comments you may have for the **hygiene and cleanness quality** and what steps you might take to feel **more** comfortable:*

……
……

1.2.5 Maintenance

a) What is your opinion of Overall maintenance in this building? ☐ **N/A**

Uncomfortable	1	2	3	4	5	Comfortable

Please explain the reasons for your rating

……
……

Comment: *Please add any comments you may have for the **maintenance** and what steps you might take to feel **more** comfortable:*

……
……

1.2.6 Building Features in Connection with Nature

If you have experienced any of the following building features, please assess your experience:

Daylighting	Uncomfortable	○	○	○	○	○	Comfortable	☐ **N/A**
Indoor Plants	Uncomfortable	○	○	○	○	○	Comfortable	☐ **N/A**
Views	Dislike	○	○	○	○	○	Like	☐ **N/A**

Other. *Please specify*……
……

Comment: *Please add any comments you may have for the above **building features** and what steps you might take to feel **more** comfortable:*

……
……

1.2.7 Image and Indoor décor

(a) H**ow satisfied are you with the overall image and décor of your workplace:**

Dislike ○ ○ ○ ○ ○ Like

Please explain the reasons for your rating

………
………

(b) Please rate how much do you like each of the following elements:

Colors:

Ceilings	Dislike	○	○	○	○	○	Like
Floors	Dislike	○	○	○	○	○	Like
Walls	Dislike	○	○	○	○	○	Like
Furniture	Dislike	○	○	○	○	○	Like

Textures and finishing materials:

Ceilings	Dislike	○	○	○	○	○	Like
Floors	Dislike	○	○	○	○	○	Like
Walls	Dislike	○	○	○	○	○	Like
Furniture	Dislike	○	○	○	○	○	Like

Interior décor

Ceilings	Dislike	○	○	○	○	○	Like
Floors	Dislike	○	○	○	○	○	Like
Walls	Dislike	○	○	○	○	○	Like
Furniture	Dislike	○	○	○	○	○	Like

Comment: *Please add any comments you may for the* ***image and indoor décor*** *and what steps you might* ***take or add*** *to feel* ***more*** *liking and satisfied with them.*

………
………
………

1.3 SOCIAL, PSYCHOLOGICAL BEHAVIORAL ENVIRONMENT

1.3.1 Please rate how much do you agree with the following statements on a scale of 1 to 5. Where 1 means DISAGREE, 5 means AGREE and 3 means NEITHER AGREE NOR DISAGREE. ***Please check one response to each question***

1	2	3	4	5
○	○	○	○	○
Disagree	Somewhat disagree	Neutral	Somewhat agree	Agree

	1	2	3	4	5
1. **I can personalize my personal workspace through personal photos, quotes …etc.**	○	○	○	○	○
2. **I am comfortable with the amount of visual privacy between me and co-workers**	○	○	○	○	○
3. **I am comfortable with having personal or private conversations at my desk**	○	○	○	○	○
4. **I find the office space is too crowded**	○	○	○	○	○
5. **I find my work environment represents and respects the culture of the city/region (through symbols, icons, logos, proverbs, pictures…other)**	○	○	○	○	○
6. **I am proud of how this office looks to visitors**	○	○	○	○	○
7. **The location of my personal workspace represents and respects my status at work**	○	○	○	○	○
8. **I feel in harmony with the Proverbs, logos, pictures, and beliefs of my organizational culture**	○	○	○	○	○
9. I find the workplace image highly aesthetical	○	○	○	○	○
10. **I have confidence in the safety & security systems in this building**	○	○	○	○	○
11. The security system responds quickly in cases of emergencies.	○	○	○	○	○
12. The alarm systems and other safety and security systems are well-maintained	○	○	○	○	○
13. **I can change the ambient conditions such as lighting and temperature to suit my comfort needs.**	○	○	○	○	○
14. **I can adjust my own furniture to suit my body comfort and work needs.**	○	○	○	○	○
15. I can adjust my workspace to work in collaboration with colleagues	○	○	○	○	○
16. This work environment makes me feel connected with nature	○	○	○	○	○
17. **Background noise caused by people in this building hinders my ability to focus on work**	○	○	○	○	○
18. Background noise caused by building systems in this building hinders my ability to focus on work	○	○	○	○	○
19. **Visitors and new employees can easily find their way around the building using existing signage**	○	○	○	○	○
20. This current work environment satisfies my quality of life during work hours	○	○	○	○	○

1.3.2 Please estimate how often you:

1	2	3	4	5
○	○	○	○	○
Always	Usually	Sometimes	Few times	Never

(a) Experience any of the following:

	Always				Never	
	○	○	○	○	○	☐ N/A
1. Open the windows near your workstation	○	○	○	○	○	☐ N/A
2. Adjust the temperature thermostats	○	○	○	○	○	☐ N/A
3. Adjust the blinds at the windows	○	○	○	○	○	☐ N/A
4. Adjust the lighting at your desk?	○	○	○	○	○	☐ N/A
5. Use your desk task lighting	○	○	○	○	○	☐ N/A
6. Leave your workstation to work alone in a private room	○	○	○	○	○	☐ N/A
7. Adjust your furniture size, location, heights…etc.	○	○	○	○	○	☐ N/A
8. Get disturbed by unwanted noise interruptions from people	○	○	○	○	○	☐ N/A
9. Get disturbed by unwanted noise interruptions from building systems and equipment *(HVAC, lighting, printers...etc.)*	○	○	○	○	○	☐ N/A

(b) WISH/NEED to do any of the following actions?

	Always				Never
1. Change the location of your workstation	○	○	○	○	○
2. Have self expression in the design of your personal workstation	○	○	○	○	○
3. Change the interior décor of this office building	○	○	○	○	○
4. Work in a green building	○	○	○	○	○

1.3.3 Personal Control

a) In your workstation: Please rate the degree of your personal ability to control, change or modify each of the following

Ventilation	No control	○	○	○	○	○ Full control	☐ N/A
Artificial/electric Lighting	No control	○	○	○	○	○ Full control	☐ N/A
Daylighting	No control	○	○	○	○	○ Full control	☐ N/A
Noise from people	No control	○	○	○	○	○ Full control	☐ N/A
Noise from building systems/equipment	No control	○	○	○	○	○ Full control	☐ N/A
Temperature	No control	○	○	○	○	○ Full control	☐ N/A
Workstation Furniture	No control	○	○	○	○	○ Full control	☐ N/A

b) In your workstation: Please rate the degree of personal accessibility to reach the location of:

Light switches	Difficult	○	○	○	○	○	Easy	☐ N/A
Temperature thermostats	Difficult	○	○	○	○	○	Easy	☐ N/A

c) In your workstation: Please rate how easy these items are to personally adjust and use:

Light switches	Difficult	○	○	○	○	○	Easy	☐ N/A
Temperature thermostats	Difficult	○	○	○	○	○	Easy	☐ N/A
Workstation furniture	Difficult	○	○	○	○	○	Easy	☐ N/A

***d)* Do you use any of the following items in work environment?** *Please mark all what apply or indicate other*

☐ Personal fan	☐ Personal heater
☐ Desk task lighting	☐ Ear plugs
☐ Back or neck cushions	☐ Other: please specify……

e) Do any of the following factors affect your feeling of safety and security? *Please mark all that apply and indicate the reasons below.*

☐ Lighting
☐ Indoor Air
☐ Indoor temperature
☐ Daylighting
☐ Noise
☐ Office layout
☐ Personal workspace
☐ Furniture
☐ Cleanliness
☐ Maintenance

Reasons:……
……
……

1.4: OVERALL EXPERIENCE

1.4.1 Based on your daily working experience do you find any of the previously MENTIONED (in this questionnaire) or other UNMENTIONED factors related to your work environment that interact positively or negatively with: *Please indicate those factors and how they affect you if available.*

a. Your physical health *(eyes, neck, back, nose, ears…etc.)*
……
……

b. Your general mood, satisfaction, and mental health *(feeling of content, stress, tranquility, anxiety, good concentration, lack of concentration, motivation, depression, ...etc.)*
……
……

c. Your general physical environmental comfort *(comfort with temperature, light, noise, odors...etc.)*
……
……

d. Performing your work tasks in a functionally comfortable way *(ability to get the work done).*
……
……

1.4.2 Please rate how do you perceive your workspace in each of the following, based on your working experience in this building

Perceived health inside the building	Unhealthy	1	2	3	4	5	Healthy
Overall comfort with the workplace	Uncomfortable	1	2	3	4	5	Comfortable
Perceived work performance *(ability to get the work done)*	Work hindering	1	2	3	4	5	Work enabling
General satisfaction with the workplace	Unsatisfied	1	2	3	4	5	Satisfied
Meeting personal needs for living and working	Unsatisfied	1	2	3	4	5	Satisfied

Section 2: Background Information

Please check the appropriate answer or indicate other.

2.1 Demographic Information:

Age:	☐ < 20 ☐ 20-30	☐ 31-40 ☐ 41-50	☐ 51-60 ☐ > 60
Gender:	☐ Male	☐ Female	
Education:	☐ Secondary ☐ College ☐ Bachelor	☐ Masters ☐ PhD ☐ Other……...	

***2.2 Health related Information*:**

a) Please indicate how many working days in a month do you feel any of the following symptoms at work?
(Please mark all what apply or specify others.)

Symptoms	Number of days /working month
☐ Eye strain	(..... days)
☐ Itchy, red, burning, dry eyes	(..... days)
☐ Headache	(..... days)
☐ Skin dryness, redness, or itchiness days)	(..... days)
☐ Coughing	(..... days)
☐ Nausea	(..... days)
☐ Back or neck pain	(..... days)
☐ Sore throat	(.... days)
☐ Irritated, stuffy or runny nose	(..... days)
☐ Stress	(..... days)
☐ Lack of concentration	(..... days)
☐ Lack of motivation	(..... days)
☐ Depression	(..... days)
☐ Other…….....	(..... days)

b) Do you smoke? ☐ Sometimes ☐ A lot ☐ Never

2.3 Job related Information

1. For how long have you been working in this company?
…… Years …… Months …… Days

2. Please mark which category best describes your job

☐ Administrative ☐ Client related
☐ Technical/professional (sales,
☐ Managerial/supervisory marketing)
☐ Research/development work ☐ Field
☐ Other ……

3. Please indicate on average the time you spend at your work office every day?
…... Hours …… minutes

4. Your tasks require (please mark all that apply)
☐ Presentations on screens
☐ Working at desk (reading, writing… etc.
☐ Working on computer
☐ Collaboration with colleagues/ team work
☐ Meeting with clients
☐ Communication via telephone
☐ Field work not in office
☐ Other, please specify: ……

5. What mean of transportation do you usually take to and from your work on a typical workday?
☐ Car ☐ Bicycle ☐ Other, please specify: ……..
☐ Public transportation ☐ Walking

6. How long does it take you to arrive at your work?
☐ Less than 10 min ☐ Less than 20 min ☐ Less than 30 min ☐ Less than 1 hr. ☐ More than 1 hr.

2.4 Do you know if your office building is a green building?
☐ Yes, it is a green building ☐ No, it is not a green building ☐ I don't know

2.5 Do you like to work in a "green building", and why?
……
……

Green Buildings: are "*environmentally responsible, profitable and healthy places to live and work.*" (USGBC, 2004). They have environmentally responsible design features such as to maximize the use of natural resources in the most efficient way. It seeks the reduction of negative impacts on the environment and the occupants.

You have reached the end of this questionnaire.
Thanks ☺ for taking the time to respond.
Your participation is extremely valuable to us.

Appendix C

INTERVIEW QUESTIONS

(Narrative Inquiry)

INVESTIGATING OVERALL PERCEIVED QoL REGARDING THE IEQ OF THEIR WORKSPACE

A. (Unstructured questions)

"Describe how you feel when you first arrive at work everyday in the morning?"

" What are the first things you do when you arrive at your office/workspace?"

" How do you feel when you are leaving your office/workspace to go home?"

Describe to me your overall experience in your work environment if you have to say it in few attributes or words

B. "What do you consider to be important to your needs and living or working experience in your current work environment? How does this affect your quality of life at work? (Semi-structured questions)

IDENTIFYING THE IEQ FACTORS PROVIDING HUMANE WORKSPACE AND THEIR SIGNIFICANCE ON OCCUPANTS QoL

What qualities in your work environment do you consider have an influence on how you feel in terms of mood? (Semi-structured question)

What qualities in your work environment do you consider have an influence on your ability to work? (Semi-structured question)

What qualities in your work environment do you consider have an influence on your heath at work? (Semi-structured question)

Which quality that you have named is the most valuable in your viewpoint and makes you satisfied? (Semi-structured question)

DEFINING THE CONCEPT OF HUMANE WORKSPACE FROM GREEN BUILDING'S OCCUPANTS VIEWPOINT

Do you consider your work environment humane? And what does humane mean to you? (Semi-structured question)

What are your expectations about a green work environment? (Unstructured question)

What are the most important elements to you that need to be provided by any work environment? (Semi-structured question)

APPENDIX D

Analysis of occupants' first feelings and impressions upon arrival to the work environment (Question A.1)

BLDG/Interviewee	Occupants' Responses	Experience	IEQ Factors	Comfort Level	QoL
CDC-1st Int.	• *very crowded space* • *no real privacy* • *There are people who have to search out a private workspace because they can not work out this environment'* • *high level of white noise* • *no sound proofing*	• Crowding • Sound Privacy	• Spatial Organization • Acoustical Quality	• Psychological comfort • Functional comfort	• Health • Productivity
CDC -2rd Int.	*neutral*	—	—	—	—
CDC -3rd Int.	• *happy* • *underground parking... That is very comfortable especially given our climate. So that's great.* • *I didn't always work in this office…now I have windows,* • *it is so much brighter* • *so much more positive space in general…big difference...* • *I say that I am lucky to have this space, because I know that not everybody has it* • *I really appreciate that it is my own space that has my own things, that I can control…*	• Parking • Connectivity with Nature • Previous experience • Comparison with others' workspaces • Natural light • Control	• Parking • Views • Daylighting • Control	• Physical comfort • Psychological comfort	• Health • Comfort
GL-1st Int.	• *pretty open and quiet* • *relaxing* • *It works really well that way; there is nothing distracting or anything.*	• Openness • Noise control	• Layout • Acoustical Quality	• Psychological comfort • Functional comfort	• Health • Comfort • Productivity
GL-2rd Int.	• *Pretty low stressed when I come in.* • *I like my desk and my area…comfortable* • *I have a window* • *generally happy* • *ownership* • *the only thing that bothers me…amount of light; like artificial light*	• Connectivity with Nature • Control • Amount of Illumination	• Views • Control • Light Quality	• Psychological comfort • Physical comfort • Functional comfort	• Health • Comfort • Productivity
GL-3rd Int.	*I don't like my workstation… I don't know; I just don't like it.*	—	—	• Psychological comfort	• Health
GL-4th Int.	*I don't know if I have any specific first impressions*	—	—	—	—
WC-1st Int.	• *space that is connected to others* • *very open* • *allows for a lot of collaboration* • *same as everyone else's space* • *ability to make it your own space*	• Social connectivity • Openness • Collaboration • Equity • Personalization	• Layout • Furniture • Personal workstation	• Social comfort • Functional comfort • Psychological comfort	• Health • Comfort • Productivity

Appendix E

Université de Montréal

Comité plurifacultaire d'éthique de la recherche

N° de certificat [redacted]

CERTIFICAT D'APPROBATION ÉTHIQUE

- 2ième renouvellement -

Le Comité plurifacultaire d'éthique de la recherche (CPER), selon les procédures en vigueur et en vertu des documents relatifs au suivi qui lui a été fournis conclu qu'il respecte les règles d'éthique énoncées dans la Politique sur la recherche avec des êtres humains *de l'Université de Montréal*

Projet	
Titre du projet	**Occupants' Experience of Indoor Quality in the Work Environment: How to Define Quality Criteria for Assessing 'Green' Office Buildings ?**
Étudiante requérant	**Mariam WIFI** [redacted] Candidate au doctorat, École de design industriel - Faculté d'aménagement Université de Montréal
Sous la direction de	Tiiu Vaikla-Poldma, professeure titulaire, École de design industriel - Faculté d'aménagement, Université de Montréal & Jacqueline Vischer, professeure titulaire, École de design industriel - Faculté d'aménagement, Université de Montréal.
Financement	
Organisme	Non financé
Programme	--
Titre de l'octroi si différent	--
Numéro d'octroi	--
Chercheur principal	--
No de compte	--

MODALITÉS D'APPLICATION

Tout changement anticipé au protocole de recherche doit être communiqué au CPER qui en évaluera l'impact au chapitre de l'éthique. Toute interruption prématurée du projet ou tout incident grave doit être immédiatement signalé au CPER.

Selon les règles universitaires en vigueur, un suivi annuel est minimalement exigé pour maintenir la validité de la présente approbation éthique, et ce, jusqu'à la fin du projet. Le questionnaire de suivi est disponible sur la page web du CPER.

[redacted]

Raphaëlle Stenne, conseillère en éthique de la recherche
Comité plurifacultaire d'éthique de la recherche
Université de Montréal

19 septembre 2016 Date de délivrance du renouvellement ou de la réémission*
4 juillet 2013 Date du certificat initial
1er octobre 2017 Date du prochain suivi
1er octobre 2017 Date de fin de validité
*Le présent renouvellement est en continuité avec le précédent certificat

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Appendix F

Université de Montréal

[Faculté de l'aménagement]
[Doctorat**; Ph.D. aménagement]**

CONSENT FORM

Research Working Title: *Occupants' Experience of Indoor Quality in the Work Environment: How to Define Quality Criteria for Assessing 'Green' Office Buildings?*

Researcher: Mariam Wifi, Ph.D candidate, Faculty of Environmental Design, Université de Montréal.

Research Director: Tiiu Poldma, Ph.D, full professor, Faculty of Environmental design, Université de Montréal.

Research co-director: Jacqueline Vischer, Ph.D, professor emeritus, Faculty of Environmental Design, Université de Montréal.

A) INFORMATION FOR PARTICIPANTS

1. Research Objectives

We spend much time at work and the quality of our work environments may influence our physical health, our emotional states such as stress or anxiety as well as can be supportive to task performance or actually hindering our ability to get the work done comfortably. This research investigates how occupants' quality of life (QoL) experience as affected by their workspaces. The research will study occupants lived experience and assessment of the quality of their work environments in LEED sustainable but not certified, and conventional office buildings, and compare whether occupants' QoL experience and expectations differ or not.

Research Aim: Based on literature review there is a gap found between what building rating systems assess for quality of environments and what people may be actually feeling when living inside especially in green buildings; where their popularity is increasing and thus we need to turn more focus on them. Hence this research aims to decrease the gap between assessed building performance and perceived building performance. Thus contribute to a better understanding of human experience with designed environments especially green buildings.

Research Purpose/Main Objective

The purpose of this study is to propose an occupants-oriented Comprehensive Sustainable and Humane Framework for the assessment criteria of green buildings' Indoor Environmental Quality (IEQ).

Research Objectives/Secondary Objectives

1. Investigating occupants' QoL experience in workspaces----*why we need quality*.
2. Comparing occupants' experience and expectations between LEED, Sustainable (not certified), and conventional office buildings----*what affects quality.*

3. Identifying Indoor Environmental Quality (IEQ) factors affecting occupants QoL---*what is quality*.
4. Identifying whether the IEQ factors affecting occupants' QoL are related to green and sustainable features or workspace design----*how quality is composed*.
5. Knowing the significance and importance of each IEQ factor to occupants' QoL----*how the influence of quality differs (the hierarchy of quality factors)*.

2. Participation in research

Your participation in this project is to fill out a questionnaire survey, and/or do an interview, and/or focus group interview to assist in the study of occupants' lived experience in office buildings. You are free to accept which activity do you like to participate in.

The **questionnaire** will be given in a printed copy; delivered and collected by the researcher in person. Based on your personal preference it could be also sent to you by e-mail or put on your Intranet server at work from (date) to (date). It will take about 20 minutes to complete. The questions will ask you to rate aspects of your experience of working in your current office building on a scale of 1-5.

The **interview** will be conducted by the researcher and will ask you to express your everyday work and life experience with you work environment through narration. The interview will also include questions related to your comfort, satisfaction, as well as assessment and expectations regarding the quality of your work environment. This interview should take about 30-45 minutes. It will be recorded, with your permission, on audio in order to facilitate later transcription. The place and time of the interview will be arranged with the interviewer, depending on your availability.

The **group interview** will consist of 5-6 employees working with you at the same office environment. The interview should take about 1 hr. It will be recorded, with your permission, on audio in order to facilitate later transcription. The place and time of the interview will be determined and arranged with the interviewers, depending on the common availability. The researcher will discuss with the interviewers issues related to their comfort, satisfaction, as well as assessment and expectations regarding the quality of their work environment. This group discussion may help better conversational conclusions and assurances.

The researcher will be also seen in the buildings for two consequent weeks to take photos and observation notes concerning daily life activities, changes/adaptations made by the occupants to the work environment and mapping different patterns of behavior at office. The researcher will assure no interference that affects employees' task performance will be made.

Your decision of participation is voluntarily and you are free to withdraw at any time.

You may receive a further invitation to participate in an individual interview for 30-45 minutes.

3. Confidentiality

The personal information you provide will remain confidential. Each research participant will be assigned a code, and only the researcher and her research supervisors will have the list of participants and their corresponding codes. In addition, the data will be kept in a safe place. No

information that can identify you in one-way or another will be published. The researcher will be adding blur to the faces of people if they appeared in any photo. The recordings will be transcribed and will be destroyed, as well as any personal information, seven years after completion of the project. Only data that does not allow identifying you will be kept after this time. Participation in this research will have no effect on the relationship between the building manager and the participant, or between the team leader and participant and it does not deal with whether liking your job or not.

4. Advantages and disadvantages

Your participation in this research, can contribute to a better understanding of human experience with work environments and hence develop better guidelines for the assessment criteria used by buildings rating systems resulting in a better indoor environments and improved quality of life (QoL) and quality of work life (QWL) for workplaces' occupants. There is no particular risk to participate in this project. It is possible, however, that some questions may revive memories of an unpleasant or frustrating daily experience. You can at any time refuse to answer a question or even terminate the interview.

5. Right of withdrawal

Your participation in this project is entirely voluntary and you can withdraw at any time by a simple verbal or written (e-mail) notice and without having to justify your decision. If you decide to withdraw from the research, you may also contact the researcher at the phone numbers listed below or via e-mail. In case of withdrawal recording, photos, and all the information that has been observed or collected until your withdrawal will be destroyed.

6. Compensation

No compensation will be given to the participants, however the city of Calgary facility management group may receive the results and findings as a contribution to better quality of working environments for the employees.

7. Dissemination of results

A copy from the results and conclusions of the research thesis can be sent by e-mail to the interested participants. Participants will be also informed with the publication of scientific articles, and publications could be provided on request.

B) THE CONSENT

I have read the information above, getting answers to my questions about my participation in the research and understand the purpose, nature, benefits, risks and limitations of this research. After some thought and a reasonable time, I freely consent to participate in this research. I know that I can withdraw at any time without prejudice, upon verbal notice and without having to justify my decision.

I accept to participate in the following research activities (please choose all what you agree to participate in):

- ☐ Filling out the questionnaire
- ☐ Make an Interview
- ☐ Participate in a focus group interview

Signature: _____ Date: _____

Surname: _____ Name: _____

I declare that I explained the purpose, nature, benefits, risks and limitations of the study and answered to the best of my knowledge the questions.

Researcher's signature: _____ Date: _____

Surname: _____ Name: _____

For any questions concerning the research or to withdraw from the project, you can contact Mariam Wifi, researcher and PhD. candidate at Université de Montréal, telephone number: [redacted] or e-mail: [redacted] or [redacted]

Any complaints about your participation in this research may be addressed to the Ombudsman of the Université de Montréal, telephone number [redacted] or email at: [redacted] accepts collect calls).

A copy of the information and signed consent forms must be given to the participant